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DIST. 11 REGION

W.P. No. 61-86-02

CONT. No. 96-49

W. O. No.

STR. SITE No. 42-191

HWY. No. 11

LOCATION Underpass, Mussora Rd #37

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 96-49

Ontario

Ministry of
Transportation

INDEX

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above-mentioned project.

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'_{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 = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	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	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
For
Highway 11 and Muskoka Road 37 Underpass
W.P. 61-86-02, Site: 42-191
Highway 11, District ~~11~~ 52, Huntsville

INTRODUCTION

This report summarizes the results of a foundation investigation which was carried out for the construction of Hwy 11 and Muskoka Road No. 37 Underpass.

The investigation was carried out at the request of Northern Region Structural Section. The report applies to proposed bridge structure and its approaches between Station 9+920 and 10+040, Muskoka Road 37 chainage (Re.: Plan E-559-11-1, dated October, 1990).

SITE DESCRIPTION

Physiographically the site is located in the Algonquin Highlands region. In general this region is underlain by granite and other hard Precambrian rocks. Overall it is broadly dome shaped. There are frequent outcrops of bare rocks. The soils are generally shallow but thickness over the bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. Several areas have deeper till and few rock outcrops and the surface of the till is smoothed and moulded with occasional drumlins appearing (Reference: Chapman and Putnam, 'The physiography of Southern Ontario; 3rd Edition, 1984).

The site for the proposed Highway 11 and Muskoka Rd 37 interchange (Underpass) is located about 200m north of existing intersection of Muskoka Rd 37 and Highway 11. The proposed interchange will replace the existing intersection of Hwy 11 and Muskoka Rd. 37.

At the proposed underpass, Highway 11 runs north-south. The land adjacent to Hwy 11 at the proposed site location is undeveloped. On the east side the ground is covered with grass and at about 45m east of Highway 11 the area is covered with woods. On the west side, adjacent to Highway 11 there are rock outcrops which are up to 8m high.

The exposed bedrock on the west side of Hwy 11 is covered with grass and shrubs. In some areas the rock surface adjacent to Highway 11 is rough and angular. Perhaps this is due to excavations which took place at this location during Hwy 11 construction. The rock surface elsewhere, including the location of the proposed west abutment is smooth. The bedrock outcrop is sound with some surficial loose pieces of rock. The exposed bedrock surface dips towards east at 4H:1V (about 14 degrees). Adjacent to Hwy 11 the bedrock contains few close spaced fractures which dip towards the east at about 20 degrees).

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 91 07 10 and 91 07 17. The field work consisted of drilling five boreholes (BH 1,2,6,15 and 17) and six dynamic cone tests (BH 3,4,5,7,14 and 16) at or near proposed footing locations. The boreholes were advanced using track-mounted auger machines equipped with 82mm ID hollow stem augers and BX size coring equipment.

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). In general samples were retrieved at 0.75m intervals for the first 6m of boring, then every 1.5m. Once practical refusal to auguring was encountered in Boreholes 2,6 and 15, BX-size bedrock cores were obtained from these boreholes.

Groundwater was monitored during drilling and after completion of the boreholes.

The Laboratory testing program for the representative samples consisted of Grain Size Analyses. The results of the laboratory tests are plotted on the Record of Borehole sheets (Appendix) and summarized on Figure 1.

Bedrock cores were logged by D.A. Williams, Petrographer in the Soils and Aggregates Section of MTO.

The boreholes were staked out by the Northern Region Surveys and Plans Section of the MTO. Ground surface elevations were also provided by the Surveys and Plans Section.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 618602-A.*

Following are detailed descriptions of the soil strata encountered.

Silty Sand to Sandy Silt

The overburden consisted of a non cohesive silty sand to sandy silt material at the entire site. This non-cohesive material was encountered in all boreholes. The upper 0.5m to 0.7m of this stratum contained roots and organics (BH 1,2 and 6). The thickness of this stratum increased gradually from west to east. On the west side the thickness of this deposit was about 1.6m (BH 15) and on the east side at a distance of about 70m from Borehole 15 the thickness of this stratum was more than 8m (BH 1). The 'N' values within this material ranged from 13 blows to more than 140 blows/0.3m which suggest that the material is in compact to very dense state. 'N' values generally increased with increasing depth. Average 'N' value was in the order of 25 blows/0.3m at the pier location (BH 6) and 38 blows/0.3m at the east abutment location. This suggests that on average the silty sand to sandy silt material is compact at the pier location and dense at the proposed location of east abutment.

Bedrock

The silty sand to sandy silt material was overlying bedrock. Bedrock was encountered at depth ranging from 1.6m (BH 15) to 10.4m (BH 2) which corresponds to elevation varying from 262.2m (BH 2) to 272.1m (BH 15). The bedrock surface dips towards the east at approximately 8 degrees. The bedrock was classified as Gneiss Bedrock with interlayered Amphibolite, Granite and Pegmatite. Eight bedrock cores were obtained from three locations. The result of the core analyses were as follows:

	Range (%)	Average (%)
Recovery	75-100	95
RQD	48-100	80

* Dwg. No 2, (Sheet 87) of the Contract Drawings.

Based on these results, the bedrock is considered to be competent for the proposed foundations.

Groundwater Conditions

Groundwater was encountered at depth ranging from 0.9m (BH 1) to 1.5m (BH 15). The groundwater elevation ranged from 271.2m (BH 2) to 272.6m (BH 6). It should be noted that the groundwater is subject to seasonal fluctuation.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of C. Davidson, a student specialist.

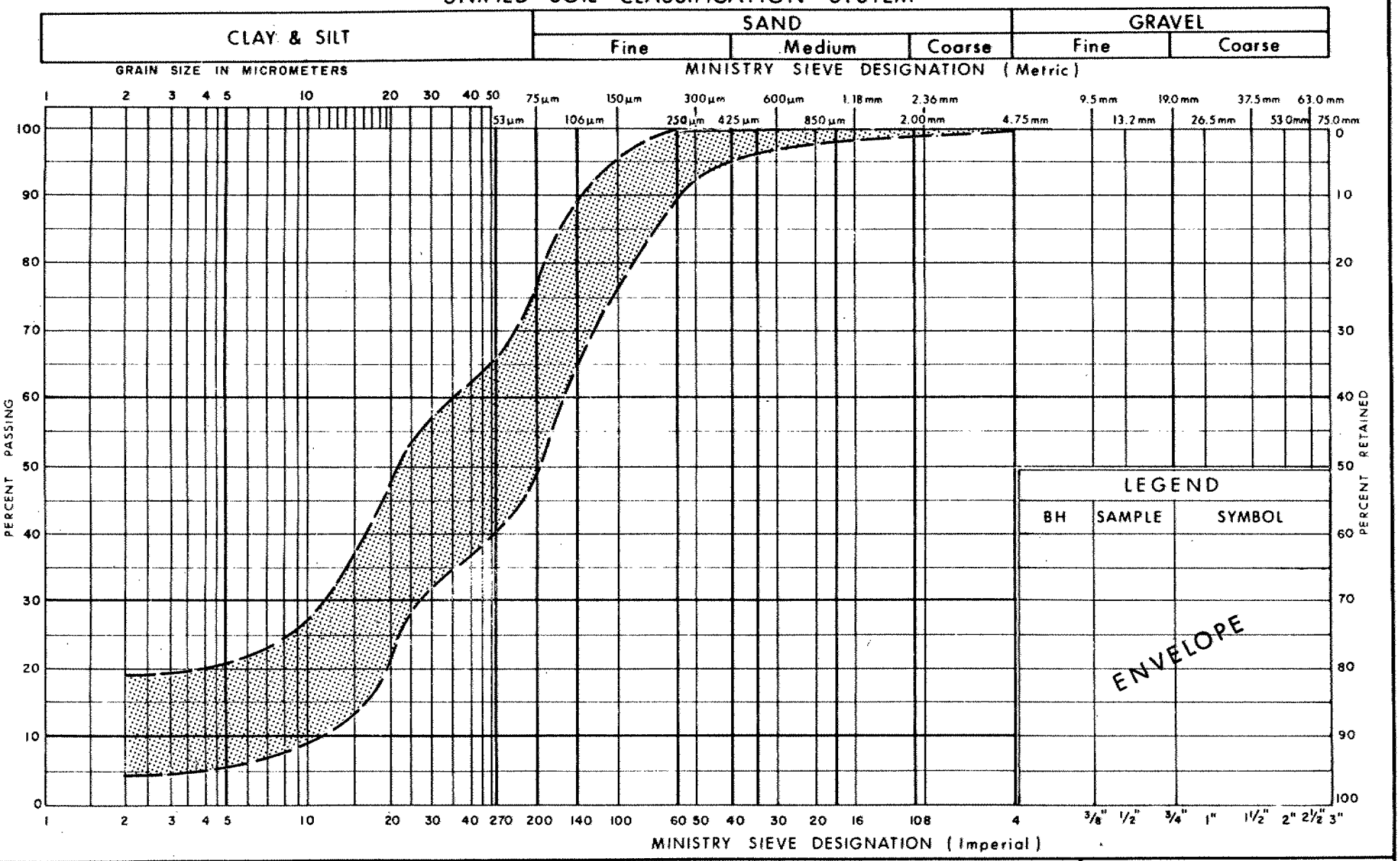
The equipment used was owned and operated by Master Soil Investigation Ltd.

The report was written by K. Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

FIG No 1
W P 61-86-02

6

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 512.2; E 320 824.2 ORIGINATED BY CD

DIST ~~11~~ 52 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CD

DATUM Geodetic DATE 1991 07 17 CHECKED BY KA

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.6	Ground Surface									
0.0	Silty Sand to Sandy Silt with Roots and Organics						272			
			1	SS	25	▼				
			2	SS	24		271			0 39 56 5
			3	SS	58		270			
			4	SS	58		269			
	Silty Sand to Sandy Silt Compact to Very Dense Greyish Brown to Grey		5	SS	37					0 32 63 5
			6	SS	36		268			
			7	SS	26		267			
			8	SS	46		266			0 37 58 5
							265			
264.5			9	SS	71					
8.1	End of Borehole									

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords; N 4 985 517.4; E 320 804.4 ORIGINATED BY CD

DIST +52 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD

DATUM Geodetic DATE 1991 07 10,11 CHECKED BY KA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.8	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
			1	SS	13	▼					0 29 54 17
			2	SS	14		271				
			3	SS	23		270				
			4	SS	32		269				
			5	SS	48						0 43 51 6
	Silty Sand to Sandy Silt Compact to Very Dense		6	SS	41		268				
			7	SS	44		267				
			8	SS	67		266				
			9	SS	61		265				
			10	SS	140	/23cm	264				
262.3							263				
10.3			11	RC	REC	93%	262				RQD 92%
	Gneiss Bedrock		12	RC	REC	75%	261				RQD 60%
			13	RC	REC	100%	260				RQD 48%
259.3											
13.4	End of Borehole										

+³, ×³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 527.6; E 320 807.0 ORIGINATED BY CD
DIST +52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD
DATUM Geodetic DATE 1991 07 10 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%) 10 20 30	γ kN/m^3	GR SA SI CL
272.7 Ground Surface											
0.0	Silty Sand to Sandy Silt with Roots and Organics										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						272				
							271				
							270				
269.7											
3.0	End of Cone Test							120/23cm			

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 536.0; E 320 808.8 ORIGINATED BY CD

DIST +52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 10 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%)	γ kN/m^3	GR SA SI CL
272.7 Ground Surface								20 40 60 80 100	10 20 30		
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
	Probable Silty Sand to Sandy Silt Compact to Very Dense						271				
							270				
							269				
267.5							268				
5.2	End of Cone Test							120/28cm			

+^{3}, ×^{5}: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords; N 4 985 545.0; E 320 776.8 ORIGINATED BY CD

DIST ~~11~~ 52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 12 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%) 10 20 30	γ kN/m^3	GR SA SI CL
272.8 Ground Surface								o UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE			
0.0	Silty Sand to Sandy Silt with Roots and Organics										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						272				
							271				
270.1							270				
2.7	End of Cone Test							120/15cm			

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 552.0; E 320 779.0 ORIGINATED BY CD
DIST +++ 52 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD
DATUM Geodetic DATE 1991 07 11 CHECKED BY KA

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.9	Ground Surface									
0.0	Silty Sand to Sandy Silt with Roots and Organics					▼				
			1	SS	29		272			
	Silty Sand to Sandy Silt Compact		2	SS	23		271			0 41 55 4
270.2			3	SS	25					
2.7			4	RC	REC	100%	270			RQD 86%
	Gneiss Bedrock						269			
267.1			5	RC	REC	100%	268			RQD 84%
5.8	End of Borehole									

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 559.3; E 320 781.2 ORIGINATED BY CD

DIST +r 52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 12 CHECKED BY KA

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100 SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 0 0 0 0 0	WATER CONTENT (%) 0 0 0	γ kN/m^3	GR SA SI CL
272.9 Ground Surface											
0.0	Silty Sand to Sandy Silt with Roots and Organics										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						272				
271.1							271				
1.8	End of Cone Test							120/13cm			

+^{3}, ×^{5}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 14 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords; N 4 985 560.0; E 320 761.5 ORIGINATED BY CD
DIST +52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD
DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 0 0 0 0 0	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 0 0 0	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
273.8	Ground Surface										
0.0	Probable Silty Sand to Sandy Silt Compact to Very Dense						273				
272.3											
1.5	End of Cone Test							120/8cm			

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 15 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 566.2; E 320 763.5 ORIGINATED BY CD
DIST ~~41~~ 52 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD
DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
273.7	Ground Surface										
0.0	Silty Sand to Sandy Silt Compact		1	SS	29		273				
272.1			2	SS	13 / 13cm	▼	272				
1.6	Gneiss Bedrock		3	RC	REC 100%		271				RQD 68%
			4	RC	REC 98%		270				RQD 93%
268.7			5	RC	REC 100%		269				RQD 100%
5.0	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 16 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 574.2; E 320 766.1 ORIGINATED BY CD
DIST ~~HW~~ 52 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD
DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
273.9	Ground Surface										
0.0	Probable Silty Sand to Sandy Silt Compact						273				
272.3											
1.5	End of Cone Test							120/4cm			

+³, ×⁵ ; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 17 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 503.2; E 320 815.0 ORIGINATED BY CD
DIST yr 52 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CD
DATUM Geodetic DATE 1991 07 17 CHECKED BY KA

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.6	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
			1	SS	17	▼					
			2	SS	31		271				
			3	SS	13		270				1 50 46 3
			4	SS	28		269				
	Silty Sand to Sandy Silt Compact to Very Dense		5	SS	21						
			6	SS	40		268				0 25 69 6
			7	SS	91		267				
			8	SS	93		266				
264.7			9	SS	109	/26cm	265				0 51 46 3
7.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT
for
Hwy 11 and Muskoka Road #37 Interchange
Connection 'A' and the EW-N Ramp
W.P. 61-86-00A
District 52, Huntsville

INTRODUCTION

This report summarizes the results of a foundation investigation carried out at the proposed Connection 'A' and EW-N Ramp alignments of the Hwy 11/Muskoka Road 37 Interchange. The investigation was carried out upon the request of the Northern Region Geotechnical Section. The main purpose of the investigation is to determine the bedrock profile in this area which will govern the construction method and ground support scheme for the proposed road formation.

The field work was carried out between 95 02 13 and 95 02 27. The work consisted of ten (10) sampled boreholes and three (3) probe-holes advanced between Sta.10+530 and 10+620 of Connection 'A' and Sta. 11+200 and 11+320 approximately. Bedrock was cored in eight (8) of the boreholes.

SITE DESCRIPTION

The site is located to the east of Highway 11, between the highway and Latvian Road. It is situated just to the north of the existing Hwy 11/Muskoka Road 37 intersection in the Township of Bracebridge, District of Muskoka.

Physiographically, the site is located in a region known as Number 11 strip, after Chapman and Putnam (1984). It typically consists of bare rock ridges and glacial deposits of sand, silt and clay.

At the site location, Hwy 11 and Latvian Road are separated by an existing slope. The height of the slope ranges from 4 $\pm$m at the south end (Sta. 11+200) to 11 $\pm$m around Sta. 11+400. The composition of the slope material also varies. Between Sta. 11+200 to 11+305 approximately, the slope comprises rock fill overlying bedrock. The area at the toe of the slope is heavily wooded. From Sta. 11+305 to Sta. 11+375 approximately, it is primarily composed of sand and silt. The slope surface is grassed. From Sta 11+375 on, massive bedrock outcrops can be found on the slope face. The slope angle varies, but typically at 2H:1V for the soil slope and steepens up for the rock fill and bedrock outcrops. The slope above Latvian Road comprises mainly bedrock outcrops. The existing slopes and roadways appeared to be in good shape with no obvious sign of distress.

