

G.I.-30 SEPT. 1976

GEOCRES No. 42E-7DIST. 19 REGION W.P. No. 381-87-02CONT. No. W. O. No. STR. SITE No. 48E-12HWY. No. 11LOCATION Hwy 11 at Main Narrows
Kenogamisis LakeNo of PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



Ministry of
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Communications

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 381-87-02 DIST 19
HWY 11 STR SITE 48E-12

Kenogamisis Lake
Main Narrows Bridge

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R.J. Krisciunas (7)
P. Bound
G. Gombola
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FOUNDATION INVESTIGATION REPORT

For

Kenogamisis Lake

Main Narrows Bridge

W.P. 381-87-02; Site 48E-12

Highway 11, District 19, Thunder Bay

INTRODUCTION

This report contains the results of a foundation investigation carried out between 1994 04 12 and 1994 05 15, and comprised of six sampled boreholes

Boreholes were advanced to a maximum depth of 22.0 m (El. 310.9) below the existing ground level using 82 mm I.D. continuous flight hollow stem auger as well as BXW casing.

SITE DESCRIPTION

The site under investigation is located about 5.7 km east of Highway 584 at the crossing of Highway 11 and Kenogamisis Lake in the Township of Ashmore.

The topography of the area is generally flat to gently undulating with isolated rock outcrops and localized organic deposits in poorly drained areas. The site is located in a glaciofluvial landforms and outwash is widespread throughout this area. The outwash sand or lake plain silt and clay in this area is often underlain by bedrock.

SUBSURFACE CONDITIONS

General

The soils encountered at this site are outwash sand or silty sand underlain by silt which overlies bedrock. The subsurface deposits on the east side of the bridge consist of 2.0 to 5.3 m compact to very loose granular fill underlain by 1.2 m to 3.2 m compact to loose silty sand which overlies the meta-andesite bedrock of the Superior Province. However, the underlying subsoil on the west side of the bridge consists of 8.2 m to 8.7 m compact to very loose granular fill underlain by 3.9 m

to 7.2 m compact to dense silt with varying proportions of sand. This silt layer is underlain by 2.8 m to 3.6 m compact to dense silty sand which overlies meta-basalt bedrock of the Superior Province. For classification purposes, the soils encountered at this site can be divided into five different zones.

- a) Sand, Some Silt, Some Gravel (Granular fill)
- b) Sand, Trace of Silt, Trace of Gravel
- c) Silt, Occasional Clayey Silt and Sand Layers
- d) Silty Sand, Trace of Gravel
- e) Meta-Andesite and Meta-Basalt Bedrock

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. A stratigraphical section is shown on Drawing No. 3818702-A. This drawing also shows the location and elevation of the borings. Description of the strata encountered are given below.

Sand, Some Silt, Some Gravel (Granular Fill)

This fill which was placed to raise the finished grade of Highway 11, consists of sand with varying proportions of silt and gravel. The thickness of the fill varies from a minimum of 2.0 m to a maximum of 8.7 m and extends to elevation 330.8 to low as 324.2. The Standard Penetration Test values vary over a wide range (2 blows/0.3 m to 25 blows/0.3 m) indicating very loose to compact state of denseness.

Sand, Trace of Silt, Trace of Gravel

This sand deposit was encountered only in BH 1 and BH 4 immediately below the fill. The thickness of this deposit was observed to be about 1.2 m to 2.9 m and extends to elevation 326.3 to 321.7. The results of the Gradation Test carried out on representative soil samples indicate that this deposit is predominantly composed of sand (84% to 94%). The Standard Penetration Test values vary from a minimum of 11 blows/0.3 m to a maximum of 26 blows/0.3 m, indicating compact state of denseness.

Silt, Occasional Clayey Silt and Sand Layers

This silt deposit was encountered immediately below the fill, only in boreholes located on the west side of the bridge. However, in BH 4, sand layer overlies this silt deposit. The thickness of this deposit varies from a minimum of 2.6 m to a maximum of 7.2 m and extends to elevation 321.9 to 317.0. Occasional clayey silt and sand layers varying in thickness from a few millimetres to a maximum of 100 mm were encountered in BH 3 and BH 4. The Standard Penetration Test results indicate compact to dense state of denseness (N-values 17 blows/0.3 m to 46 blows/0.3 m).

