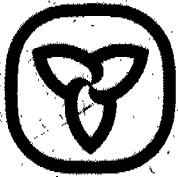


GEOCRES No. 31M-58DIST. 54 REGION W.P. No. 61-87-02GWP-524-90-00CONT. No. 2000-0225W. O. No. STR. SITE No. 43-03HWY. No. 11LOCATION Hwy 11 & Net Lake
(7 km N of Temagami)No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



Ontario

Ministry
of
Transportation

432 km

Office to site **FILE No.** _____ **DATE** _____

REMARKS _____

Kanichsee

Mined



FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 61-87-02 DIST 52
HWY 11 STR SITE 43-03

Net Lake Bridge

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FOUNDATION INVESTIGATION REPORT

For

Net Lake Bridge

W.P. 61-87-02, Site No. 43-03

Highway 11, District 52, Huntsville

INTRODUCTION

This report summarizes the results of a field investigation carried out for the construction of a new bridge structure and a detour structure over Net Lake, on Hwy 11. The new bridge will replace the existing bridge. The investigation was carried out at the request of Northern Region Structural Section.

SITE DESCRIPTION

The site for the proposed new Net Lake bridge is located approximately 7 km north of Temagami in the Township of Strathy. At this location, Hwy 11 crosses the Net Lake over a three span steel girder bridge. The shores of the Net Lake are covered with trees and shrubs. There is a residential house on the southwest side of the crossing. The existing roadway consists of steeply sided 4m high rock fill causeway.

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 97 05 27 and 97 06 05. Seven boreholes (BH 1 through BH 7) were advanced for the subsurface investigation. Two boreholes BH1 and BH2 were put down near the southwest and northeast corners of the existing bridge through the existing rock fill. The boreholes on the embankment were advanced using a track-mounted auger machines equipped with 82mm ID hollow stem augers. The other five boreholes (BH 3 through BH 7) were advanced using washboring techniques with a conventional diamond drill rig adapted for soil sampling purposes. A raft was used for the execution of those boreholes located on the lake. Two boreholes BH 4 and BH 5 were drilled at the location of proposed detour structure. Other three boreholes BH 3, 6 and 7 were put down along the proposed causeway for the detour. The bedrock was proven by obtaining bedrock core samples from BH 1, BH2 and BH 4.

Samples were recovered by means of a 50mm OD split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586). Soil samples were retrieved at intervals ranging from 0.75m to 1.5m. The field vane shear tests were carried out within the cohesive layer to determine the undrained and remoulded shear strength of the materials.

The boreholes were staked out by Pavements and Foundations Section of the MTO. The locations and elevations were interpolated from an E-plan, E-386-11-1, dated 06-96.

The Laboratory testing program for the representative samples consisted of:

- Grain Size Analyses
- Natural Moisture Content Determinations
- Atterberg Limit Tests, and
- Bedrock Core Logging

The results of the laboratory tests are plotted on the Record of Borehole sheets attached. The bedrock cores were logged by D.A. Williams, Petrographer in the Soils and Aggregates Section of MTO. The results of the bedrock core logging are attached to this report.

Groundwater was observed during drilling of the boreholes and immediately after completion of the field work.

SUBSURFACE CONDITIONS

Based on the information obtained in seven boreholes, the predominant natural deposit at the site is a 1.2m (BH 7) to 5.6m (BH 2) thick silt with a trace of clay, underlain by 0.2m (BH 7) to 7.4m (BH 5) thick gravelly sand. At the existing Hwy 11 alignment the silt deposit was overlain by rock fill up to 4m thick placed to construct the existing Hwy 11 causeway over the Net Lake.

The Records of Borehole Sheets (attached) illustrate the subsurface conditions at the borehole locations. The locations of the boreholes are shown on Drawing No. 618702-A.

Following are the detailed descriptions of the soil strata encountered.

Fill

Rock fill was only encountered in Boreholes 1 and 2 drilled at the existing approach embankment of Hwy 11. The rock fill was overlain by granular material 1.1m to 1.8m thick. The overall thickness of the fill below the road surface was 4.0m (BH2) to 5.8m (BH1). The thickness of only rock fill, underlying the granular material ranged from 2.9m (BH2) to 4.0m (BH1).