The site is bounded by Hwy 11 to the west and Latvian Road to the east. There is no major land use except a snowmobile trail runs along the toe of the slope.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by insitu and laboratory testing. The procedures employed are discussed below:

Field

The field investigation work was carried out between 95 02 13 and 95 02 27 and consisted of ten (10) sampled boreholes advanced to a depth ranging from 3.9 to 17.4 m. In addition, probing was done by augering to refusal at shallow depths (0.6-0.8 m) at three (3) locations.

Two track mounted auger machines were mobilized to speed up the progress. The boreholes were advanced using conventional hollow/solid stem augering techniques with continuous flight augers. The sampling program consisted of disturbed samples taken by split spoon sampler in accordance with Standard Penetration Test (ASTM D1586). Standard Penetration ('N') values were recorded for assessment of the denseness of the non-cohesive material encountered. Bedrock was cored at eight (8) hole locations. Wire line rock coring techniques were employed in one of the machines to retrieve rock core samples for rock quality determination and classification purposes. Standard N size core barrel and casings were used. Conventional rock coring was carried out in the other machine with B size core barrel and casings. All subsoil samples were identified in the field and returned to the laboratory for further examination and appropriate testing.

Ground water level was monitored in the boreholes during the investigation. All boreholes were backfilled upon completion of the field work.

Borehole locations and elevations were provided by Northern Region Planning and Design Section. The proposed borehole locations were staked out in the field. No drilling was carried out on the existing slope as the slope gradient is too steep for the machines. Boreholes offset from the original stake locations were tied in by our field staff upon completion of the field work.

Laboratory

The laboratory testing on selected soil samples consisted of the following:

- Grain Size Distribution
- Natural Moisture Content
- Organic Content Determination

Laboratory results are given in the following section of this report and are illustrated on Record of Borehole sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations of the boreholes are shown in Drg. No. 618600A-A.

A series of boreholes were advanced along Latvian Road with rock coring carried out on most of them to prove bedrock (except BHs 2, 8 and 10). The bedrock surface was found to be undulating with depths varying from 1.4 to 5.6 ±m. The overburden comprises mainly granular/rock fill or sand and gravel with boulders. Boreholes were also advanced at the toe of the existing slope. At BH 12 location, bedrock was deeply seated at 15.4 m depth with native silty sand and non-cohesive glacial till material overlying it. At BH 11 and 11A locations, bedrock was encountered at 5 and 6.7 ±m respectively.

Following are the specific descriptions of the materials encountered in the investigation.

Fill

Granular fill is generally contacted at the ground surface for all the boreholes advanced along the existing Latvian Road (BHs 1 to 10). This fill layer is about 0.6 to 0.8 m thick and consists of sand and gravel. At BH 7 and BH 9, the fill layer extend to 2.6 and 2.1 m respectively and consists of boulders and rock fragments, probably pushed in during construction of the road. Some organic inclusions were found in BH 9. Laboratory tests carried out on a sample retrieved from BH 7 indicate moisture content of 10.5% and Grain Size Distribution of 47% gravel, 45% sand and 8% silt & clay. A sample retrieved from BH 9 was also selected for testing. The results indicate moisture content of 20.5%, organic content of 4% and Grain Size Distribution of 26% gravel, 62% sand and 12% silt & clay.

Sand and Gravel with Boulders

This non-cohesive soil stratum was encountered at BHs 1, 3 to 6 and 9 below the fill layer, overlying bedrock. It consists of sand and gravel with boulders and the thickness of this stratum varies from 0.6 to 5.0 m. Due to the bouldery nature of this deposit, Standard Penetration Tests carried out typically encountered refusal on boulders. Laboratory tests carried out on a sample retrieved from BH 5 indicate moisture content of 13% and Grain Size Distribution of 27% gravel, 61% sand and 12% silt & clay. A sample retrieved from BH 9 was also selected for testing. The results indicate a moisture content of 13% and Grain Size Distribution of 18% gravel, 71% sand and 11% silt & clay.

Silty Sand to Sandy Silt

This is a major deposit contacted in the boreholes advanced at the bottom of the existing slope (BHs 11, 11A and 12). The thickness of this non-cohesive layer varies from 3.8 to 12.8 m. It is described as silty sand to sandy silt with isolated sand layers, silt zones as well as clay pockets. Standard Penetration 'N' values range from 9 to 63 blows/30 cm indicating compact to very dense state of denseness. Three (3) samples were selected for laboratory testing and the results indicate natural moisture contents of 7.5, 24.5 and 33.5%, and Grain Size Distribution of 0-8% gravel, 16-89% sand and 3-84% silt & clay.

Heterogeneous Mixture of Sand, Silt and Gravel (Glacial Till)

This non-cohesive layer was contacted in BH 11 and BH 12 overlying bedrock. Numerous boulders and cobbles were encountered in BH 12. Based on the SPT 'N' values (60 blows/30 cm and 54 blows/28 cm), the material is very dense. Laboratory testing carried out on two representative samples indicates natural moisture contents of 11$\pm$% and Grain Size Distribution of 18-28% gravel, 48-55% sand, 22-25% silt and 2% clay.

Bedrock

Bedrock was cored in BHs 1, 3 to 7, 9 and 12. It is a slightly weathered to unweathered igneous/metamorphic rock of the Grenville Province. The rock retrieved from BHs 1, 3 to 7 and 9 advanced from Latvian Road is a strong Hornblende-Biotite Gneiss. Core Recovery (CR) obtained generally varies from 66 to 100%. The CR is exceptionally poor in BH 6, ranging from 5 to 100% with a void between 5.41 and 5.72 m depths. Rock Quality Designation (RQD) varies widely from 0 to 100%. The rock retrieved from BH 12 at the toe of the slope consists of a medium strong Amphibolite overlying strong Granite. CR obtained ranges from 87 to 100% and RQD ranges from 36 to 89%.

Rock cores from the field were examined and classified by MTO petrographer, D. Williams. Detailed descriptions of the rock are attached in the Appendix.

Groundwater

During the time of the investigation, the boreholes along Latvian Road (BH 1 to 10) were dry before water was pumped in for rock coring. The holes caved in immediately when the casings were extracted after completion of drilling and no measurements were made. The ground water level measured in BHs 11, 11A and 12 at the toe of the slope was generally close to the ground surface, at El. 274 $\pm$m in BHs 11 and 11A and El. 272 $\pm$m in BH 12. Seasonal fluctuations in water levels are expected.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the joint supervision of D. Kwok, Project Foundation Engineer, J. Crabb, Engineering Trainee and T. Hickey, Technical Trainee. The drilling machines and equipment were owned and operated by Dominion Soil Investigation Inc. and Canadian Soil Drilling. Bedrock was examined and classified by MTO petrographer D. Williams.

The report was written by D. Kwok, reviewed and approved by T. Kim, Senior Foundation Engineer.

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

APPENDIX

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+622.5 o/s 2.3 m Lt.C.L. Conn. 'A' ORIGINATED BY DK

DIST 52 HWY 11 BOREHOLE TYPE H.S. Augers, NQ Core Barrel COMPILED BY TH

DATUM Geodetic DATE 95 02 13 - 95 02 15 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.6	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Sand & Gravel (Granular Fill)		1	SS	50/8cm	DRY *					
0.6 282.2	Sand and Gravel with Boulders		2	RC	REC	100%	282				RQD 38%
1.4			3	RC	REC	85%					RQD 0%
			4	RC	REC	100%					RQD 38%
	Bedrock		5	RC	REC	100%					RQD 31%
279.2			6	RC	REC	100%	280				RQD 74%
4.4	End of Borehole										
	+ 95 02 13										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+603 o/s 2.0 m Lt C.L. Conn.'A' ORIGINATED BY TH
DIST 52 HWY 11 BOREHOLE TYPE S.S. Auger COMPILED BY DK
DATUM Geodetic DATE 95 02 24 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
284.2	Ground Surface										
284.0	Granular Fill					DRY *	284				
0.6	End of Borehole	**									

* 95 02 24

** Auger refusal on probable boulders

+³, ×⁵ : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+580 o/s 4.2 m Lt C.L. Conn. 'A' ORIGINATED BY DK

DIST 52 HWY 11 BOREHOLE TYPE H.S.Augers, BQ Core Barrel COMPILED BY JC

DATUM Geodetic DATE 95 02 14 - 95 02 15 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.1	Ground Surface										
0.0 / 283.3	Silty Sand with Gravel (Granular Fill)					DRY *					
0.8 / 282.5	Sand and Gravel with Boulders										
1.6	Bedrock		1	RC	REC	100%	282				RQD 50%
			2	RC	REC	87%					RQD 27%
280.2			3	RC	REC	100%					RQD 90%
3.9	End of Borehole										

* 95 02 14

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+565 o/s 6.2 m Lt C.L. Conn. 'A' ORIGINATED BY TH
DIST 52 HWY 11 BOREHOLE TYPE H.S. Augers, NQ Core Barrel COMPILED BY TH
DATUM Geodetic DATE 95 02 23 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.7 Ground Surface								20 40 60 80 100	10 20 30		
0.0	Sand & Gravel (Granular Fill)					DRY *					
0.6	Sand and Gravel with Boulders						282				
280.7			1	RC	REC	100%					RQD 0%
			2	RC	REC	100%					RQD 0%
3.0	Bedrock		3	RC	REC	100%	280				RQD 79%
			4	RC	REC	79%					RQD 0%
			5	RC	REC	100%					RQD 83%
			6	RC	REC	100%					RQD 100%
			7	RC	REC	100%					RQD 93%
277.6			9	RC	REC	100%	278				
6.1	End of Borehole										
	95 02 23										

^{3}, ^{5} : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+550 o/s 7.2 m Lt C.L. Conn. 'A' ORIGINATED BY JC

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger, BQ Core Barrel COMPILED BY JC

DATUM Geodetic DATE 95 02 15 - 95 02 17 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.2	Ground Surface										
0.0	Sand & Gravel (Granular Fill)					DRY *	282				
0.6	Silty Sand and Gravel with Boulders						280				
			1	WS	–				o		27 61 (12)
277.5							278				
5.6	Bedrock		2	RC	REC 100%						RQD 100%
							276				
			3	RC	REC 97%						RQD 97%
274.5											
8.7	End of Borehole										

• 95 02 15

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 10+530 o/s 9.5 m Lt C.L. Conn. 'A' ORIGINATED BY JC

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger, NQ Core Barrel COMPILED BY TH

DATUM Geodetic DATE 95 02 20 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
282.5	Ground Surface										
282.8 0.0	Sand & Gravel (Granular Fill)		1	SS	6 /5cm	DRY	282				
0.7	Silty Sand with Gravel and Boulders										
279.1			2	RC	REC	69%	280				RQD 0%
3.4	Bedrock		3	RC	REC	73%					RQD 27%
	fractured zone		4	RC	REC	80%	278				RQD 41%
275.1			5	RC	REC	100%	276				RQD 80%
7.4	End of Borehole										
	• 95 02 20										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Stg 11+200 o/s 3.7 m Rt C.L. EW-N Ramp ORIGINATED BY TH

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger, NQ Core Barrel COMPILED BY TH

DATUM Geodetic DATE 95 02 16 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
280.3	Ground Surface										
0.0	Sand and Gravel, Trace Silt with Cobbles and Boulders (Fill)		SS 1		43	DRY *	280				
			2	SS	44	/15cm					47 45 (8)
277.6			3	SS	61	/13cm	278				
2.6	Bedrock		4	RC	REC	100%					RQD 79%
			5	RC	REC	100%					RQD 82%
			6	RC	REC	100%	276				RQD 87%
274.5			7	RC	REC	100%					RQD 82%
5.8	End of Borehole										

* 95 02 16

+³, ×⁵ : Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+221 o/s 6.5 m Rt C.L. EW-N Ramp ORIGINATED BY TH

DIST 52 HWY 11 BOREHOLE TYPE S.S. Auger COMPILED BY DK

DATUM Geodetic DATE 95 02 24 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
280.8	Ground Surface										
280.2	Granular Fill					DRY					
0.6	End of Borehole * 95 02 24 ** Auger refusal on probable boulders or rock fill	**									

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

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+240 o/s 8.5 m Rt C.L. EW-N Ramp ORIGINATED BY TH/JC

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger, NQ Core Barrel COMPILED BY TH

DATUM Geodetic DATE 95 02 17 - 95 02 20 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.3	Ground Surface										
0.0	Silty Sand with Gravel		1	SS	50 /13cm	DRY	280				
	Some Rock Fragments		2	SS	50 /13cm						
	(Fill) Boulders with topsoil inclusions		3	SS	50 /3cm						organic content=4%
279.2											26 62 (12)
278.6	Silty Sand, Some Gravel		4	SS	90 /23cm						18 71 (11)
2.7	Bedrock		5	RC	REC 87%		278				RQD 87%
			6	RC	REC 100%						RQD 60%
			7	RC	REC 89%						RQD 89%
275.7			8	RC	REC 95%		276				RQD 95%
5.6	End of Borehole										

* 95 02 17

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+261 o/s 10.5 m Rt C.L. EW-N Ramp ORIGINATED BY TH

DIST 52 HWY 11 BOREHOLE TYPE S.S. Auger COMPILED BY DK

DATUM Geodetic DATE 95 02 24 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
281.2	Ground Surface										
0.0 / 280.4	Granular Fill					DRY •					
0.8	End of Borehole	**									
	• 95 02 24										
	•• Auger refusal on probable boulders										

^{3}, ^{5}: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+280 o/s 0.2 m Rt C.L. EW-N Ramp ORIGINATED BY JC

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger, BQ Core Barrel COMPILED BY TH

DATUM Geodetic DATE 95 02 23 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
276.0	Ground Surface										
0.0	wood pieces & trace organics		1	SS	18	▼*					
			2	SS	50		274				
	Sand, Trace Silt & Gravel Compact to Very Dense		3	SS	63				o		8 89 (3)
272.2	occasional boulders and silt pockets		4	SS	62		272				
3.8	Heterogeneous Mixture of Sand, Silt and Gravel										
271.1	Very Dense (Glacial Till)		5	SS	54	/28cm			o		28 45 22 2
4.9	End of Borehole Probable Bedrock										

* 95 02 23

+³, ×⁵ : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11A 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+280 o/s 3.2 m Lt C.L. EW-N Ramp ORIGINATED BY JC

DIST 52 HWY 11 BOREHOLE TYPE H.S. Auger COMPILED BY JC

DATUM Geodetic DATE 95 02 27 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
275.8	Ground Surface										
0.0	Silty Sand to Sandy Silt					▼*	274				
269.1							272				
6.7	Probable Bedrock **						270				
265.1							268				
10.7	End of Borehole						266				

* 95 02 27

** Auger hit rock surface and slided down the rock face at an angle

+³, ×⁵ : Numbers refer to Sensitivity

$15^{20}_{10}\diamond 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 12 1 OF 1 METRIC

W.P. 61-86-00 LOCATION Sta 11+321.5 o/s 7.5 m Lt C.L. EW-N Ramp ORIGINATED BY DK
DIST 52 HWY 11 BOREHOLE TYPE H.S.Auger, BQ core barrel COMPILED BY JC
DATUM Geodetic DATE 95 02 20 - 95 02 22 CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
273.3	Ground Surface										
0.0	Sand, Trace Silt Compact to Dense		1	SS	23	▼	272				
			2	SS	37						
			3	SS	18						
	Silty Sand		4	SS	9		270		o		0 71 15 14
	Occasional Clay Pockets		5	SS	12		268				
	Compact		6	SS	12						
			7	SS	13		266				
	more silty		8	SS	15		264		o		0 16 (84)
			9	SS	19		262				
260.5			10	SS	17						
12.8	Heterogeneous Mixture of Sand, Silt and Gravel Numerous Boulders and Cobbles Very Dense (Glacial Till)		11	SS	60		260		o		18 55 25 2
257.9							258				
15.4	Bedrock		12	RC	REC	93%					RQD 65%
255.9			14	RC	REC	89%	256				RQD 36%
17.4	End of Borehole										

• 95 02 20

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \frac{20}{10} 5$ (%) STRAIN AT FAILURE