Silty Sand, Trace of Gravel

The silt layer is underlain by this silty sand deposit. However, in borehole No. 5, the granular fill is underlain by this deposit. The thickness of this deposit varies from a minimum of 1.3 m to a maximum of 3.6 m and extends to elevation 319.1 to 313.4 on the west side of the bridge (BH 2 & BH 3). The Standard Penetration Test results (15 blows/0.3 m to 40 blows/0.3 m) indicate compact to dense state of denseness.

Meta-Andesite and Meta-Basalt Bedrock

The rock cores were obtained using BXL core barrel and the description of the bedrock is included in the Appendix of this report.

The elevation of the bedrock on the east side of the bridge varies from elevation 329.2 to 324.2 with rock outcrops within about 150 m from the bridge. The quality of the bedrock on this side may be described as fair to excellent (RQD values 63% to 100%) and classified as unweathered meta-andesite bedrock of the Superior Province.

However, the bedrock on the west side of the bridge was encountered between elevation 319.1 to 313.4. The quality of the bedrock on this side may be described as poor to fair and classified as unweathered meta-basalt bedrock of the Superior Province.

Groundwater Conditions

The groundwater level measurements were taken in open boreholes and was observed at or near lake level, i.e. elevation 329.5. Seasonal fluctuation of the groundwater level may be expected due to the influence of the lake. The water level in each borehole is as follows:

<u>Borehole No.</u>	<u>Elevation</u>	<u>Remarks</u>
1	329.7	
2	329.6	
3	329.5	Lake water level
4	329.6	
5	-	Dry
6	329.5	Lake water level

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing timber bridge at the crossing of Highway 11 and Kenogamisis Lake (Main Narrow). Two alternatives are under consideration for the replacement structure and the alternatives are as follows:

- 1) Single Span 53.8 m long with minimum profile grade elevation 335.6 which is about 2.7 m higher than the existing grade (Option #1)
- 2) Three spans (approximately 16.2 m end spans and 21.4 m centre span) with minimum profile grade elevation 334.4 which is about 1.5 m higher than the existing grade (Option #2).

The new structure will be constructed along the same alignment as the existing bridge. Two construction alternatives are under consideration for the replacement structure and the alternatives are as follows:

- 1) Replace the structure on existing alignment with single lane detour located 15 m south of the existing bridge.
- 2) Staged construction utilizing half of existing bridge for traffic.

The existing timber bridge consists of twelve spans with a length of 4.6 m and total length of 55.2 m. The structure is supported by timber piles which are extended to the bridge deck. The founding level or embedded length of the piles is not available. Number of piles as well as the deck have deteriorated at several locations.

The approach embankment in the proximity of the abutments is protected by rock lining. However, surface erosion as well as undermining has been noticed near both abutments.

Structure FoundationsOption #1East Abutment

The bedrock at this location was encountered at about elevation 326.3 and the fill height varies from 6.9 m to a maximum of 8.1 m. It is recommended that the abutment be supported on steel H-piles driven to bedrock. The following axial capacity values are recommended for the design of the pile.

	<u>HP 310 x 110</u>	<u>HP 310 x 79</u>
Factored Axial Capacity at U.L.S.	1600 kN	1150 kN
Axial Capacity at S.L .S.	1150 kN	900 kN

West Abutment

It is recommended that the abutment at this location also be supported on steel H-Piles driven to bedrock which will be encountered at about elevation 313.4. The recommendation given for the east abutment may be used for the design of the piles.

Option #2Abutments

The recommendation given under Option #1 should be used for the abutment foundations as well as for the design of piles.

Centre Piers

The bedrock at the proposed east pier and west pier location was encountered at elevation 324.2 and 319.1, respectively. It is recommended that both piers be supported on steel H-piles driven to bedrock and for design of piles, the axial capacities suggested for abutments be used. Considering the lake water levels and construction difficulties, pile bents may be used to support the bridge deck.