Silt

Underlying the rock fill in the existing causeway, and below the lake water, all boreholes except BH3 encountered silt with a trace of clay. The top elevation of the silt deposit ranged from 294.0m (BH1) to 295.8m (BH2). The thickness of the silt deposit ranged from 1.2m (BH7) to 5.6 (BH2). The Standard penetration N-values obtained within this deposit ranged from 1 to 17 blows/0.3m with an average N-value of 8 blows/0.3m. This suggested that the deposit is in very loose to compact state, but on average it is loose.

Gravelly Sand

The silt deposit was underlain by gravelly sand. This deposit was encountered in all boreholes. The top elevation of this deposit ranged from 289.9m (BH4) to 293.9m (BH3). The thickness of this deposit ranged from 0.2m (BH7) to 7.4m (BH5). The Standard Penetration Test N-values recorded in this deposit ranged from 6 blows to more than 50 blows. On an average the N-value was 20 blows/0.3m. This suggested that the gravelly sand deposit is in loose to very dense state. However, on average the deposit is compact.

Bedrock

Bedrock was encountered in all boreholes. The bedrock was proven by coring at three borehole locations BH1, 2 and 4. The top elevation of the bedrock ranged from 283.2m (BH 5) to 293.1 (BH7).

Groundwater Condition

Groundwater was monitored in open boreholes at BH1 and BH2. Groundwater level in the boreholes was slightly above the water level in the creek. The groundwater table in both boreholes was encountered at a depth of 3.5m below the ground surface. The groundwater table in the boreholes was at elevation 296.3m. It should be noted that the groundwater is subject to seasonal fluctuation.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing bridge with a single span steel girder and a concrete deck bridge. The existing bridge was constructed in 1938. The existing bridge is a three span, simply supported steel girder and a concrete deck supported on timber piles. It is proposed to construct the new bridge with integral abutments. Three options are under consideration:

1. Construct the new bridge on existing alignment with a temporary Modular Bridge detour.
2. Construct the new bridge on a new alignment to the east, using the existing structure for the detour.
3. Construct the new bridge on a new alignment 2.5m west of the existing alignment with temporary Modular Bridge detour.

The new grade will be 0.5m higher than the existing grade. The new embankments would consist of rock fill. The existing roadway consists of 4m high rock fill causeway.

Structure Foundations

New Main Bridge

We recommend that the new bridge should be constructed at the existing alignment. At the existing alignment most of the settlement due to the embankments would have taken place and the settlement due to 0.5m grade raise will be small. Whether the new bridge is constructed on the existing alignment, 2.5m west of the existing alignment or 20m east of the existing alignment, the very loose to compact silt or the existing rock fill are not suitable for spread footing.

The bridge structure can be supported on steel H-piles driven to the bedrock. If the new bridge is constructed at the existing bridge location or 2.5m west of the existing alignment, then it is expected that the pile tips will reach the bedrock at elevation 285.5m (BH 2) at the north abutment and at elevation 289.7m (BH 1) at the south abutment.

If the bridge is constructed at a new location 20m east of the existing alignment, then it is expected that the pile tips will reach to elevation 283.2m (BH 5) at the north abutment and 288.3m (BH 4) at the south abutment. However, it is possible that the pile may not reach to the bedrock and stop few metres above the bedrock within the very dense gravelly sand with boulders deposit. In that case the pile driving should be controlled by the Hiley formula as per MTO Standards SS 103-10 or SS 103-11, assuming the ultimate capacities as shown below. If the piles are driven to the bedrock then Hiley formula will not be used.

The recommended bearing resistance of H-piles founded on bedrock or very dense sand and gravel are as follows:

	<u>HP 310X110</u>	<u>HP 310X79</u>
Factored Axial Resistance at ULS	1600 kN/pile	1150 kN/pile
Factored Horizontal Resistance at ULS	80 kN/pile	60 kN/pile
Horizontal Resistance at SLS.	60 kN/pile	40 kN/pile
Ultimate Pile Resistance for Hiley Formula	3450 kN/pile	2475 kN/pile

The serviceability Limit State (SLS) would not govern for piles founded on bedrock or unyielding soil.

If integral abutments are not considered, then the lateral capacities of the piles may be supplemented by the horizontal component of the battered piles.

To facilitate pile driving, and pile cap construction at the existing alignment, the rock fill will have to be excavated. Particle sizes of any fill placed beneath the pile locations should be restricted to 75mm. The piles should be equipped with driving shoes as detailed on OPSD - 3301.00. The piles should be advanced with a hammer capable of developing sufficient energy to drive the piles. Also, piles should be driven after the embankment fill is placed and the settlement has taken place.