ROCK CORE DESCRIPTION
WP 61-86-00

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	2	1.32-1.60	100	36	1.32-1.45	**OVERBURDEN** (boulder till).
	3	1.60-1.93	85	0	1.45-4.44	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, dipping to near vertical, undulating to planar, rough to smooth.
	4	1.93-2.23	100	38		
	5	2.23-3.45	100	31		
	6	3.45-4.44	100	74		
3	1	1.01-1.22	100	0	1.01-1.60	**OVERBURDEN** (boulder till).
	2	1.22-1.60	100	33	1.60-3.86	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, dipping to near vertical, undulating to planar, smooth to rough.
	3	1.60-2.06	100	50		
	4	2.06-2.90	66	27		
	5	2.90-3.86	100	92		
4	5	2.97-3.10	100	0	2.97-6.15	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, flat to dipping, undulating to planar, rough to smooth.
	6	3.10-3.35	100	0		
	7	3.35-3.51	100	0		
	8	3.51-4.34	79	79		
	9	4.34-4.42	100	0		
	10	4.42-5.03	100	83		
	11	5.03-5.39	100	100		
	12	5.39-5.43	100	0		
	13	5.43-6.15	100	93		

*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

ROCK CORE DESCRIPTION
WP 61-86-00

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
5	1	5.61-7.14	100	100	5.61-8.66	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to close spaced, dipping to flat, undulating, smooth to rough.
	2	7.14-8.66	97	97		
6	2	0.66-0.79	40	0	0.66-3.40	**OVERBURDEN** (boulder till).
	3	0.79-1.24	44	22	3.40-7.42	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered (void, 5.41-5.72 m); fractures moderate to close spaced, dipping to near vertical, undulating to planar, smooth to rough.
	4	1.24-1.52	63	0		
	5	1.52-1.93	56	0		
	6	1.93-2.69	27	0		
	7	2.69-3.18	5	0		
	8	3.18-3.51	69	0		
	9	3.51-5.03	73	20		
	10	5.03-6.40	80	41		
	11	6.40-7.42	100	80		
7	4	2.64-3.30	100	79	2.64-5.77	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to close spaced, dipping to near vertical, planar to undulating, smooth to rough.
	5	3.30-3.73	100	82		
	6	3.73-4.80	100	87		
	7	4.80-5.77	100	82		

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

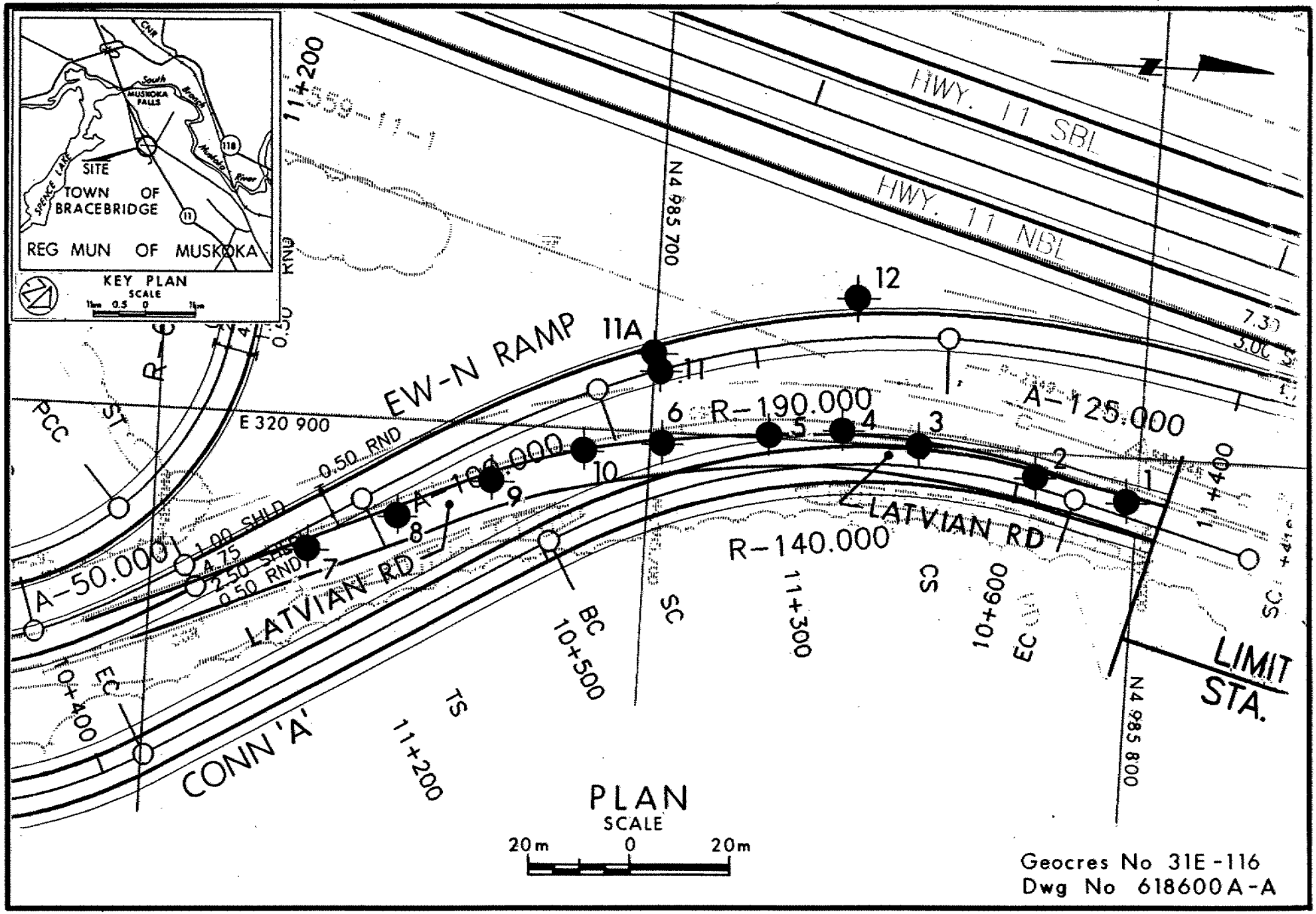
Note: Depths are approximated where core recovery is less than 100%
Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 61-86-00

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
9	6	2.74-3.51	87	87	2.74-5.59	**HORNBLENDE-BIOTITE GNEISS**, greyish black to very light grey to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, dipping to flat, undulating to planar, rough to smooth.
	7	3.51-3.96	100	60		
	8	3.96-4.44	89	89		
	9	4.44-5.59	95	69		
12	13	15.37-16.46	93	65	15.37-16.46	**AMPHIBOLITE** (biotite-bearing), greyish black; medium grained; medium strong; unweathered to slightly weathered; fractures moderate to close spaced, dipping to near vertical, planar to undulating, smooth.
	14	16.46-17.37	89	36		
					16.46-17.37	**GRANITE** (biotite-bearing and gneissic), greyish orange pink to moderate reddish orange; medium to coarse grained; strong; unweathered to slightly weathered; fractures close to very close spaced, dipping to near vertical, planar to undulating, smooth.

*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


KEY PLAN
SCALE
SITE
TOWN OF BRACEBRIDGE
REG MUN OF MUSKOKA
MUSKOKA FALLS
SPENCE LAKE
HWY. 11 SBL
HWY. 11 NBL
EW-N RAMP 11A
LATVIAN RD
CONN 'A'
R-190.000
A-125.000
R-140.000
A-50.000
A-100.000
0.50 RND
1.00 SHLD
2.50 SHLD
11+200
10+500
11+300
10+600
0+400
N4 985 700
N4 985 800
E 320 900
PCC
PT
BC
EC
TS
SC
CS
LIMIT STA.
PLAN
SCALE
20m 0 20m
Geocres No 31E-116
Dwg No 618600A-A

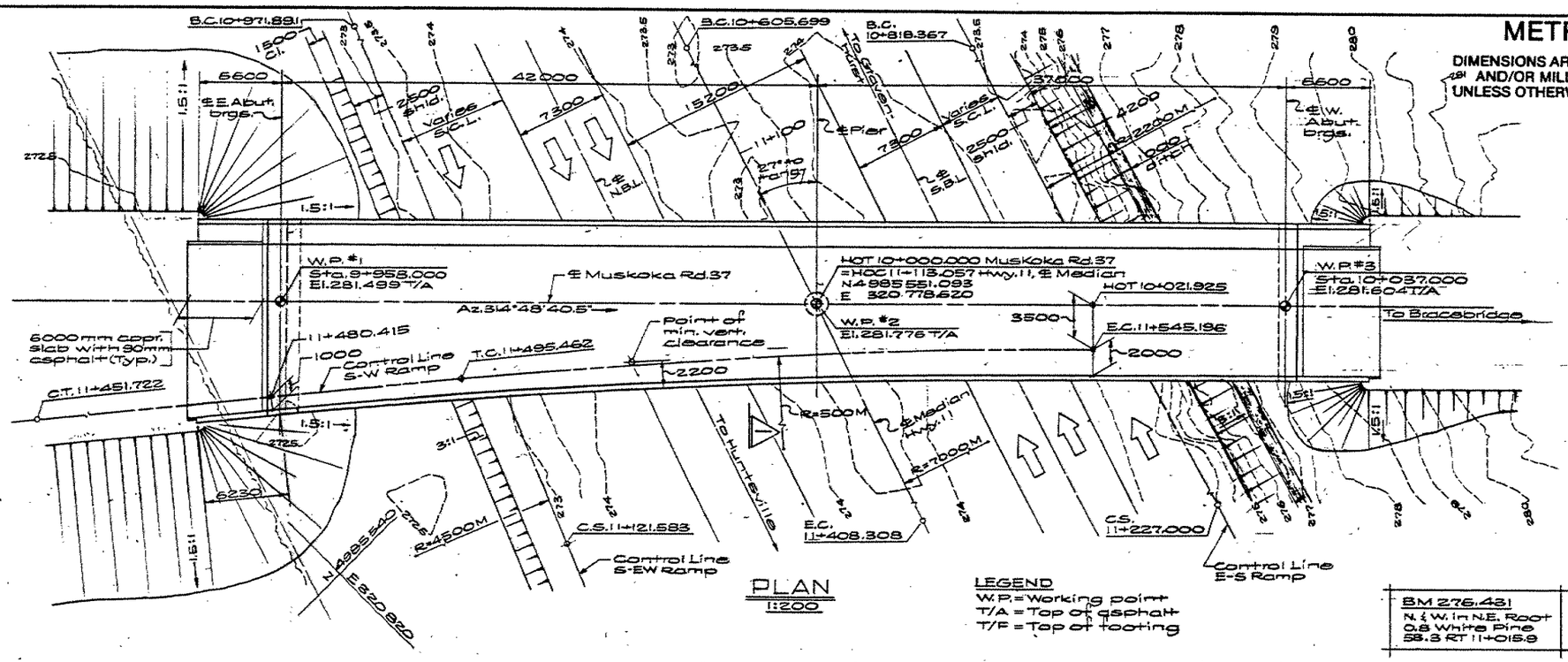
METRIC

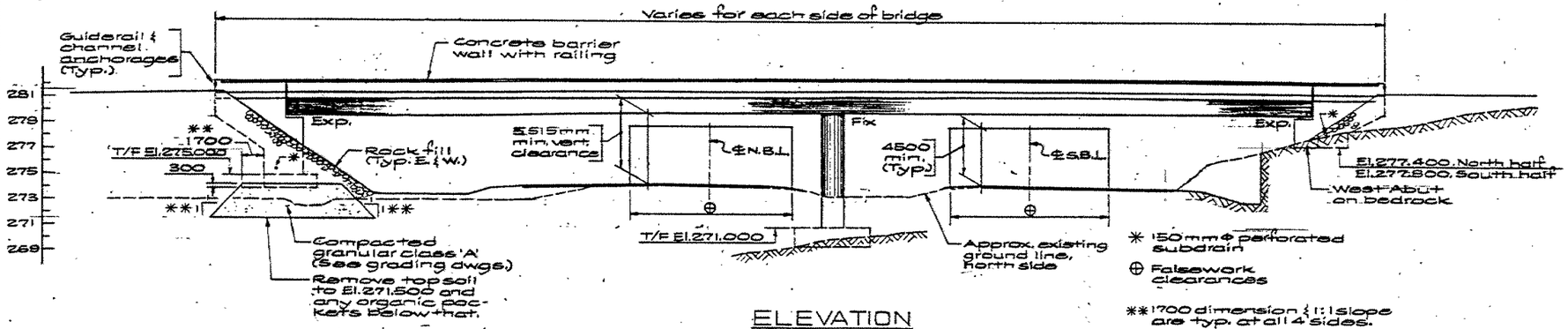
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST. 11
CONT No 96-49
WP No 61-86-02

MUSKOKA RD. 37 INTERCHANGE
Hwy. 11, 1.9 Km North of Hwy. 118
GENERAL ARRANGEMENT

SHEET





ELEVATION
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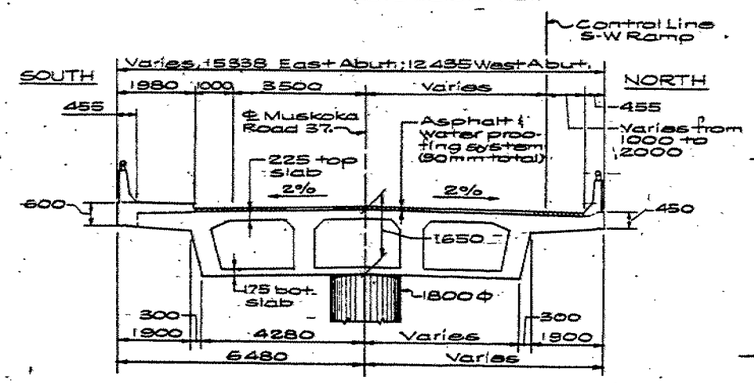
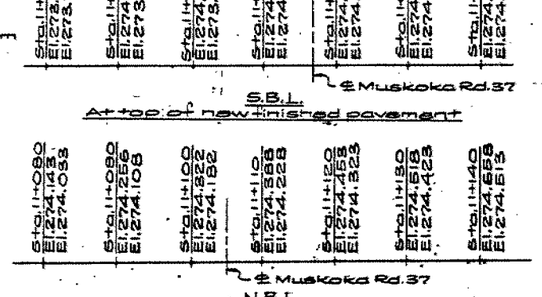
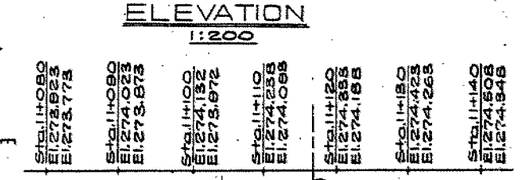
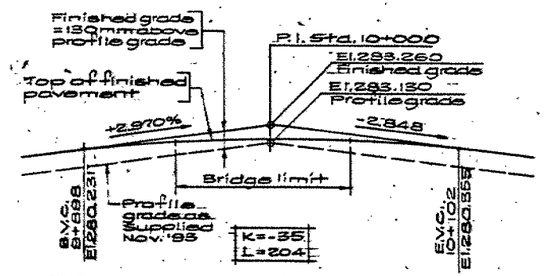






PROFILE OF HWY. 11 N.T.S



PROFILE OF MUSKOKA RD. 37
N.T.S.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

NOTES

CLASS OF CONCRETE

Pier, deck & sidewalk	35 MPa
Remainder	30 MPa

CLEAR COVER TO REINF. STEEL

Footings	100±25
Abutments & wingwalls	70±20
Pier	70±20
Deck:	
Top slab, top	70±20
bot.	40±10
Bot. slab, top	40±10
bot.	50±10
Webs	50±10
Remainder Unless otherwise noted	70±20

REINFORCING STEEL

Reinforcing steel shall be grade 400 unless otherwise specified. Bar marks with suffix 'C' denotes coated bars.

CONSTRUCTION NOTES

The Contractor shall establish the bearing seat elevations by reducing the actual bearing thicknesses from the top of bearing elevations. If the actual bearing thicknesses are different from those given with the design data, the Contractor shall adjust the reinforcing steel to suit.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWINGS

OPSD 4602.00 Falsework clearances
OPSD 3501.00 Minimum granular backfill requirements.