The pile tips should be reinforced with pile driving shoes as per MTO Standard (DD-3301 latest revision). The large boulders which were placed to protect the existing abutments from erosion

should be removed to facilitate driving of piles.

Pile caps at the abutments should have a minimum of 2.6 m earth cover to protect against the frost penetration.

Lateral Earth Pressure

Earth pressure should be computed as per Section 6.7.4.5 of the O.H.B.D.C., and the coefficient of earth pressure at rest shall be used for rigid and unyielding walls. The granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	<u>Granular A</u>	<u>Granular B</u>
Angle of Internal Friction	$\phi = 35^{\circ}$	$\phi = 30^{\circ}$
Unit Weight (kN/m ³)	$\gamma = 22.8$	$\gamma = 21.2$

Approach Embankment

The proposed finished grade of Highway 11, depending on the option, is expected to be about 1.5 m to 2.7 m higher than the existing grade. If the finished grade is set at or below elevation 335.6, no major instability problems are anticipated for approach embankments constructed with 2 horizontal to 1 vertical side slopes. The fill should consist of granular material up to a height of at least 1.0 m above the high water level and the remaining portion may consist of well compacted acceptable material. Any spongy or soft area observed within the base width of the embankment should be removed before placing the fill. The benching for the approach fill should be carried out in accordance with OPSD 208.01. The fill should be protected by about 0.6 m thick rock lining consisting of 200 mm to 300 mm boulders to a height of at least 1.0 m above the high water level.

Other Considerations

If the traffic is diverted through a single lane detour during construction, steel H-piles may be used to support the temporary structure and the piles may be designed assuming the axial capacities recommended above.

If staged construction is utilized for traffic, the excavation may be supported by soldier piles and timber lagging. The supporting system may be designed assuming the following parameters.

Angle of Internal Friction $\phi = 30^{\circ}$

Unit Weight (kN/m^3) $\gamma = 20$

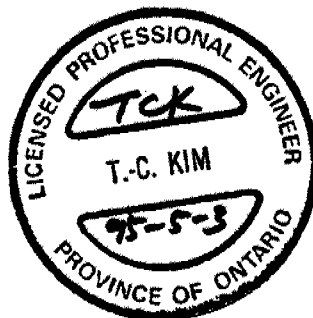
MISCELLANEOUS

The fieldwork for the investigation was carried out under the supervision of D.A. Daneff, Project Soils Engineer, Geotechnical Section, Northwestern Region and M. Vasavithasan, Foundation Engineer. The equipment used was owned and operated by Dominion Soil Thunder Bay Ltd. This report was prepared by M. Vasavithasan and reviewed by T.C. Kim, Senior Foundation Engineer.



M. Vasavithasan

M. Vasavithasan, P. Eng.
Foundation Engineer



T.C. Kim

T.C. Kim, P. Eng.
Sr. Foundation Engineer





APPENDIX

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA 15 + 524.3; O/S 3.7m LT. @ HWY. 11 ORIGINATED BY M V
 DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & BW CASING COMPILED BY M V
 DATUM GEODETIC DATE 94 04 12 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								• UNCONFINED		+ FIELD VANE							• QUICK TRIAXIAL	
332.8	Hwy. 11 Shoulder						20	40	60	80	100	10	20	30				
0.0	Asphalt																	
	SAND, Some Silt, Some Gravel, Compact to Very Loose (Granular Fill)		1	SS	19													
			2	SS	5													
327.5			3	SS	2													
5.3	SAND, Trace of Silt, Trace of Gravel Occasional Cobbles, Compact		4	SS	26										10 84 (6)			
326.3			5	SS	67	/20cm									RQD = 63%			
8.5	META - ANDESITE BEDROCK Unweathered		6	RC BX	REC 97%										RQD = 100%			
323.8			7	RC BX	REC 100%													
9.2	End of Borehole																	

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA 15 + 454.9; O/S 3.6m RT. @ HWY. 11 ORIGINATED BY M V
DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & BW CASING COMPILED BY M V
DATUM GEODETIC DATE 94 04 12 & 13 CHECKED BY T C K