Detour Bridge

If the detour bridge is to be constructed on the east side of the bridge (20m from the centreline to centreline) then the abutments of the detour bridge can be founded on piles driven to bedrock. The recommended bearing resistance of H-piles founded on bedrock or very dense sand and gravel are as follows:

	<u>HP 310X110</u>	<u>HP 310X79</u>
Factored Axial Resistance @ ULS	1600 kN/pile	1150 kN/pile
Factored Horizontal Resistance at ULS	80 kN/pile	60 kN/pile
Horizontal Resistance at SLS.	60 kN/pile	40 kN/pile
Ultimate Pile Resistance for Hiley Formula	3450 kN/pile	2475 kN/pile

The serviceability Limit State (SLS) would not apply for piles founded on bedrock or very dense gravelly sand.

The lateral capacities of the piles may be supplemented by the horizontal component of the battered piles.

The piles should be driven after the approach fill is constructed and all the settlement has taken place. To facilitate pile driving, particle sizes of any fill placed beneath the pile locations should be restricted to 75mm. The piles should be equipped with driving shoes as detailed on OPSD - 3301.00. The piles should be advanced with a hammer capable of developing sufficient energy to drive the piles.

As an alternative, the bridge can be founded on spread footings constructed on the rock fill. It is recommended that rock fill within 1m below the underside of the footing should be of smaller size not exceeding 300mm.

If the rock fill is composed of hard rock fragments such as granitic and metamorphic type rocks and incorporating an angle of internal friction of $\phi = 35^\circ$, the recommended bearing capacities for the spread footings, on the rock fill as per OHBDC are as follows:

Factored Bearing Resistance @ ULS	= 750 kPa
Bearing Resistance @ SLS	= 250 kPa

In the bearing resistance calculations, it was assumed that the top of the footing would have at least 1m rock fill cover. To calculate the lateral resistance a $\phi = 35^\circ$ should be used for friction between concrete and the rock fill.

Integral Abutment

Integral abutments may be considered for this site if the preaugured holes can be constructed in dry. For the proposed grade and the span of the structure, the preaugured hole will be below the water level. A major dewatering scheme (including cofferdam) will be required to construct the preaugured hole. Permanent liner will be required for the preaugured hole containing uniformly graded sand (Ottawa sand). The skew of the abutment and the span should be checked if they meet the requirements for the integral abutment.

If integral abutments are considered for this site, it will be constructed on steel piles driven to bedrock. The piles for integral abutments should be in one row. The piles shall be driven through

0.6m diameter and 3m deep holes filled with uniformly graded sand. Following is the NSSP for the special sand used for integral abutments.

NSSP - Backfill to Integral Abutment-Augured Hole

The annular space between the preaugured oversize hole and the pile shall be backfilled with uniformly graded sand. The gradation for the uniformly graded sand shall be as follows:

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

Alternatively, commercially available material which meets the above gradation may be considered instead of Ottawa sand.

Embankment Stability

The height of the embankment adjacent to the existing bridge is about 4m. The side slopes of the existing embankments are at 2H:1V and the forward slopes at about 1.25H:1V. It is proposed to raise the height of the embankment by 0.5m. In addition, the embankment will be widened by 5m toward the west. The width of the highway will therefore, change from existing 9.5m to 14.5m. If rock fill is used for the new embankments, then the sides of the embankments should be constructed at 1.25H:1V or flatter.

To widen the embankment at the existing alignment and to construct the causeway for the detour, the rock fill should be placed without any excavation. Any excavation to remove the soft material before placing the rock fill will definitely reduce the post construction settlement but may not be

feasible due to environmental concern. To reduce the post construction settlement, a surcharge load with an additional 2m of rock fill should be placed on the embankment (at both existing and new embankments). If possible the surcharge should be maintained for as long as possible but preferably for a minimum period of three months.

No stability problems are anticipated for the proposed height of the embankments if the embankments are constructed as recommended.

Embankment Settlement

The embankment will be constructed by placing rock fill over the silt and gravelly sand deposits. The settlement will be elastic in nature, and will take place during the construction. After the surcharge is removed, some long term settlement will take place due to movement within the rock fill. It is expected that the settlement due to rock fill will be about 50mm at the existing bridge location and 100mm at the detour.