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN A.A.	CHK	CODE OHBDC 91	LOAD	DATE JUNE '94
DRAWN D.C.	CHK	SITE 42-191	STRUCT	SCHEME	DWG. 1

METRIC

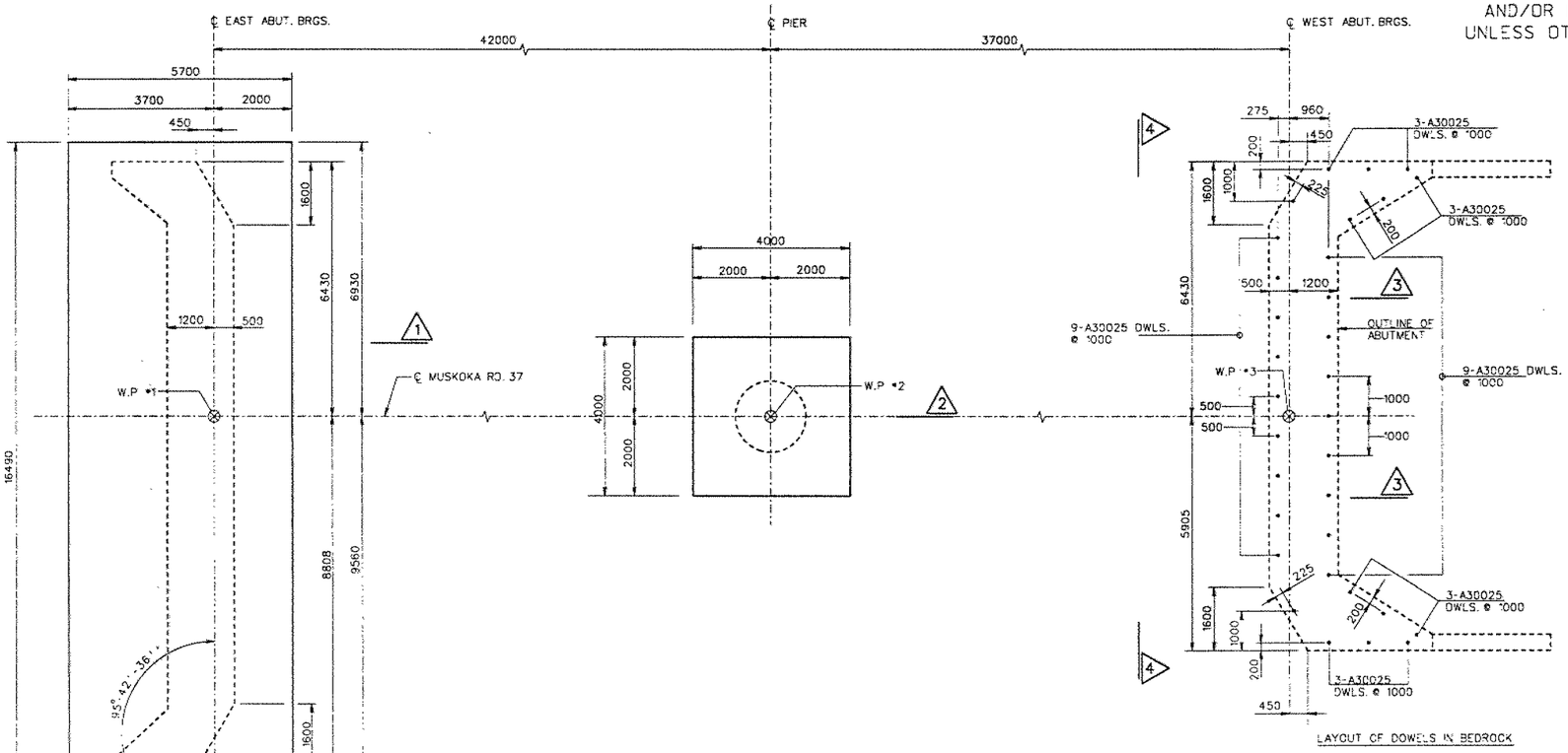
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 61-86-02

MUSKOKA RD. 37 INTERCHANGE

FOUNDATION LAYOUT

SHEET

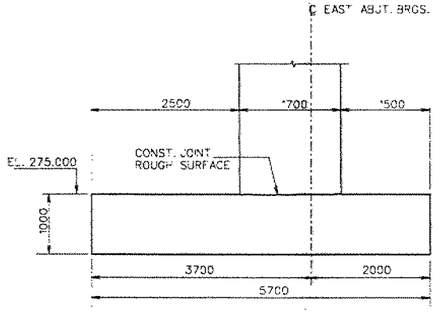


NOTES:

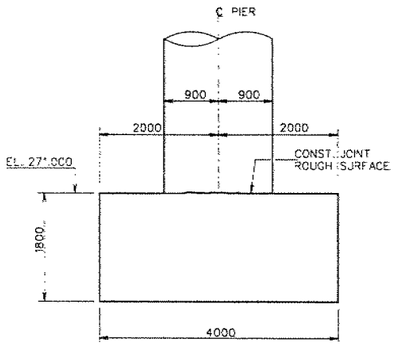
1. THE CONTRACTOR IS TO ENSURE THAT THE EMBEDMENT LENGTH OF THE DOWEL IS SUFFICIENT TO RESIST 150% OF THE WORKING LOAD ON THE DOWEL TO BE ESTABLISHED BY THE PULL-OUT TESTS.
   THE WORKING LOAD PER DOWEL IS 140 KN
2. THE ENGINEER IS TO BE NOTIFIED BEFORE DOWELS ARE PLACED IN BEDROCK
3. ABUTMENTS (INCLUDING WINGWALLS) AND PIER FOOTING SHALL BE PLACED ON SOUND (UNWEATHERED) BEDROCK
4. ROCK SURFACES IN OVER EXCAVATED AREAS SHALL BE SUBJECT TO APPROVAL BY THE ENGINEER
5. OVER EXCAVATION SHALL BE REPLACED WITH CONCRETE OF THE SAME CLASS AS ABUTMENT CONCRETE

WORKING POINT DATA

LOCATION	STATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
W.P #1	9+958.000	4,985,521.492	320,808.417
W.P #2	10+000.000	4,985,557.093	320,778.620
W.P #3	10+037.000	4,985,577.769	320,752.371



SCALE 1:50



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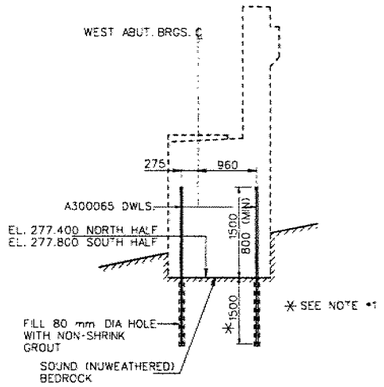

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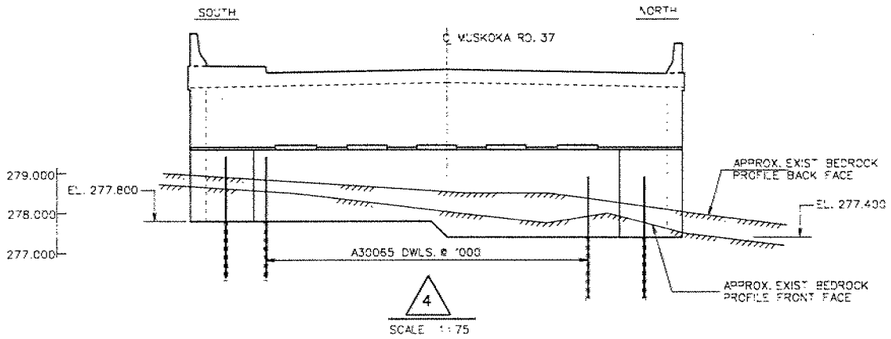


SCALE 1:75

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION

DESIGN AA	CHK	CODE 0+880-91	LOAD	DATE	JUNE, 1994
DRAWN WP	CHK	SITE 42-'91	STRUCT	SCHEME	DWG 3

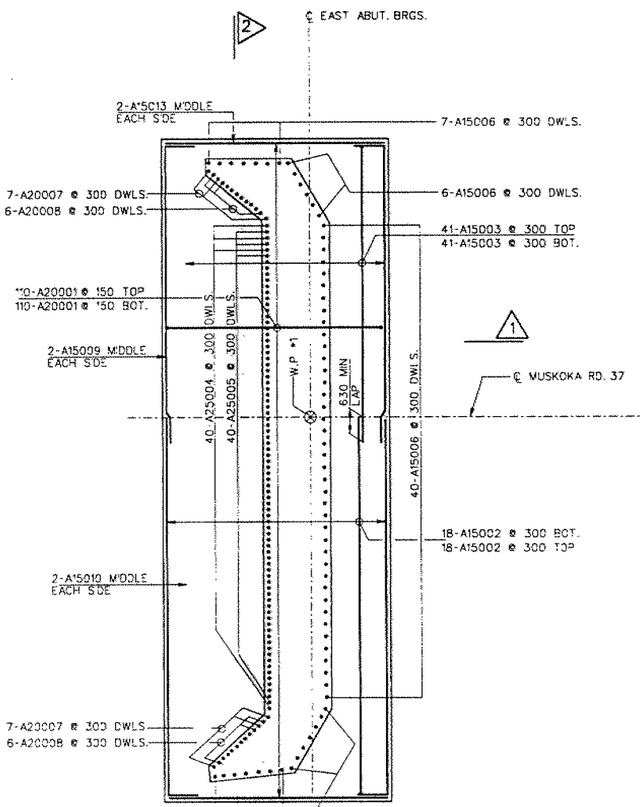
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 61-86-02

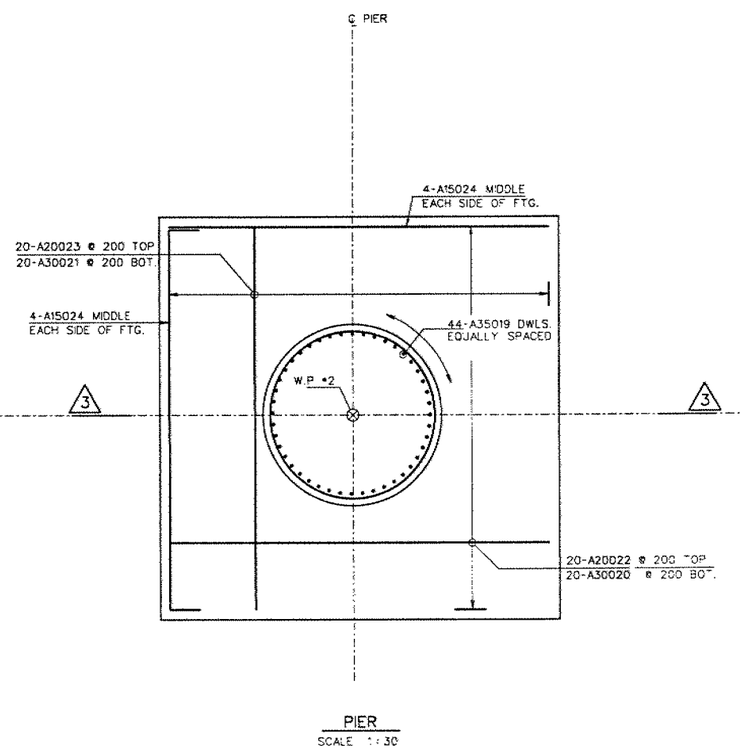
MUSKOKA RD. 37 INTERCHANGE

FOOTING REINFORCING

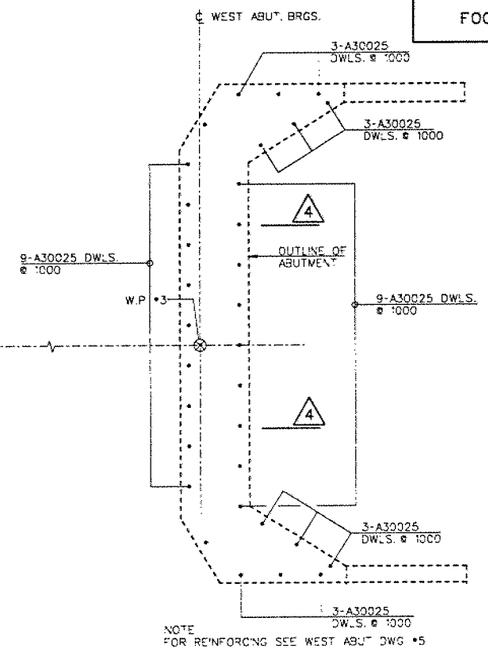
SHEET



EAST ABUTMENT
SCALE 1 : 75



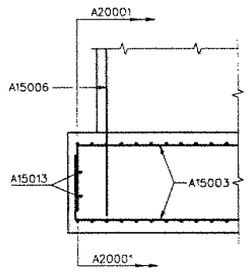
PIER
SCALE 1 : 30

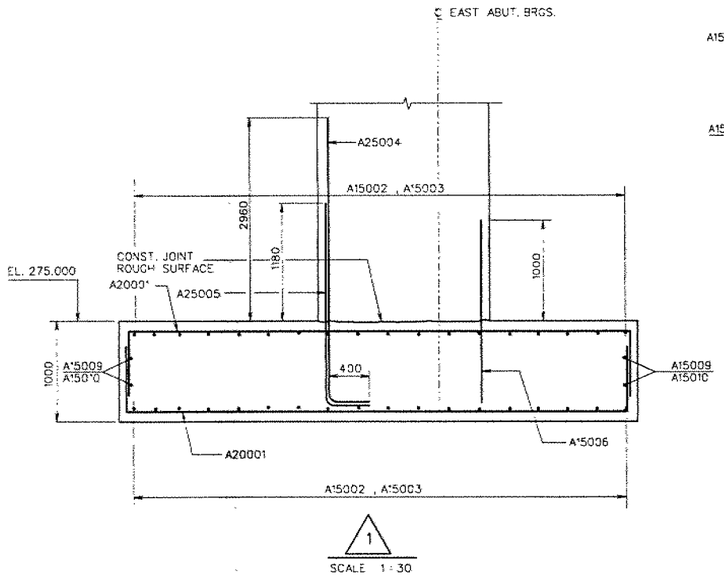


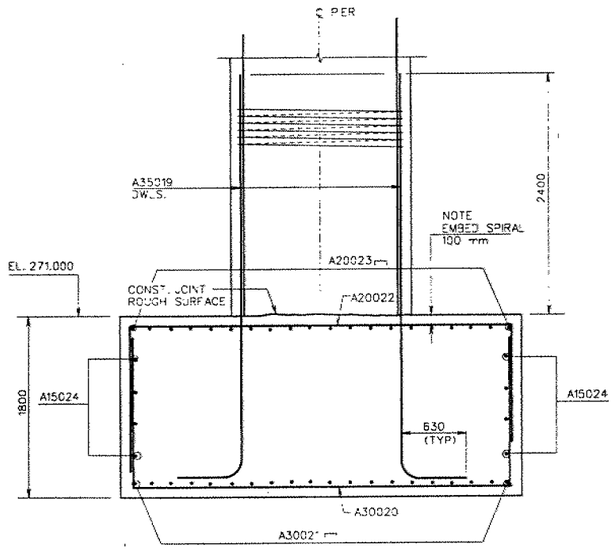
NOTE
FOR REINFORCING SEE WEST ABUT DWG #5

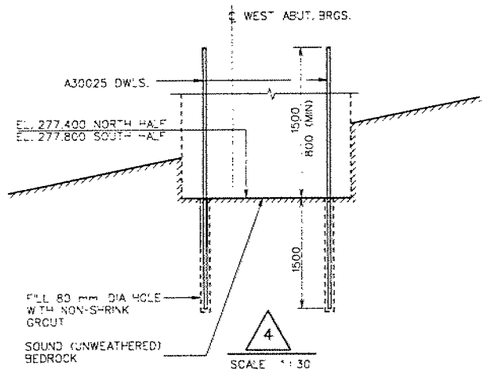
WEST ABUTMENT
SCALE 1 : 75

PLAN OF FOOTING
SCALE AS SHOWN









DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS						
			DESCRIPTION			
DESIGN AA	CHK	CODE CHBDC-91	LOAD	DATE JUNE, 1994		
DRAWN WP	CHK	SITE 42-19	STRUCT	SCHEME	DWG 4	