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		
332.9	Hwy. 11 Shoulder													
0.0	Asphalt													
			1	SS	25									
	SAND, Some Silt, Some Gravel, Compact to Very Loose (Granular Fill)		2	SS	3									
			3	SS	4									
			4	SS	6									
			5	SS	9									
			6	SS	9									
			7	SS	14									
324.2			8	SS	14									
8.7	Organic Silt		9	SS	27									
	Occasional Organic Silt Layers		10	SS	46									
			11	SS	32									
	SILT, Some Sand, Dense to Compact		12	SS	18									
			13	SS	19									
317.0			14	SS	31									
15.9	SILTY SAND, Trace of Gravel, Dense		15	SS	40									
313.4			16	RC	REC									
19.5	META - BASALT BEDROCK Unweathered		17	RC	REC									
310.9														
22.0	End of Borehole													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA. 15 + 478.5; O/S 3.7m LT. @ HWY. 11 ORIGINATED BY M.V.
 DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
 DATUM GEODETIC DATE 94 04 14 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
332.9	Top of Bridge Deck																
0.0	Asphalt																
329.5	Water Level																
3.4	Water																
326.8	Lake Bottom																
6.1	SILTY SAND, Some Gravel, Very Loose (Fill)		1	SS	2												
325.8			2	SS	29												
7.1	Occasional Organic Silt Layers		3	SS	17												
			4	SS	20												
	SILT, Occasional Clayey Silt and Sand Layers, Compact		5	SS	17												
321.9			6	SS	22												
11.0			7	SS	23												
	SILTY SAND, Trace of Gravel, Compact		8	SS	15												
319.1			9	SS	76	13cm											
13.8	End of Borehole																
	Probable Bedrock																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA 15 + 427.4; O/S 4.3m LT. @ HWY. 11 ORIGINATED BY M.V.
 DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
 DATUM GEODETIC DATE 94 04 14 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60
332.8	Hwy. 11 Shoulder														
0.0	Asphalt														
	SAND, Some Silt, Some Gravel, Compact to Loose (Granular Fill)	[Pattern]	1	SS	15										
			2	SS	6										
			3	SS	4										
			4	SS	6										
			5	SS	4										
			6	SS	9										
324.6			7	SS	7										
8.2	SAND, Trace of Silt, Trace of Gravel, Compact	[Pattern]	8	SS	15										
			9	SS	13										
			10	SS	11										
321.7			11	SS	46										
11.1	SILT, Occasional Clayey Silt Layers, Compact	[Pattern]	12	SS	25										
318.6	Sandy Silt		13	SS	30										
14.2	End of Borehole														

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA 15 + 547.1; O/S 4.2m RT. C HWY. 11 ORIGINATED BY M V
 DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 94 04 14 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
332.8	Hwy. 11 Shoulder																
0.0	SAND, Some Silt, Some Gravel, Compact (Granular Fill)					DRY *	332										
330.8																	
2.0	Organics -----		1	SS	15		330										
329.2	SILTY SAND, Trace of Gravel Compact to Dense		2	SS	35												
3.6	End of Borehole																
	Probable Bedrock																

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 381 - 87 - 02 LOCATION STA 15 + 500.9; O/S 3.6m RT. @ HWY. 11 ORIGINATED BY M.V.
 DIST 19 HWY 11 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
 DATUM GEODETIC DATE 94 04 15 CHECKED BY T.C.K.

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					
332.9	Top of Bridge Deck																
0.0	Asphalt																
329.5	Water Level																
3.4	Water																
327.4	Lake Bottom																
5.5	Organics		1	SS	17												
			2	SS	26												
			3	SS	7												
			4	SS	21												
324.2	SILTY SAND, Some Gravel, Compact to Loose		5	SS	92	/20cm											
8.7	End of Borehole																
	Probable Bedrock																

ROCK CORE DESCRIPTION

WP 381-87-02

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	1	6.45-7.70	97	63	6.45-9.22	META-ANDESITE (with calcite veinlets up to 4 cm thick), dark greenish grey to greenish black; fine grained; medium strong; unweathered to slightly weathered; fractures wide to very close spaced, near vertical to flat, undulating to planar, smooth to rough.
	2	7.70-9.22	100	100		
2	1	19.51-20.50	95	45	19.51-22.02	META-BASALT, greenish black; fine grained; medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, near vertical to dipping, undulating, smooth.
	2	20.50-22.02	98	52		