Lateral Earth Pressure

Free draining granular material such as Granular 'A' or 'B', or rock fill is recommended as appropriate backfill to abutment walls to prevent hydrostatic pressure build up.

If rock fill is used for approaches, special care will be required to avoid damaging to the abutment. It would be preferable to place a 0.3m cushion of Granular 'A' or smaller rock fill (with a diameter of less than 300mm), between the structure and the main mass of the rock fill. Granular material may also be used at the approaches.

For design purposes, the following properties for backfill are recommended:

Granular 'A'	$\gamma = 22.8 \text{ kN/m}^3$	$\phi = 35^\circ$
Granular 'B'	$\gamma = 21.2 \text{ kN/m}^3$	$\phi = 30^\circ$
Rock fill	$\gamma = 18.0 \text{ kN/m}^3$	$\phi = 35^\circ$

At rest condition (K_0) may be assumed to apply for unyielding structures. If the structure is designed to be yielding then active condition (K_a) should be used.

Frost Protection

A soil cover of 2.1m or equivalent will be required for frost cover for pile caps. The pile caps should be constructed below the frost depth or the scour depth whichever is greater.

Excavation and Dewatering

Excavation for the pile caps or abutment walls will take place within silt deposit below the water level in the lake (Elev. 296.2m). Excavation for the pile caps can be carried out within the confines of continuous steel sheeting driven into the silt deposit. For basal stability, the sheeting should extend a minimum of 0.5 B below the base of the excavation (where B is the width of the excavation). For design of the sheeting, an earth pressure coefficient of $K=1.0$ should be used. Sump pumps may be used to control the seepage and lowering the water level within the cofferdams. Clear stone may be placed at the base of the excavation to act as construction platform.

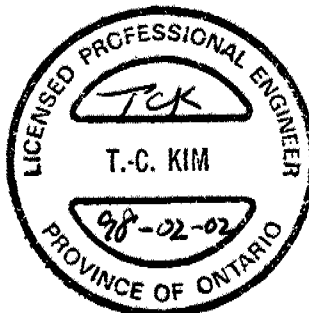
MISCELLANEOUS

The field work for this project was carried out by Issam ElKhatib and Ann-Marie Gibson Engineering Students under the direct supervision of K.S.Q. Ahmad, Foundation Engineer. The equipment used was owned and operated by Master Soil Investigations Ltd.

The report was written by K.S.Q. Ahmad, Foundation Engineer. The report was reviewed and approved by T.C. Kim, Senior Foundation Engineer.



for Taecheul Kim
K.S.Q. Ahmad, P. Eng.
Foundation Engineer



Taecheul Kim
T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords: N 5 219 243.7; E 396 378.8 ORIGINATED BY KA
 DIST 54 HWY 11 BOREHOLE TYPE HS Auger, N Casing, BX Rock Core COMPILED BY KA
 DATUM Geodetic DATE 1997 05 27,28,29 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
299.8	Road Surface																
0.0																	
	Sand and Gravel Dry, Brown, Compact (Fill)		1	SS	11		299										33 57 (10)
298.0			2	SS	11		298										50 43 (7)
1.8							297										
	Rock Fill						296										
							295										
294.0							294										
5.8			3	SS	*		293										
	Silt, with a trace of Clay Grey, Wet Very Loose to Compact						292										3 2 85 10
291.6			4	SS	17		291										
8.2							290										
	Gravelly Sand with a trace of Silt Wet, Compact		5	SS	14		289										25 59 (16)
289.7							288										
10.1			6	RC	REC	100%											RQD 0%
	Granite Bedrock		7	RC	REC	50%											RQD 0%
287.8			8	RC	REC	100%											RQD 0%
12.0	End of Borehole																
	* Disturbed. Rod Dropped																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords.: N 5 219 273.8; E 396 382.1 ORIGINATED BY AG
 DIST 54 HWY 11 BOREHOLE TYPE N and B Casings, BX Rock Core COMPILED BY KA
 DATUM Geodetic DATE 1997 06 02.03 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
299.8	Road Surface													
0.0	Probable Sand and Gravel (Fill)													
298.7														
1.1														
	Rock Fill													
295.8														
4.0			1	SS	15									
			2	SS	9									
	Silt, with a trace of Clay Grey, Wet Loose to Compact													2 3 86 9
			3	SS	9									
			4	SS	12									
290.2														
9.6														
			5	SS	8									
			6	SS	9									
	Sand with Gravel Wet, Loose to Dense													14 59 (17)
			7	SS	32									
285.5														
14.3	Gabbro Bedrock		8	RC	REC	75%								RQD 33%
284.9														
14.9	End of Borehole													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords.: N 5 219 221.4; E 396 399.0 ORIGINATED BY IE
 DIST 54 HWY 11 BOREHOLE TYPE N Casings COMPILED BY KA
 DATUM Geodetic DATE 1997 06 02 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _P	W	W _L		
296.2	Water Surface																
0.0	Water																
293.9																	
2.3	Sand with Gravel Trace of Clay, Compact		1	SS	13											22 57 (21)	
292.4																	
3.8	End of Borehole Probable Bedrock																

RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 61-87-02 LOCATION Co-ords.: N 5 219 245.0; E 396 400.0 ORIGINATED BY IE
 DIST 54 HWY 11 BOREHOLE TYPE N Casings COMPILED BY KA
 DATUM Geodetic DATE 1997 05 30, 31 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80
296.2	Water Surface															
0.0	Water															
294.3																
1.9			1	SS	1											
	Silt, with a trace of Clay Grey, Very Loose to Compact															
			2	SS	14											
289.9			3	SS	25											
6.3	Gravelly Sand Occasional Boulders Compact															
288.3			4	RC	REC	92%										
7.9	Granite Bedrock		5	RC	REC	50%										
			6	RC	REC	88%										
			7	RC	REC	81%										
			8	RC	REC	100%										
286.3																
9.9	End of Borehole															

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords.: N 5 219 275.8; E 396 401.0 ORIGINATED BY IE
DIST 54 HWY 11 BOREHOLE TYPE N Casings COMPILED BY KA
DATUM Geodetic DATE 1997 06 03,04,05 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
296.2	Water Surface						296								
0.0	Water						295								
294.9							294								
1.3			1	SS	8		293								0 3 93 4
			2	SS	1		292								
	Silt, with a trace of Clay Some Sand, Grey Very Loose to Compact		3	SS	11		291								
			4	SS	13		290								
290.6							289								
5.6			5	SS	6		288								
			6	SS	34		287								
			7	SS	23		286								
	Coarse Sand with Gravel Occasional Boulders Loose to Very Dense		8	SS	50	/8cm	285								5 85 (10)
			9	SS	45	/3cm	284								
283.2															
13.0	End of Borehole Probable Bedrock														

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords: N 5 219 291.3; E 396 396.4 ORIGINATED BY JE
 DIST 54 HWY 11 BOREHOLE TYPE N Casings COMPILED BY KA
 DATUM Geodetic DATE 1997 06 03 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
296.2	Water Surface													
0.0	Water													
295.1														
1.1														
	Silt, with a trace of Clay Wet, Grey Very Loose to Compact		1	SS	3									
			2	SS	1									
			3	SS	11									
			4	SS	11									
290.6														
5.6														
	Coarse Sand, Some Gravel Grey, Compact		5	SS	15									
288.6														
7.6	End of Borehole Probable Bedrock													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 61-87-02 LOCATION Co-ords: N 5 219 200.5; E 396 400.2 ORIGINATED BY JE
 DIST 54 HWY 11 BOREHOLE TYPE N Casings COMPILED BY KA
 DATUM Geodetic DATE 1997 06 03 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _P	W	W _L		
296.2	Water Surface																
0.0	Water																
294.5																	
1.7	Silt, with a trace of Clay Grey, Wet, Compact		1	SS	13												
293.3																	
293.1	Sand with Gravel, Grey, Wet		2	SS	17	/5cm										16 62 (22)	
3.1	End of Borehole Probable Bedrock																

ROCK CORE DESCRIPTION

WP 61-87-02

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	1	10.06-10.67	100	0	10.06-12.04	GRANITE, moderate reddish orange to moderate reddish brown; coarse grained; strong; slightly weathered; fractures very close to extremely close spaced, near vertical to dipping, planar to undulating, smooth to rough.
	2	10.67-11.58	50	0		
	3	11.58-12.04	100	0		
2	1	14.33-14.94	75	33	14.33-14.94	GABBRO, dark greenish grey to dark grey; coarse to medium grained; strong; slightly weathered; fractures close to very close spaced, dipping to near vertical, undulating to planar, smooth.
4	1	7.92-8.08	92	0	7.92-9.85	GRANITE, moderate orange pink to moderate reddish orange; coarse grained; strong; slightly weathered; fractures moderate to extremely close spaced, near vertical to dipping, undulating to planar, smooth to rough.
	2	8.08-8.69	50	0		
	3	8.69-8.89	88	0		
	4	8.89-9.30	81	0		
	5	9.30-9.85	100	82		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%

Logged by: DAW, Soils and Aggregates Section

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \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 DENSENESS.