METRIC

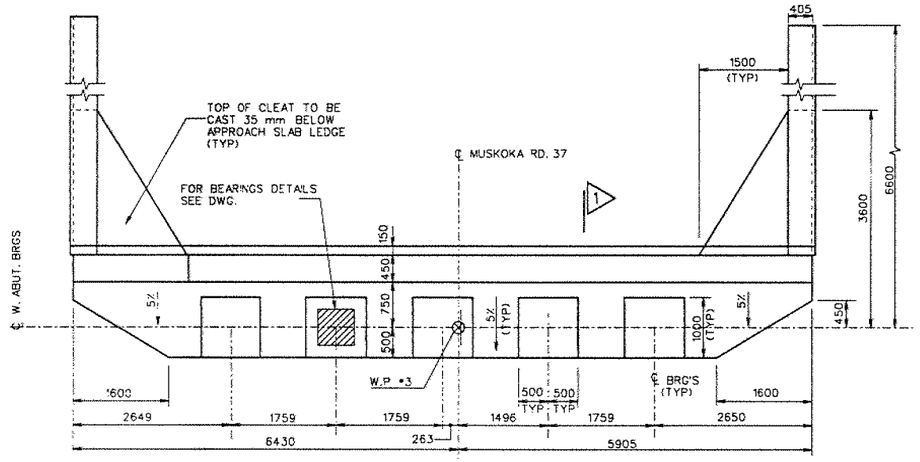
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 61-86-02

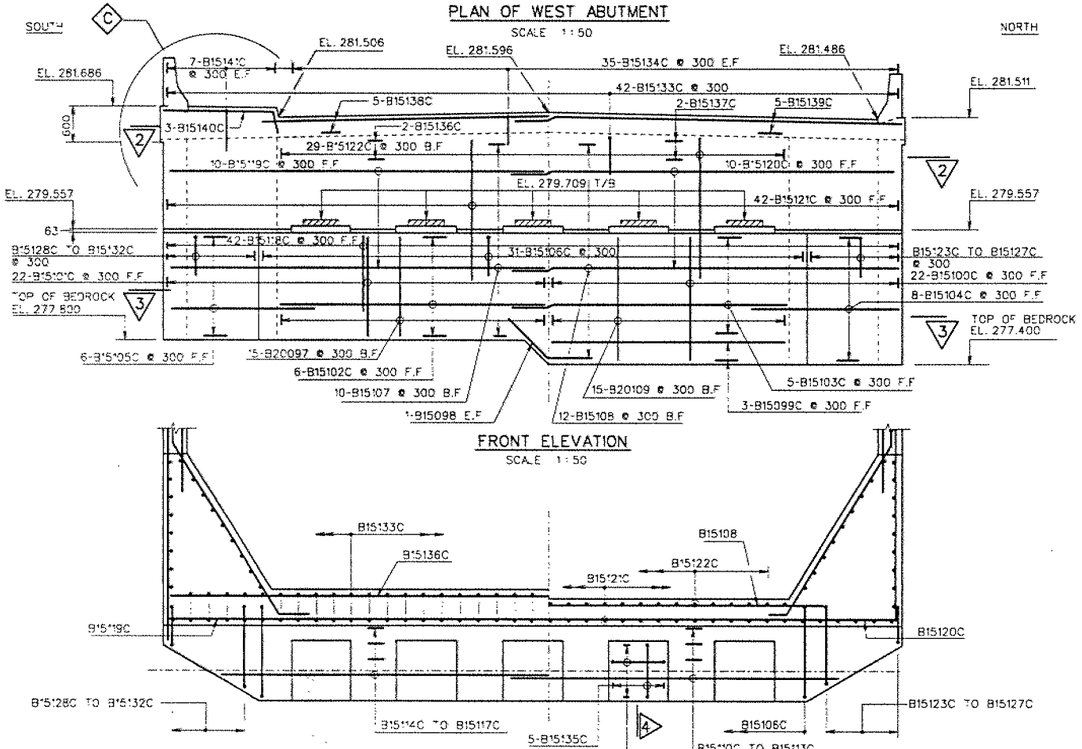
MUSKOKA RD. 37 INTERCHANGE

WEST ABUTMENT

SHEET

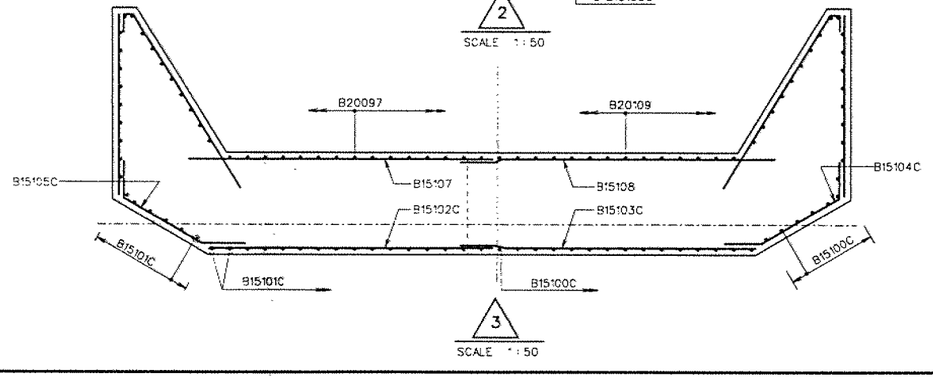


PLAN OF WEST ABUTMENT
SCALE 1 : 50

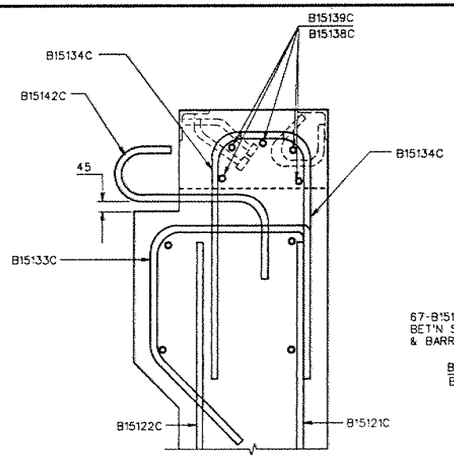


FRONT ELEVATION
SCALE 1 : 50

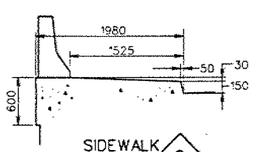
2
SCALE 1 : 50



3
SCALE 1 : 50



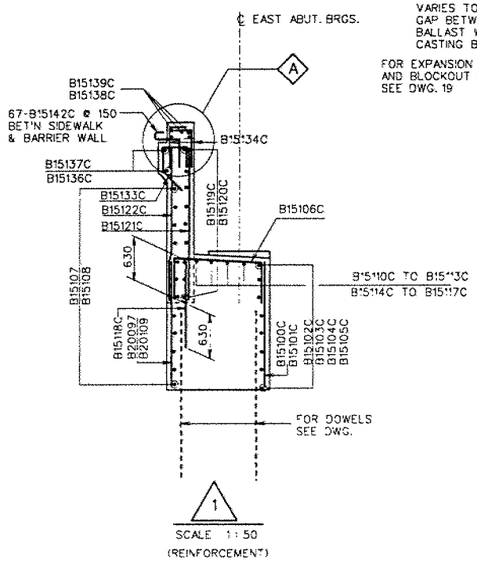
A
SCALE 1 : 10



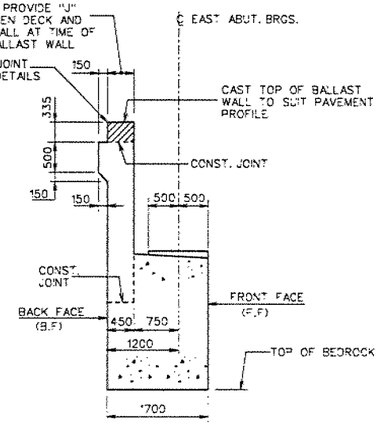
SIDEWALK C

NOTE

B.F DENOTES BACK FACE
F.F DENOTES FRONT FACE
E.F DENOTES EACH FACE
T/B DENOTES TOP OF BEARINGS



1
SCALE 1 : 50
(REINFORCEMENT)



1
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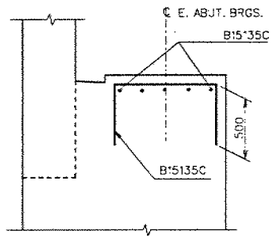
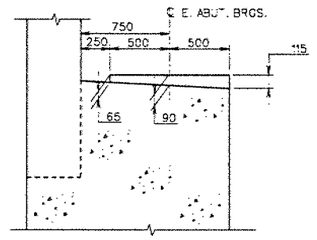
(DIMENSIONS)



4
BEARING PAD REINF. (TYP.)
SCALE 1 : 25



BEARING PAD DETAILS. (TYP.) B
SCALE 1 : 25

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS					
			DESCRIPTION		
DESIGN AA	CHK	CODE CHBDC-91	LOAD	DATE JUNE, 1994	
DRAWN WP	CHK	SITE 42-19	STRUCT	SCHEME	DWG 5

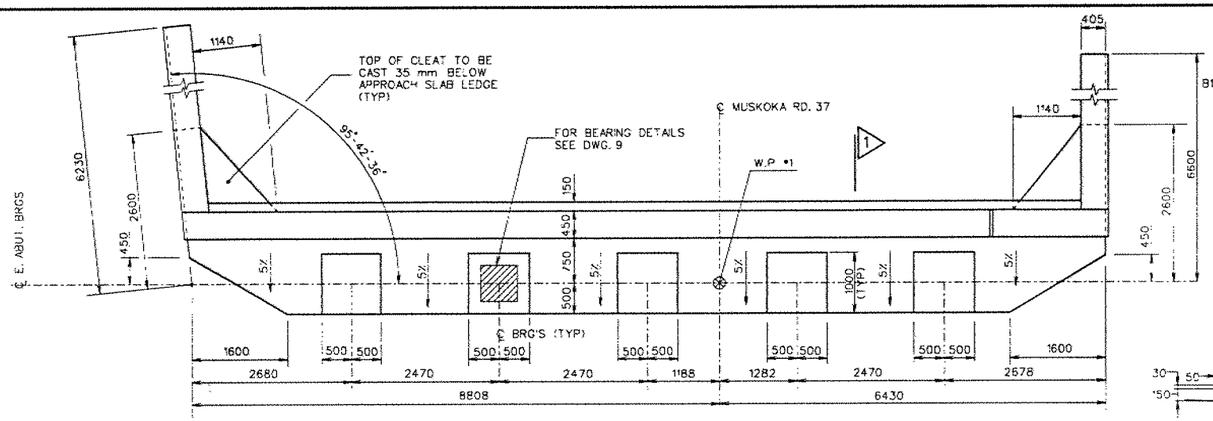
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 61-86-02

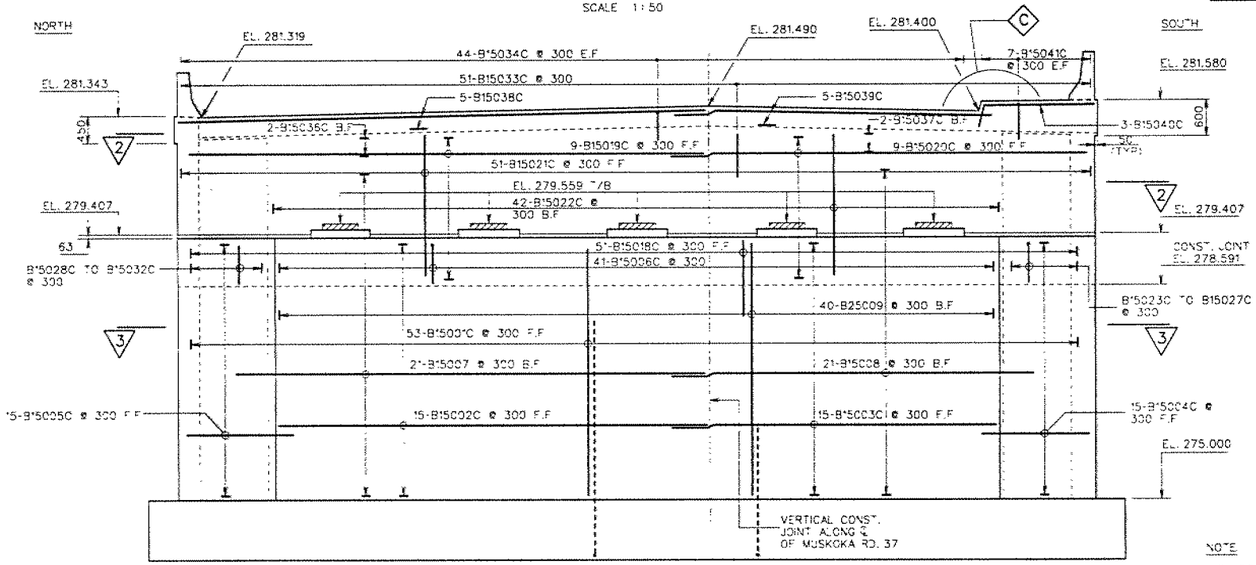
MUSKOKA RD. 37 INTERCHANGE

EAST ABUTMENT

SHEET

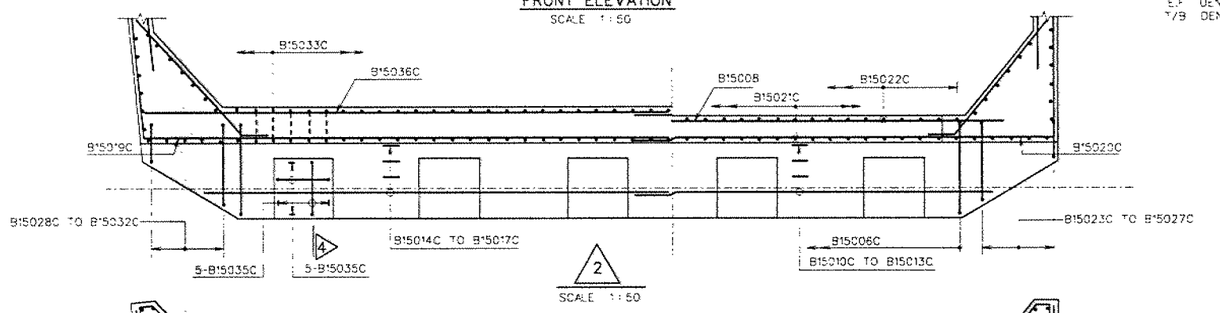


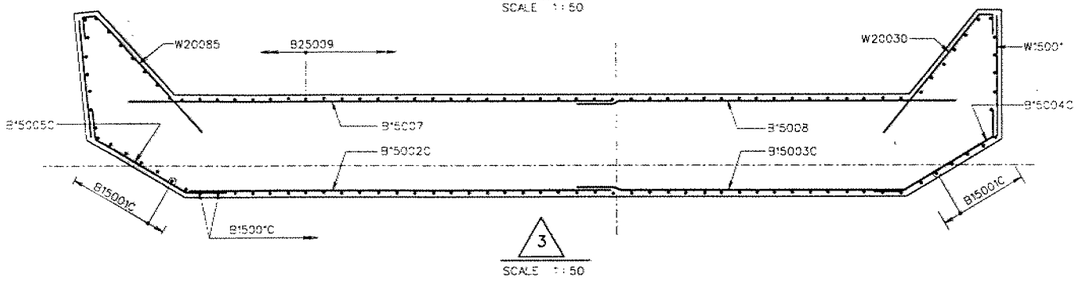
PLAN OF EAST ABUTMENT
SCALE 1:50

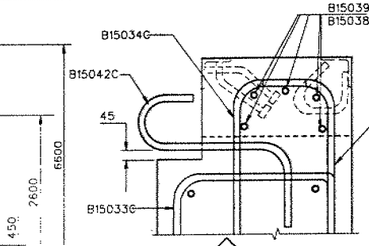


NOTE
B.F DENOTES BACK FACE
F.F DENOTES FRONT FACE
E.F DENOTES EACH FACE
T/B DENOTES TOP OF BEARINGS

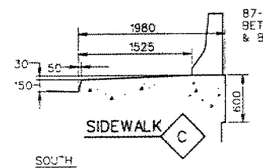
FRONT ELEVATION
SCALE 1:50

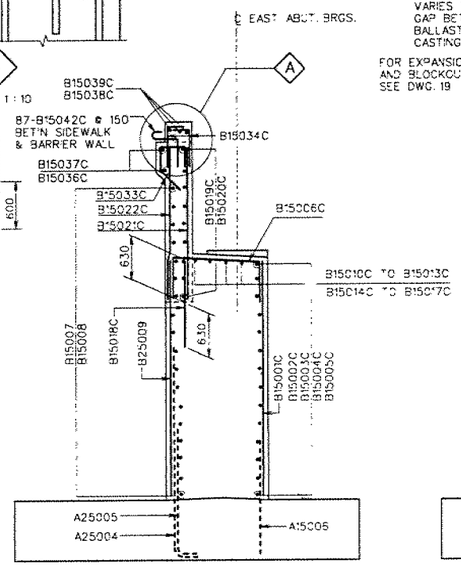




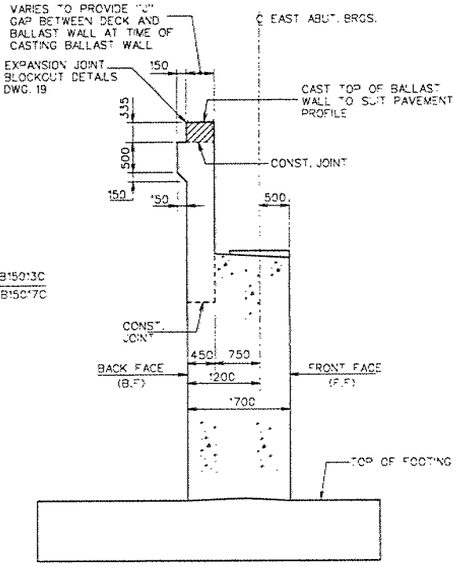


SCALE 1:10

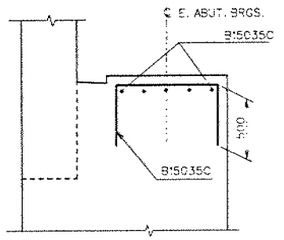




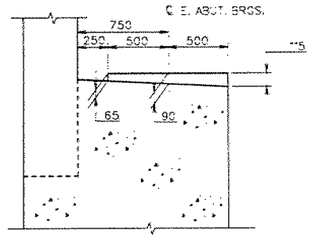
1 SCALE 1:50 (REINFORCEMENT)