*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 (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

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

MECHANICAL PROPERTIES OF SOIL

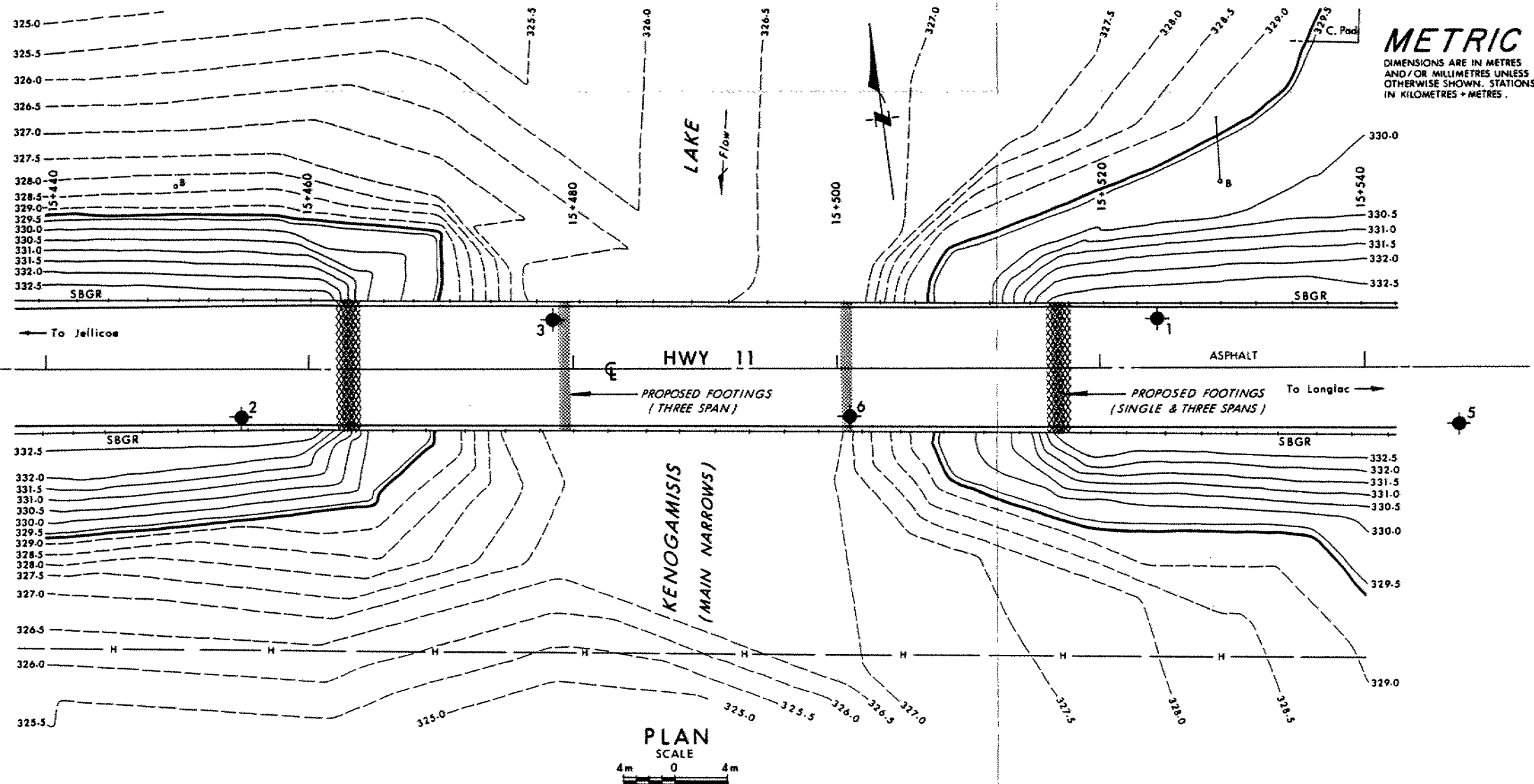
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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 = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
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