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

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS 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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	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

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

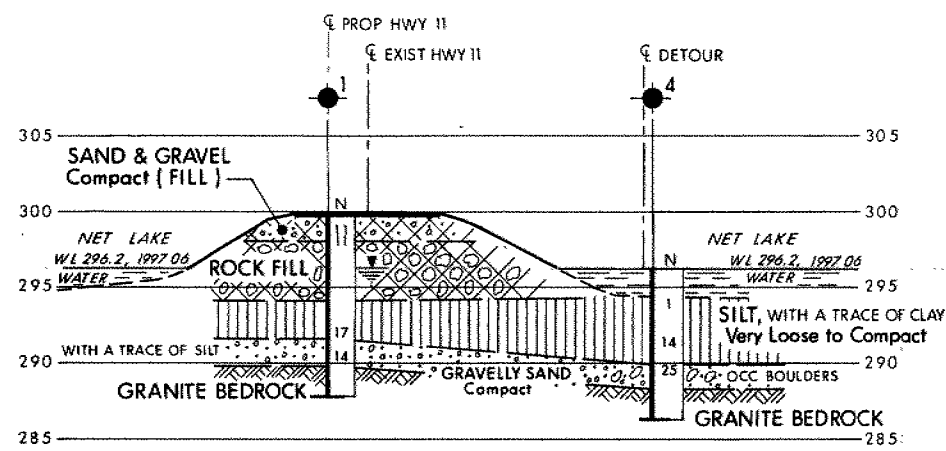
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

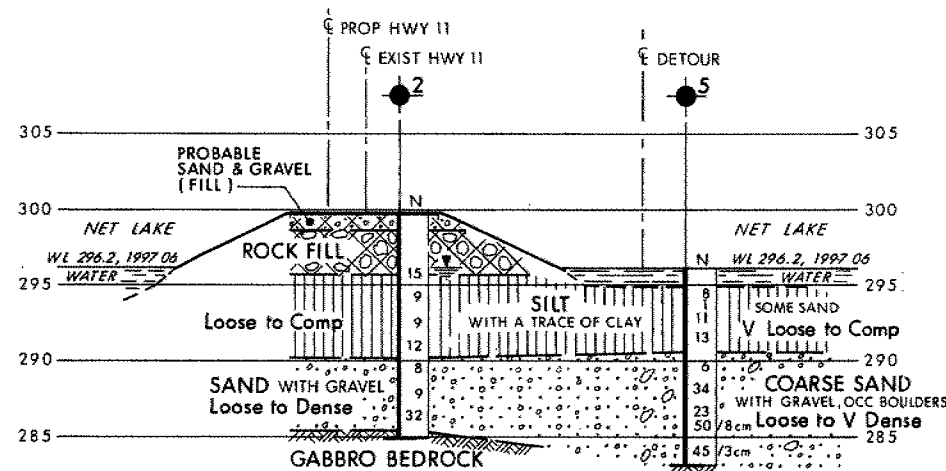
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
C_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