1 SCALE 1:50 (DIMENSIONS)



4 BEARING PAD REINF. (TYP.) SCALE 1:25



BEARING PAD DETAILS. (TYP.) B SCALE 1:25

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

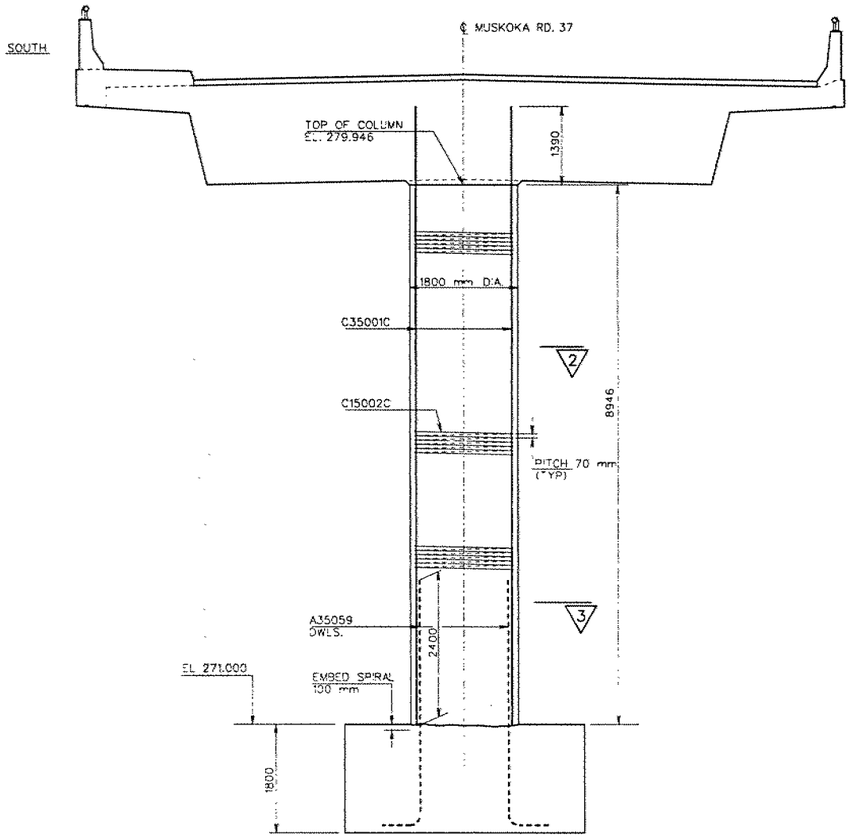
REVISIONS							
				DESCRIPTION			
DESIGN AA	CHK	CODE 0-B30-9'	LOAD	DATE JUNE, '99			
DRAWN WP	CHK	SITE 42-'91'	STRUCT	SCHEME	DWG 7		

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

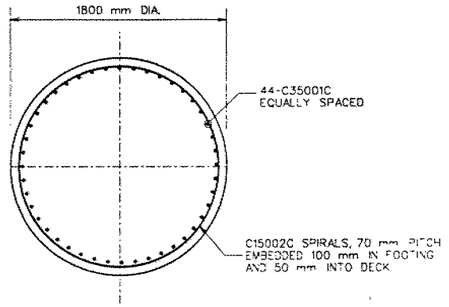
CONT No
WP No 61-86-02

MUSKOKA RD. 37 INTERCHANGE
HWY. 11, 1.9 Km NORTH OF HWY. 118
PIER AND BEARINGS

SHEET



ELEVATION OF PIER
SCALE 1:50



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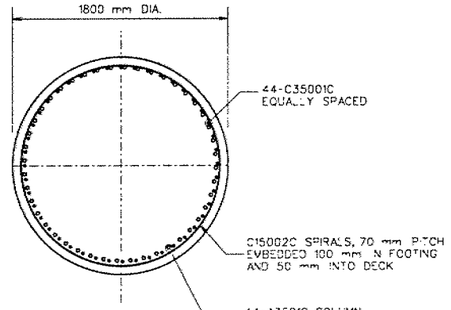
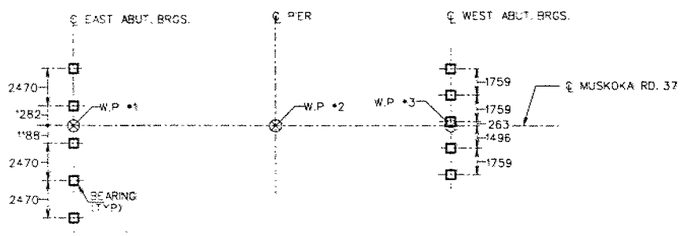
SCALE 1:25



3
SCALE 1:25

ELASTOMERIC BEARING DESIGN DATA						
LOCATION	LOADING (KN)		MAXIMUM MOVEMENT (mm)	MAX. ALLOW. SHEAR RATE (KN/mm)	No. REQ'D	BEARING SIZE
	D	D+L+I				
EAST ABUTMENT	1500	2000	± 32	3.7	5	600 x 600 x 130
WEST ABUTMENT	1300	1800	± 28	3.7	5	600 x 600 x 130



BEARING LAYOUT
N.T.S

ELASTOMERIC BEARING

THE SUPERSTRUCTURE SHALL BE JACKED AT BOTH ABUTMENTS THREE MONTHS AFTER COMPLETION OF ALL POST-TENSIONING OPERATIONS, BY A METHOD APPROVED BY THE MINISTRY

THE JACKING SHALL BE SUFFICIENT ONLY TO RELIEVE THE LOAD ON EACH BEARING SO AS TO ALLOW EACH BEARING TO RETURN TO ITS ORIGINAL UNDEFORMED STATE

BEARINGS SHALL BE NATURAL RUBBER

GIVEN LOADS, PER BEARING ARE AT SERVICEABILITY LIMIT STATE "1"

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION

DESIGN AA	CHK	CODE OHBDC-91	LOAD	DATE JUNE 1994		
DRAWN WP	CHK	SITE 42-79	STRUCT	SCHEME	DWG 9	

FILE

Ministry
of
Transportation
Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 96-49

WP 61-86-02 DIST 11

HWY 11 STR SITE 42-191

Highway 11 and Muskoka Road 37 Underpass

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FOUNDATION INVESTIGATION REPORT
For
Highway 11 and Muskoka Road 37 Underpass
W.P. 61-86-02, Site: 42-191
Highway 11, District 11, Huntsville

INTRODUCTION

This report summarizes the results of a foundation investigation which was carried out for the construction of Hwy 11 and Muskoka Road No. 37 Underpass.

The investigation was carried out at the request of Northern Region Structural Section. The report applies to proposed bridge structure and its approaches between Station 9+920 and 10+040, Muskoka Road 37 chainage (Re.: Plan E-559-11-1, dated October, 1990).

SITE DESCRIPTION

Physiographically the site is located in the Algonquin Highlands region. In general this region is underlain by granite and other hard Precambrian rocks. Overall it is broadly dome shaped. There are frequent outcrops of bare rocks. The soils are generally shallow but thickness over the bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. Several areas have deeper till and few rock outcrops and the surface of the till is smoothed and moulded with occasional drumlins appearing (Reference: Chapman and Putnam, 'The physiography of Southern Ontario; 3rd Edition, 1984).

The site for the proposed Highway 11 and Muskoka Rd 37 interchange (Underpass) is located about 200m north of existing intersection of Muskoka Rd 37 and Highway 11. The proposed interchange will replace the existing intersection of Hwy 11 and Muskoka Rd. 37.

At the proposed underpass, Highway 11 runs north-south. The land adjacent to Hwy 11 at the proposed site location is undeveloped. On the east side the ground is covered with grass and at about 45m east of Highway 11 the area is covered with woods. On the west side, adjacent to Highway 11 there are rock outcrops which are up to 8m high.

The exposed bedrock on the west side of Hwy 11 is covered with grass and shrubs. In some areas the rock surface adjacent to Highway 11 is rough and angular. Perhaps this is due to excavations which took place at this location during Hwy 11 construction. The rock surface elsewhere, including the location of the proposed west abutment is smooth. The bedrock outcrop is sound with some surficial loose pieces of rock. The exposed bedrock surface dips towards east at 4H:1V (about 14 degrees). Adjacent to Hwy 11 the bedrock contains few close spaced fractures which dip towards the east at about 20 degrees).

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 91 07 10 and 91 07 17. The field work consisted of drilling five boreholes (BH 1,2,6,15 and 17) and six dynamic cone tests (BH 3,4,5,7,14 and 16) at or near proposed footing locations. The boreholes were advanced using track-mounted auger machines equipped with 82mm ID hollow stem augers and BX size coring equipment.

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). In general samples were retrieved at 0.75m intervals for the first 6m of boring, then every 1.5m. Once practical refusal to auguring was encountered in Boreholes 2,6 and 15, BX-size bedrock cores were obtained from these boreholes.

Groundwater was monitored during drilling and after completion of the boreholes.

The Laboratory testing program for the representative samples consisted of Grain Size Analyses. The results of the laboratory tests are plotted on the Record of Borehole sheets (Appendix) and summarized on Figure 1.

Bedrock cores were logged by D.A. Williams, Petrographer in the Soils and Aggregates Section of MTO.

The boreholes were staked out by the Northern Region Surveys and Plans Section of the MTO. Ground surface elevations were also provided by the Surveys and Plans Section.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 618602-A.

Following are detailed descriptions of the soil strata encountered.

Silty Sand to Sandy Silt

The overburden consisted of a non cohesive silty sand to sandy silt material at the entire site. This non-cohesive material was encountered in all boreholes. The upper 0.5m to 0.7m of this stratum contained roots and organics (BH 1,2 and 6). The thickness of this stratum increased gradually from west to east. On the west side the thickness of this deposit was about 1.6m (BH 15) and on the east side at a distance of about 70m from Borehole 15 the thickness of this stratum was more than 8m (BH 1). The 'N' values within this material ranged from 13 blows to more than 140 blows/0.3m which suggest that the material is in compact to very dense state. 'N' values generally increased with increasing depth. Average 'N' value was in the order of 25 blows/0.3m at the pier location (BH 6) and 38 blows/0.3m at the east abutment location. This suggests that on average the silty sand to sandy silt material is compact at the pier location and dense at the proposed location of east abutment.

Bedrock

The silty sand to sandy silt material was overlying bedrock. Bedrock was encountered at depth ranging from 1.6m (BH 15) to 10.4m (BH 2) which corresponds to elevation varying from 262.2m (BH 2) to 272.1m (BH 15). The bedrock surface dips towards the east at approximately 8 degrees. The bedrock was classified as Gneiss Bedrock with interlayered Amphibolite, Granite and Pegmatite. Eight bedrock cores were obtained from three locations. The result of the core analyses were as follows:

	Range (%)	Average (%)
Recovery	75-100	95
RQD	48-100	80

Based on these results, the bedrock is considered to be competent for the proposed foundations.

Groundwater Conditions

Groundwater was encountered at depth ranging from 0.9m (BH 1) to 1.5m (BH 15). The groundwater elevation ranged from 271.2m (BH 2) to 272.6m (BH 6). It should be noted that the groundwater is subject to seasonal fluctuation.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct a two-span bridge at the proposed interchange. The centreline of the proposed structure will be located at HOC 11+113.057 Highway 11 centreline. It is understood that consideration will be given to a concrete cast in place type of structure. At present there are three schemes under review. In each scheme locations and orientations of the abutments will be different. Proposed locations of abutments may be shifted east or west by a few metres. In any case, the pier will be located at centreline of Highway 11 (in the median). Suggested spans are 36m to 38m on the east and 36m to 40m on the west side. Abutments may be square or skewed at 20 degrees. The bridge structure will be 11m wide on the west side and 23.2m wide on the east side. The proposed structure will carry two lanes of through traffic 3.5m wide and a variable width speed change lane ramp. On the south side lane clearance will be 2m wide and on the north side 1m wide. Minimum design clearance requirement from soffit to roadway is 5.3m.

At present Highway 11 is 4 lanes. The width of Highway 11 will remain unchanged. The existing grade of Hwy 11 is about 274m. The existing grade of Hwy 11 may be raised by 100mm (10cm).

The east abutment will be perched within the approach embankment. The west abutment will be a closed type and will be founded on exposed bedrock.

Structure Foundations

East Abutment

The east abutment footing may be perched within the approaches and founded on compacted Granular 'A' material (Granular Pad). The granular pad should have a minimum thickness of 3.0m and should be constructed as follows:

The soil above elevation 271.5m should be removed. If any organic pockets are identified below elevation 271.5m they should be removed as well. The granular material should be placed in small lifts and compacted according to MTO Standard. The granular pad will extend 1m beyond the plan limits of the abutment footing at the footing level and will slope at 1H:1V. If desired the remainder of the approach fill could consist of rock fill.

The recommended bearing capacities for the footings on a granular pad, as per the OHBDC are as follow:

Factored Bearing Capacity at U.L.S. = 900 kPa
Bearing Capacity at S.L.S. Type II = 350 kPa

A friction angle of 35 degrees may be assumed to determine sliding resistance between the footing and compacted Granular 'A' pad.

A minimum earth cover of 1.8m is required for frost protection.

It is expected that a settlement up to 25mm will occur at the east abutment. Since the pier will be constructed on sound bedrock, there may be differential settlement between the east abutment and the pier. If this movement cannot be tolerated by the structural design, contact the Foundation Design Section for recommendations.

Consideration may be given to preload the proposed Granular 'A' pad at the east abutment. If schedule permits the proposed granular pad should be preloaded with at least 2m thick granular material for a minimum period of one month. This will reduce post construction settlement.

Pier

The pier can be founded on spread footing constructed on sound bedrock. In order to construct the footing on bedrock the soil above the bedrock should be removed. Please refer to Dewatering Section for details regarding recommendations for constructing below the prevailing groundwater elevation.

The recommended bearing capacities for the spread footings, on sound bedrock as per the OHBDC, are as follows:

Factored Bearing Capacity @ U.L.S. = 10,000 kPa
Bearing Capacity at S.L.S. Type II will not govern

West Abutment

The west abutment, can be founded on spread footings constructed on sound bedrock. This implies that all loose or shattered rock under the plan limits of the footings should be removed and replaced with concrete. Depending on the selection of three schemes, the footing elevation will depend on the abutment locations. At this time the exact location of west abutment is not known. It is expected that the west abutment footing would be constructed below elevation 278m.

If the footing is to be constructed at elevations above sound bedrock elevations, then all loose rock should be removed above the sound bedrock and mass concrete may be used to bring the base of the footing to the desired elevation. Depending on the west abutment location if the abutment is founded by cutting bedrock, then the abutment may be constructed against the bedrock without backfill.