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						

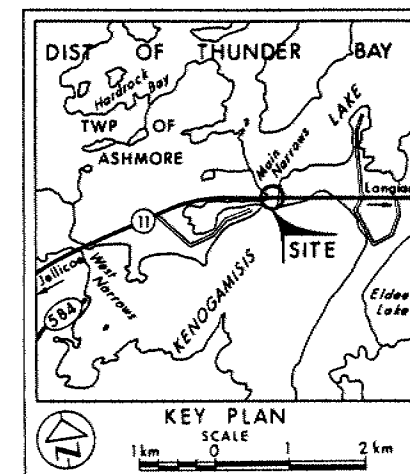


CONT No
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KENOGAMIS LAKE
(MAIN NARROWS)
BORE HOLE LOCATIONS & SOIL STRATA

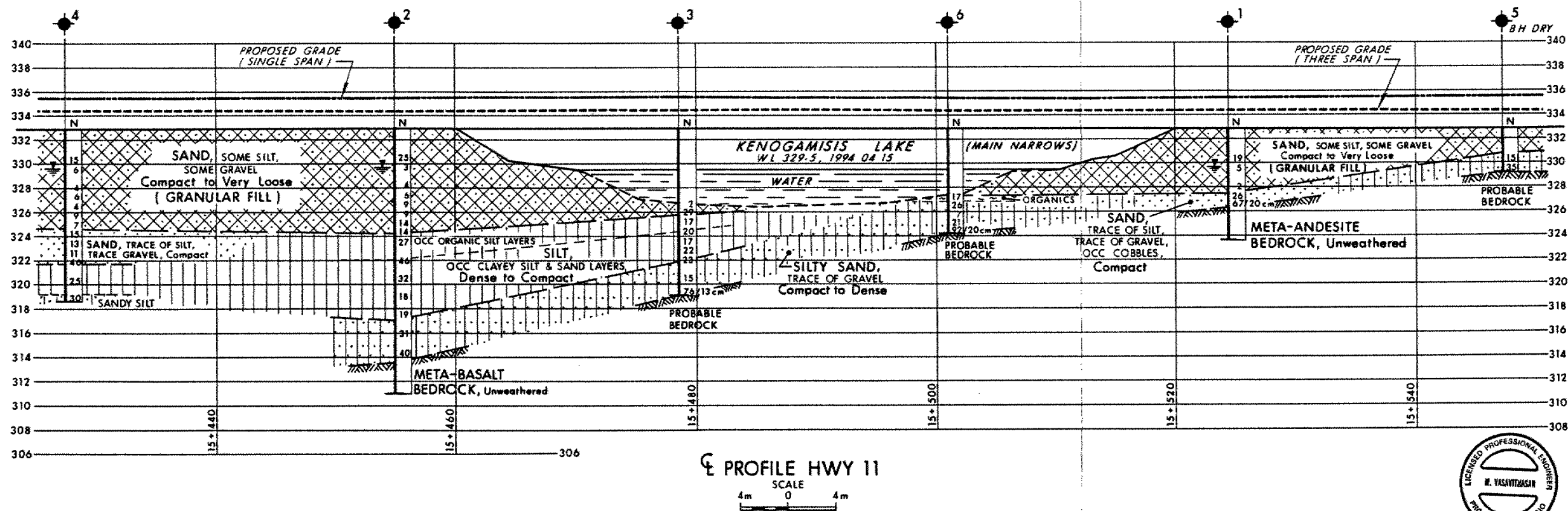


SHEET



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)
- W L at time of investigation 1994 04



No	ELEVATION	STATION	OFFSET
1	332.8	15+524.3	3.7mLT
2	332.9	15+454.9	3.6mRT
3	332.9	15+478.5	3.7mLT
4	332.8	15+427.4	4.3mLT
5	332.8	15+547.1	4.2mRT
6	332.9	15+500.9	3.6mRT

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 GC 2.01 of OPS Gen. Cond.

REV	DATE	BY	DESCRIPTION
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