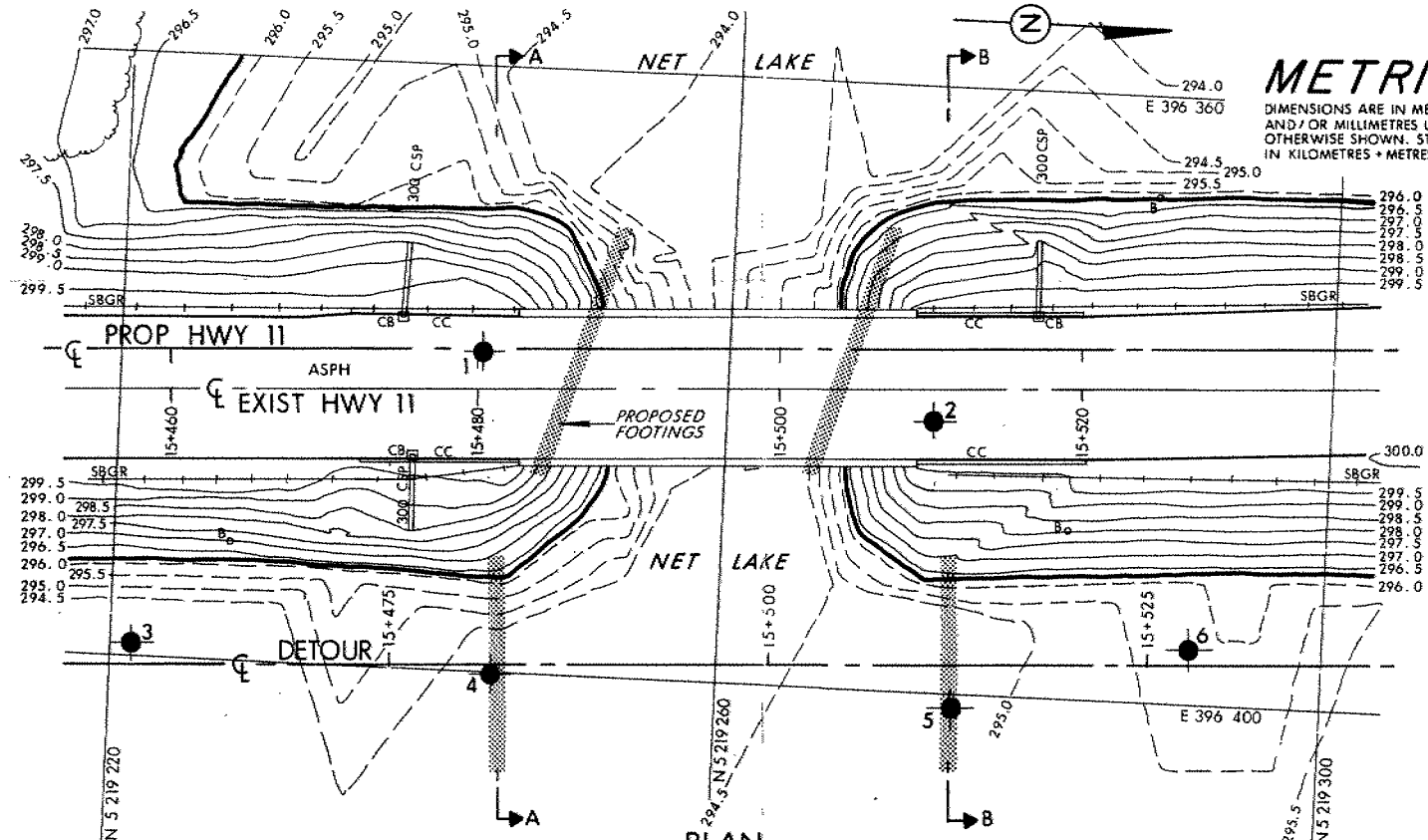
ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