The recommended bearing capacities for the spread footings, on sound bedrock, as per the OHBDC are as follows:

Factored Bearing Capacity @ U.L.S. = 10,000 kPa
Bearing Capacity at S.L.S. Type II will not govern

Roadway Protection

For roadway protection, the following parameters should be used for the shoring design:

ϕ = 30 Degrees
Cu = 0 kPa
γ = 20.5 kN/m^3

WL elevation 272.6m

Embankment Stability

It is understood that rock fill will be used in approach fills. It is expected that rock fill will be up to 9.5m high. For side slopes of rock fill 1.25H:1V a nominal berm (1 to 2m wide) should be provided so that no uninterrupted slope is more than 6m high. No berm will be needed for embankment up to 10m high if a side slope of 1.5H:1V is considered. There is no concern of any deep seated stability.

Foundation Stability at the West Abutment

In order to ensure stability of the rock face at the west abutment of the proposed structure, footings should be located far enough from the face of rock cuts to be outside a plane defined as 0.5H:1V from the toe of the cut slope or a minimum of 1m from the crest of the rock cut (whichever is greater).

Lateral Earth Pressure

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

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

Granular 'A'	γ = 22.8 kN/m^3	ϕ = 35°
Granular 'B'	γ = 21.2 kN/m^3	ϕ = 30°
Rock Fill	γ = 18.0 kN/m^3	ϕ = 35°

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the OHBDC. At-rest condition (K_o) may be assumed to apply at the west abutment and active condition (K_a) will apply at the east abutment unless it is structurally constructed to impose the at-rest condition.

Resistance to Lateral Forces

Sliding resistance should be calculated in accordance with Section 6-7.3.3.2 of the OHBDC. For concrete footings on granular pads sliding resistance should be calculated assuming unfactored angle of friction ϕ = 35°. An unfactored angle of friction ϕ = 30° should be used to calculate sliding resistance between concrete footing and bedrock or between concrete surfaces.

If the bedrock surface is roughened with chiselled groves then an unfactored angle of friction ϕ = 35° can be assumed to calculate sliding resistance between concrete footings and bedrock.

If necessary, sliding resistance can be supplemented by dowelling into bedrock or between concrete surfaces.

For design purposes, the following OHBDC capacities may be assumed for the bond between bedrock and grout.

Factored Bearing Capacity @ U.L.S. = 500 kPa
Bearing Capacity at S.L.S. Type II will not govern

The minimum dowel embedment should be 1m. Neither the structural strength of the dowel, nor the compressive strength of the grout should be exceeded. Also, the annular space around the dowel (to be grouted) should be in the order of 2 cm wide (between the dowel and the bedrock).

The capacity of dowels between concrete surfaces will be dependent on the strength of the concrete and the dowel.

Settlement Consideration

Total and differential settlement of the spread footing at the east abutment and embankment fill is expected to be less than 25mm. Most of this will take place immediately after the completion of the construction. No settlement is anticipated at the west abutment and at the pier location where the footing would be constructed on sound bedrock.

Frost Protection

At the east abutment a 1.8m frost cover is required. Frost protection is not required for footings on unweathered bedrock, such as at pier and west abutment locations. Frost protection requirements at the east abutment could be reduced if it could be ensured that groundwater will always be below footing level.

Dewatering

The proposed foundation at the pier location will be below the groundwater table. It will be either required to lower the groundwater below the excavation or other measures would have to be taken to construct the footing either in dry or without creating unbalanced hydrostatic pressure. It will be necessary to put a special provision in the contract that footing at the pier location is to be constructed without disturbing adjacent ground. Although construction procedures are the responsibility of the contractor the situation could be addressed by the following procedure.

Assuming that lanes at Highway 11 will be open during construction and considering roadway protection will be required to maintain traffic, a suitable scheme will be to drive sheet piles to the bedrock and utilize sheet piling for dewatering as well as shoring. Once the material above the bedrock is removed, the concrete will be poured using a tremie seal to control inflow if necessary.

In any case, the contractor should submit his proposal for review a minimum of 10 working days prior to the construction.

Excavation

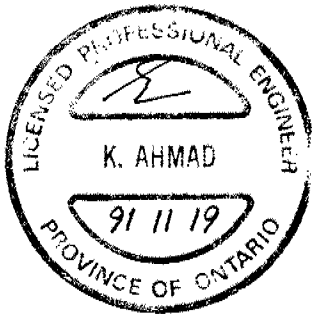
Rock excavation will be required for the construction of west abutment. Cut rock slopes will be stable with near vertical faces provided that blasting is carefully controlled. If advice on controlled blasting techniques are required, please contact this office.

MISCELLANEOUS

The field work for this project was carried out under the supervision of C. Davidson, a student specialist.

The equipment used was owned and operated by Master Soil Investigation Ltd.

The report was written by K. Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



K. Ahmad, P. Eng.
Foundation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

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'_{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 = $\frac{c_u}{\tau_r}$

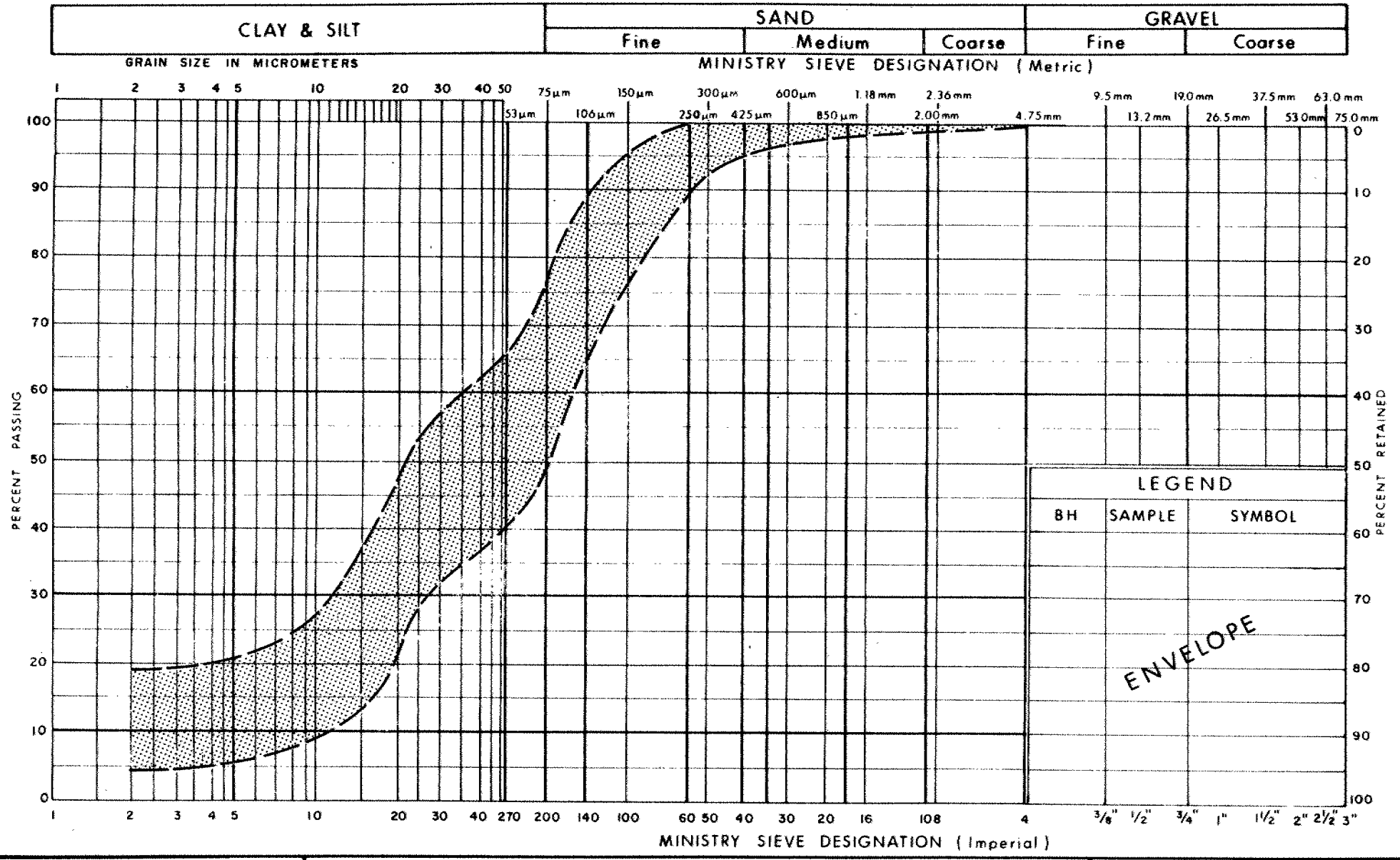
PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	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	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

FIG No 1
W P 61-86-02

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 61-86-02 LOCATION Co-ords; N 4 985 512.2; E 320 824.2 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CD

DATUM Geodetic DATE 1991 07 17 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
272.6	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics										
			1	SS	25	▼	272				
			2	SS	24		271				0 39 56 5
			3	SS	58		270				
			4	SS	58		269				
	Silty Sand to Sandy Silt Compact to Very Dense Greyish Brown to Grey		5	SS	37						0 32 63 5
			6	SS	36		268				
			7	SS	26		267				
			8	SS	46		266				0 37 58 5
264.5			9	SS	71		265				
8.1	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 — 1 OF 1 — METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 517.4; E 320 804.4 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD

DATUM Geodetic DATE 1991 07 10,11 CHECKED BY KA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.6	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
			1	SS	13	▼					0 29 54 17
			2	SS	14		271				
			3	SS	23		270				
			4	SS	32		269				
			5	SS	48						0 43 51 6
	Silty Sand to Sandy Silt Compact to Very Dense		6	SS	41		268				
			7	SS	44		267				
			8	SS	67		266				
			9	SS	61		265				
			10	SS	140	/23cm	264				
262.3							263				
10.3			11	RC	REC	93%	262				RQD 92%
	Gneiss Bedrock		12	RC	REC	75%	261				RQD 60%
259.3			13	RC	REC	100%	260				RQD 48%
13.4	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 527.6; E 320 807.0 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 10 CHECKED BY KA

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	WATER CONTENT (%)	γ kN/m³	GR SA SI CL
272.7 Ground Surface								20 40 60 80 100	10 20 30		
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
	Probable Silty Sand to Sandy Silt Compact to Very Dense						271				
							270				
269.7											
3.0	End of Cone Test							120/23cm			

+³, x⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 536.0; E 320 808.8 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 10 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
272.7	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics						272				
							271				
							270				
	Probable Silty Sand to Sandy Silt Compact to Very Dense						269				
							268				
267.5											
5.2	End of Cone Test							120/ 26cm			

+³, ×³: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 545.0; E 320 776.8 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 12 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)	γ kN/m^3	GR SA SI CL
272.8 Ground Surface								20 40 60 80 100	10 20 30		
0.0	Silty Sand to Sandy Silt with Roots and Organics										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						272				
							271				
270.1							270				
2.7	End of Cone Test							120/15cm			

+^{3}, ×^{5} : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 552.0; E 320 779.0 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD

DATUM Geodetic DATE 1991 07 11 CHECKED BY KA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.9	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics					▼					
			1	SS	29		272				
	Silty Sand to Sandy Silt Compact										
			2	SS	23		271				0 41 55 4
270.2			3	SS	25						
2.7			4	RC	REC	100%	270				RQD 86%
	Gneiss Bedrock						269				
			5	RC	REC	100%	268				RQD 84%
267.1											
5.8	End of Borehole										

+^{3}, x^5 : Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords; N 4 985 559.3; E 320 781.2 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 12 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 0 0 0 0 0	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 0 0 0	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
272.9	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						272				
271.1							271				
1.8	End of Cone Test							120/13cm			

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 14 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 560.0; E 320 761.5 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 0 0 0 0 0	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 0 0 0	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
273.8 0.0	Ground Surface										
	Probable Silty Sand to Sandy Silt Compact to Very Dense						273				
272.3 1.5	End of Cone Test							120/8cm			

+³, ×⁵ ; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 15 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 566.2; E 320 763.5 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Hollow Stem Auger, BX Core COMPILED BY CD

DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
273.7	Ground Surface										
0.0	Silty Sand to Sandy Silt Compact		1	SS	29		273				
272.1			2	SS	13/13cm	▼	272				
1.6	Gneiss Bedrock		3	RC	REC 100%		271				RQD 68%
			4	RC	REC 98%		270				RQD 93%
268.7			5	RC	REC 100%		269				RQD 100%
5.0	End of Borehole										

+^{3}, x^5: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 574.2; E 320 766.1 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Cone Test COMPILED BY CD

DATUM Geodetic DATE 1991 07 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
273.9	Ground Surface										
0.0	Probable Silty Sand to Sandy Silt Compact						273				
272.3											
1.5	End of Cone Test							120/4cm			

+³, ×³: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 17 1 OF 1 METRIC

W.P. 61-86-02 LOCATION Co-ords: N 4 985 503.2; E 320 815.0 ORIGINATED BY CD

DIST 11 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CD

DATUM Geodetic DATE 1991 07 17 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
272.8	Ground Surface										
0.0	Silty Sand to Sandy Silt with Roots and Organics										
			1	SS	17	▼	272				
			2	SS	31		271				
			3	SS	13		270				1 50 46 3
			4	SS	28						
	Silty Sand to Sandy Silt Compact to Very Dense						269				
			5	SS	21						
			6	SS	40		268				0 25 69 6
			7	SS	91		267				
			8	SS	93		266				
264.7			9	SS	109	/26cm	265				0 51 46 3
7.9	End of Borehole										

+³, ×³: Numbers refer to Sensitivity

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

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10

METRIC

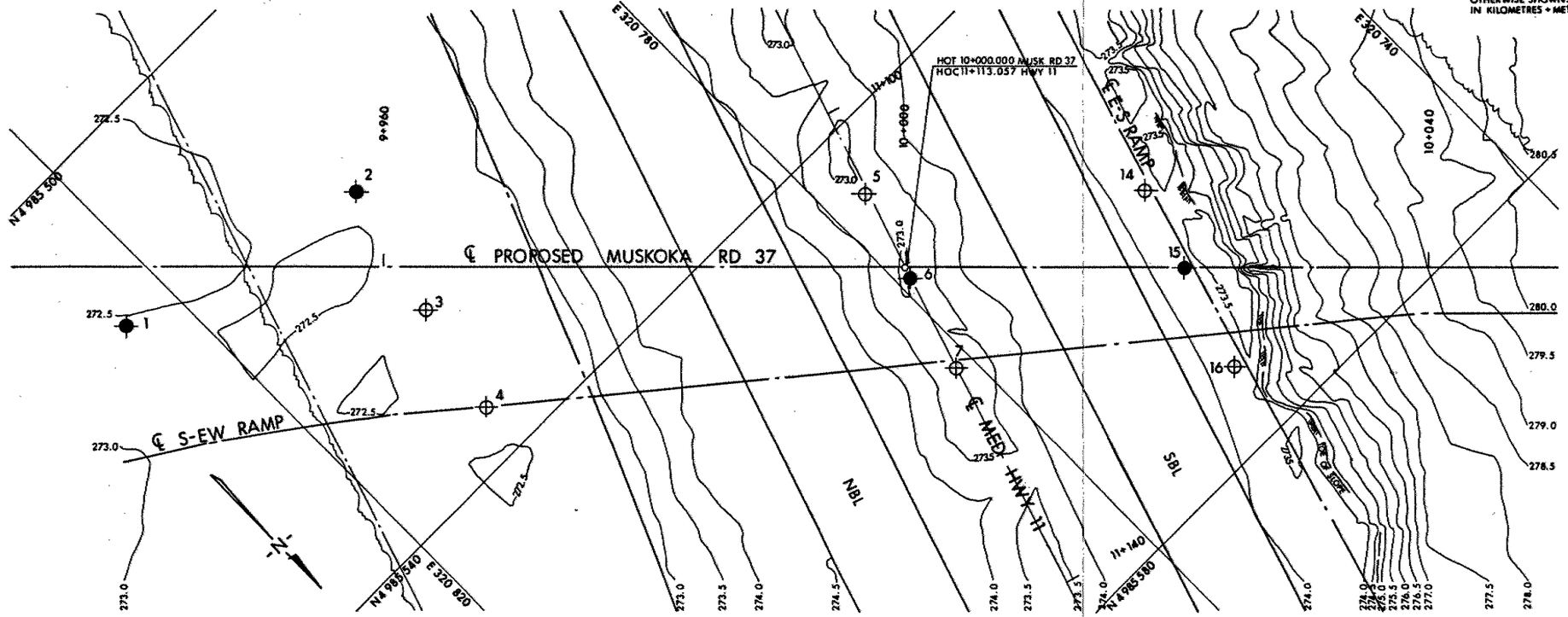
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 61-86-02