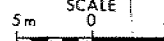
SECTION A-A



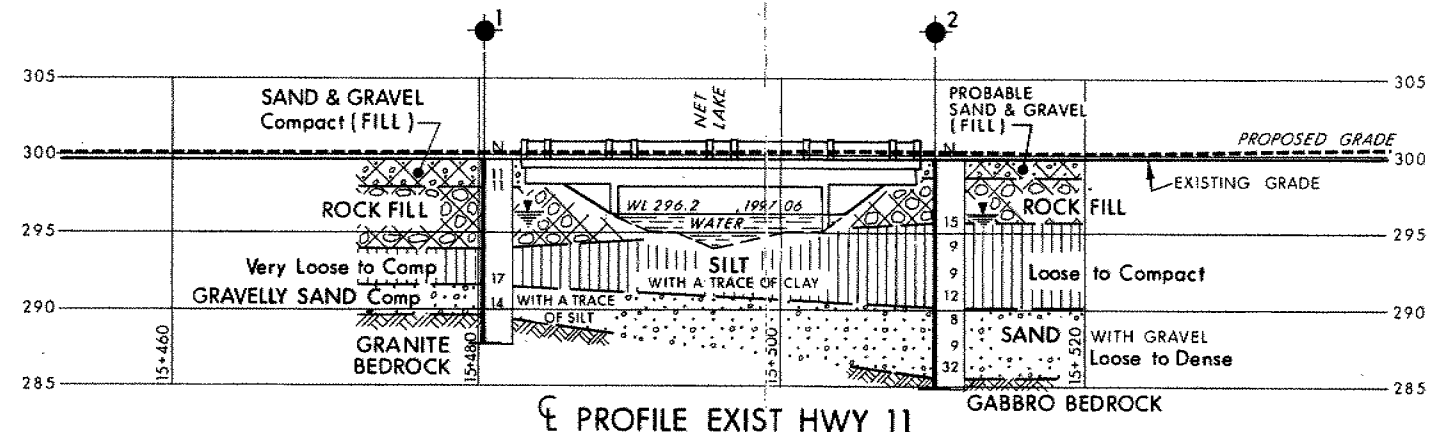
SECTION B-B



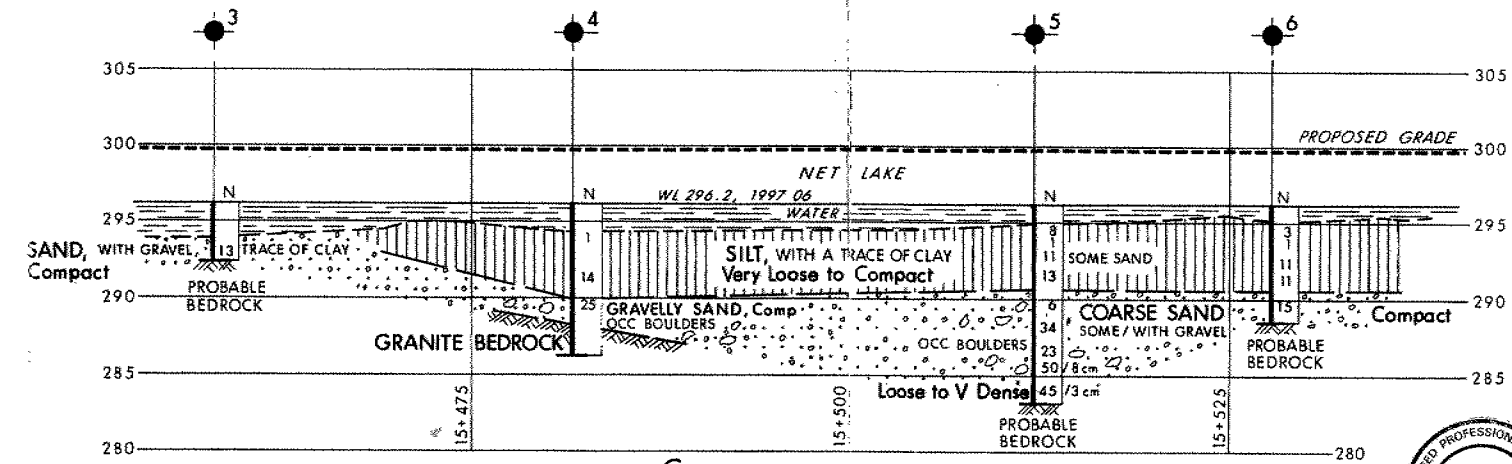
PLAN



NOTE
FOR BOREHOLE No 7 OUTSIDE THE PLAN LIMITS
REFER TO RECORD OF BOREHOLE SHEET.



PROFILE EXIST HWY 11



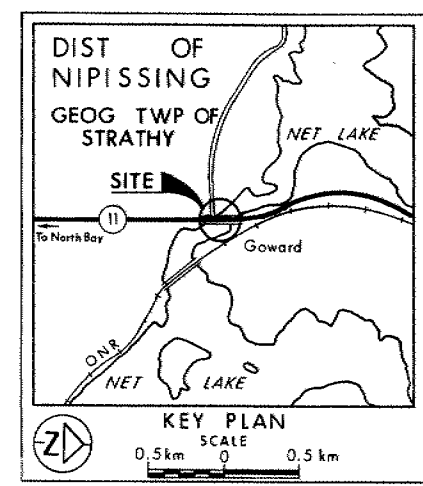
PROFILE DETOUR



CONT No
WP No 61-87-02
NET LAKE
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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)
- WL at time of investigation 1997 05 and 06.

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	299.8	5219 243.7	396 378.8
2	299.8	5219 273.8	396 382.1
3	296.2	5219 221.4	396 399.0
4	296.2	5219 245.0	396 400.0
5	296.2	5219 275.8	396 401.0
6	296.2	5219 291.3	396 396.4
7	296.2	5219 200.5	396 400.2

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen.Cond

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