MUSKOKA ROAD 37

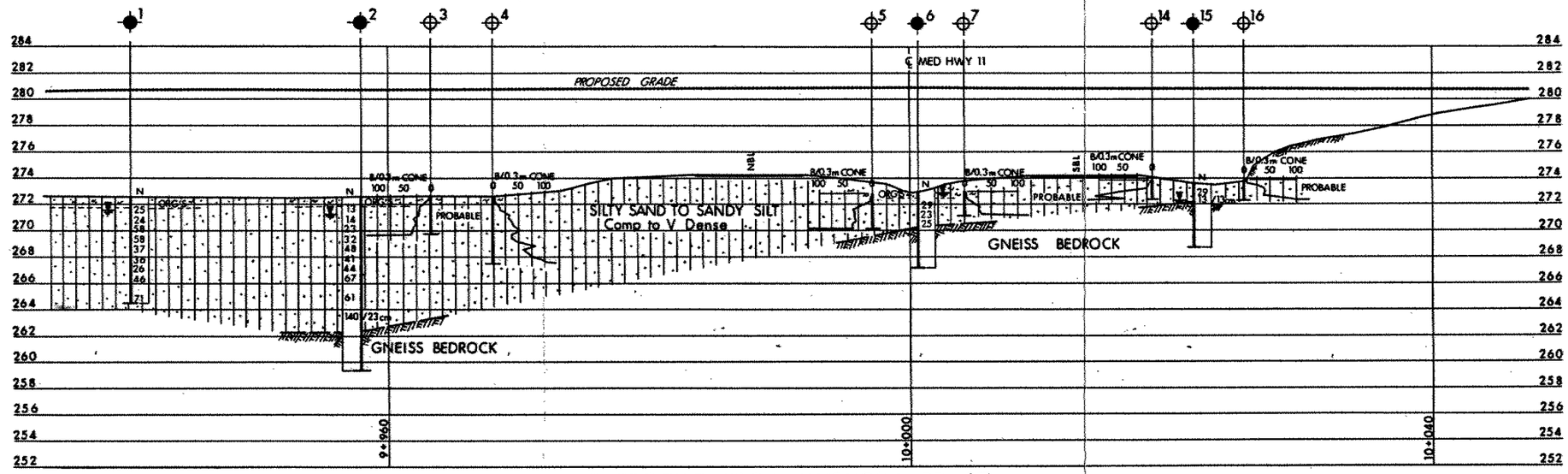
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

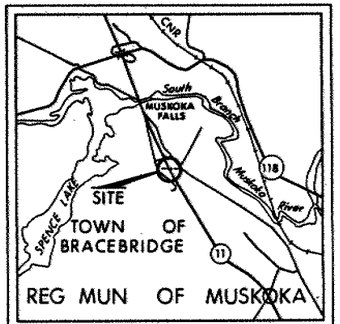


PLAN
SCALE
4m 2 0 4m

NOTE: BORE HOLE 17 NOT SHOWN ON PLAN SEE RECORD OF BORE HOLE FOR SUBSOIL INFORMATION



℄ PROFILE PROP MUSKOKA RD 37
SCALE
4m 2 0 4m



KEY PLAN
SCALE
1km 0.5 0 1km

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 1991 07

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	272.6	4 985 512.2	320 824.2
2	272.6	4 985 517.4	320 804.4
3	272.7	4 985 527.6	320 807.0
4	272.7	4 985 536.0	320 808.8
5	272.8	4 985 545.0	320 776.8
6	272.9	4 985 552.0	320 779.0
7	272.9	4 985 559.3	320 781.2
14	273.8	4 985 560.0	320 761.5
15	273.7	4 985 566.2	320 763.5
16	273.9	4 985 574.2	320 766.1
17	272.6	4 985 503.2	320 815.0

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 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 31E-106

HWY No 11			DIST 11
SUBM'D KA	CHECKED	DATE 1991 10 10	SITE 42-191
DRAWN SO	CHECKED	APPROVED	DWG 618602-A

REF NO E-559-11-1

memorandum

Ontario

To: *Mr. Per Furst, Head,*
Structural Section,
2nd Floor,
NORTHERN REGION.

Date: *May 4 1993*

(705) 497-5463

ATTENTION: *C. Verhulst*

FROM: Engineering and Right-of-Way Office,
Planning and Design Section,
NORTHERN REGION.

RE: ***W.P. 61-86-00, Muskoka Road 37 Interchange,***
Highway 11, 1.9 km North of Highway 118, Site 42-191,
District 11, Huntsville.

'Structure Cross-Section'

To clarify any misunderstanding in my memo of 93-05-03, the lane clearance on the through lane opposite the ramp tapers on the south side should be 2.5m.

The lane clearance on the ramp tapers should be 1.0m and 2.0m for the through lane on the north side.

J.E.D. Chretien,
Senior Project Manager.

JEDC/ll

cc *B. Farago*
M. Devata
D. Armatage
L. Authier
S. Wilson
T. Rogers

RECEIVED
MAY - 6 199?
FOUNDATION DESIGN SECTION

D.D

7540-1478 (Rev 10/89)

MEMORANDUM

(416) 235-3731

To: P. Furst, P. Eng. 1991 09 12
Head, Structural Section
Northern Region
North Bay, Ontario P1B 8L2

Attn: C. Verhulst
Structural Officer

From: Foundation Design Section
Room 315, Central Building, Downsview, Ontario
Central Region, MTO

Re: Foundation Recommendations
Highway 11 and Muskoka Road No. 37 Underpass
W.P. 61-86-02, Site: 42-191
District 11, Huntsville

The field investigation for the above-mentioned project has been completed. The fieldwork was carried out for the proposed bridge structure and approach embankments.

This memorandum outlines the preliminary foundation recommendations that should provide sufficient information for you to carry out your structural design. Although we do not anticipate any changes, the recommendations may be slightly modified in the final report due to further analyses. The final report will be provided as soon as the soil test results are available and the drawing is prepared.

Introduction

This report summarizes the results of a field investigation which was carried out for the construction of Hwy 11 and Muskoka Road No. 37 Underpass.

The investigation was carried out at the request of Northern Region Structural Section. These recommendations apply to proposed bridge structure and its approaches between Station 9+920 and 10+040, Muskoka Road 37 chainage (Re.: Plan E-559-11-1, dated October, 1990).

Site Description

Physiographically the site is located in the Algonquin Highlands region. In general this region is underlain by granite and other hard Precambrian rocks. Overall it is broadly dome shaped. There are frequent outcrops of bare rocks. The soils are generally shallow but thickness over the bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. Several areas have deeper till and few rock outcrops and the surface of the till is smoothed and moulded with occasional drumlins appearing (Reference: Chapman and Putnam, 'The physiography of Southern Ontario; 3rd Edition, 1984).

The site for the proposed Highway 11 and Muskoka Rd 37 interchange (Underpass) is located about 200m north of existing intersection of Muskoka Rd 37 and Highway 11. The proposed interchange will replace the existing at-grade crossing of Hwy 11 and Muskoka Rd. 37.
At the proposed underpass, Highway 11 runs north-south. The land adjacent to Hwy 11 at the proposed site location is undeveloped. On the east side the ground is covered with grass and at about 45m east of Highway 11 the area is covered with woods. On the west side, adjacent to Highway 11 there are rock outcrops which are up to 8m high.

The exposed bedrock on the west side of Hwy 11 is covered with grass and shrubs. In some areas the rock surface adjacent to Highway 11 is rough and angular. Perhaps this was the result of excavation during Hwy 11 construction. The rock surface elsewhere, including at locations of proposed west abutment is smooth. The bedrock outcrop is sound with some surficial loose pieces of rock. The exposed bedrock surface dip towards east at 4H:1V (about 14 degrees). Adjacent to Hwy 11 the bedrock contains few close spaced fractures which dip towards the east at about 20 degrees).

Investigation Procedure

The field investigation for this project was conducted between 91 07 10 and 91 07 17. The field work consisted of drilling five boreholes (BH 1,2,6,15 and 17) and six dynamic cone tests (CT 3,4,5,7,14 and 16) at or near proposed footing locations. The boreholes were advanced using track-mounted auger machines equipped with 82mm ID hollow stem augers and BX size coring equipment.

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). In general samples were retrieved at 0.75m intervals for the first 6m of boring, then every 1.5m. Once practical refusal to auguring was encountered in Boreholes 2,6 and 15, bedrock cores were obtained from these boreholes.

Groundwater was monitored during drilling and after completion of the boreholes.

The Laboratory testing program for the representative samples consisted of Grain Size Analyses. The results of the laboratory tests will be plotted on the Record of Borehole sheets and figures which will be provided in the final report.

Bedrock cores were logged by D.A. Williams, Petrographer in the Soils and Aggregates Section of MTO.

The boreholes were staked out by the Northern Region Surveys and Plans Section of the MTO. Ground surface elevations were also provided by the Surveys and Plans Section.

Subsurface Conditions

The overburden consists of a non cohesive silty sand to sandy silt material at the entire site. This non-cohesive material was encountered in all boreholes and was the only deposit overlying the bedrock. The thickness of this stratum increased gradually from west to east. On the west side the thickness of this deposit was about 1.5m (BH 15) and on the east side at a distance of about 70m from Borehole 15 the thickness of this stratum was more than 10m (BH 1). The 'N' values within this material ranged from 13 blows to more than 140 blows/0.3m which suggest that the material is in compact to very dense state. 'N' values generally increased with increasing depth. Average 'N' value was in the order of 25 blows/0.3m at the pier location (BH 6) and 38 blows/0.3m at the east abutment location. This suggests that on average the silty sand to sandy silt material is compact at the pier location and dense at the east abutment location.

The silty sand to sandy silt material was overlying bedrock. Bedrock was encountered at depth ranging from 1.6m (BH 15) to 10.4m (BH 2) which corresponds to elevation varying from 262.2m (BH 2) to 272.1m (BH 15). The bedrock surface dips towards east at approximately 8 degrees. The bedrock was classified as Gneiss Bedrock with interlayered Amphibolite, Granite and Pegmatite. Eight bedrock cores were obtained from three locations. The result of the core analyses were as follows:

	Range (%)	Average (%)
Recovery	75-100	95
RQD	48-100	80

Based on these results, the bedrock is considered to be competent for the proposed foundations.

Groundwater Condition

Groundwater was encountered at depth ranging from 0.9m (BH 1) to 1.5m (BH 15). The groundwater elevation ranged from 271.2m (BH 2) to 272.6m (BH 6). It should be noted that the groundwater is subject to seasonal fluctuation.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct a two-span bridge at the proposed interchange. The centreline of the proposed structure will be located at HOC 11+113.057 Highway 11 centreline. It is understood that consideration will be given to a concrete cast in place type of structure. At present there are three schemes under review. In each scheme locations and orientations of the abutments will be different. Proposed locations of abutments may be shifted east or west by a few metres. In any case, the pier will be located at centreline of Highway 11 (in the median). Suggested spans are 36m to 38m on the east and 36m to 40m on the west side. Abutments may be square or skewed at 20 degrees. The bridge structure will be 11m wide on the west side and 23.2m wide on the east side. The proposed structure will carry two lanes of through traffic 3.5m wide and a variable width speed change lane ramp. On the south side lane clearance will be 2m wide and on the north side 1m wide. Minimum design clearance requirement from soffit to roadway is 5.3m.

At present Highway 11 is 4 lanes. The width of Highway 11 will remain unchanged. The existing grade of Hwy 11 is about 274m. The existing grade of Hwy 11 may be raised by 100mm (10cm).

The east abutment will be perched within the approach embankment. The west abutment will be a closed type and will be founded on exposed bedrock.

Structure Foundations

East Abutment

The east abutment footing may be perched within the approaches and founded on compacted Granular 'A' material (Granular Pad). The granular pad should have a minimum thickness of 3.0m and should be constructed as follows:

The soil above elevation 271.5m should be removed. If any organic pockets are identified below elevation 271.5m they should be removed as well. The granular material should be placed in small lifts and compacted according to MTO Standard. The granular pad will extend 1m beyond the plan limits of the abutment footing at the footing level and will slope at 1H:1V. If desired the remainder of the approach fill could consist of rock fill.

The recommended bearing capacities for the footings on a granular pad, as per the OHBDC are as follow:

Factored Bearing Capacity at U.L.S. = 900 kPa
Bearing Capacity at S.L.S. Type II = 350 kPa

A friction angle of 35 degrees may be assumed to determine sliding resistance between the footing and compacted Granular 'A' pad.

A minimum earth cover of 1.8m is required for frost protection.

It is expected that a settlement up to 25mm will take place at the east abutment. Since the pier will be constructed on sound bedrock, there may be differential settlement between the east abutment and the pier. If this movement cannot be tolerated by the structural design, contact the Foundation Design Section for recommendations.

Consideration may be given to preload the proposed Granular 'A' pad at the east abutment. If schedule permits the proposed granular pad should be preloaded with at least 2m thick granular material for a minimum period of one month. This will reduce post construction settlement.

Pier

The pier can be founded on spread footing constructed on sound bedrock. In order to construct the footing on bedrock the soil above the bedrock should be removed. Please refer to Dewatering Section for details regarding recommendations for constructing below the prevailing groundwater elevation.

The recommended bearing capacities for the spread footings, on sound bedrock as per the OHBDC, are as follows:

Factored Bearing Capacity @ U.L.S. = 10,000 kPa
Bearing Capacity at S.L.S. Type II will not govern

West Abutment

The west abutment, can be founded on spread footings constructed on sound bedrock. This implies that all loose or shattered rock under the plan limits of the footings should be removed and replaced with concrete. Depending on the selection of three schemes, the footing elevation will depend on the abutment locations. At this time the exact location of west abutment is not known. It is expected that the west abutment footing would be constructed below elevation 278m.

If the footing is to be constructed at elevations above sound bedrock elevations, then all loose rock should be removed above the sound bedrock and mass concrete may be used to bring the base of the footing to the desired elevation. Depending on the west abutment location if the abutment is founded by cutting bedrock, then the abutment may be constructed against the bedrock without backfill.

The recommended bearing capacities for the spread footings, on sound bedrock, as per the OHBDC are as follows:

Factored Bearing Capacity @ U.L.S. = 10,000 kPa
Bearing Capacity at S.L.S. Type II will not govern

Roadway Protection

For roadway protection, the following parameters should be used for the shoring design:

ϕ = 30 Degrees
Cu = 0 kPa
γ = 20.5 kN/m^3

WL elevation 272.6m

Embankment Stability

It is understood that rock fill will be used in approach fills. It is expected that rock fill will be up to 9.5m high. For side slopes of rock fill 1.25H:1V a nominal berm (1 to 2m wide) should be provided so that no uninterrupted slope is more than 6m high. No berm will be needed for embankment up to 10m high if a side slope of 1.5H:1V is considered. There is no concern of any deep seated stability.

Foundation Stability at the West Abutment

In order to ensure stability of the rock face at the west abutment of the proposed structure, footings should be located far enough from the face of rock cuts to be outside a plane defined as 0.5H:1V from the toe of the cut slope or a minimum of 1m from the crest of the rock cut (whichever is greater).

Lateral Earth Pressure

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

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

Granular 'A'	γ = 22.8 kN/m^3	ϕ = 35°
Granular 'B'	γ = 21.2 kN/m^3	ϕ = 30°
Rock Fill	γ = 18.0 kN/m^3	ϕ = 35°

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the OHBDC. At-rest condition (K_o) may be assumed to apply at the west abutment and active condition (K_a) will apply at the east abutment unless it is structurally constructed to impose the at-rest condition.

Resistance to Lateral Forces

Sliding resistance should be calculated in accordance with Section 6-7.3.3.2 of the OHBDC. For concrete footings on granular pads sliding resistance should be calculated assuming unfactored angle of friction ϕ = 35°. An unfactored angle of friction ϕ = 30° should be used to calculate sliding resistance between concrete footing and bedrock or between concrete surfaces.

If the bedrock surface is roughened with chiselled groves then an unfactored angle of friction ϕ = 35° can be assumed to calculate sliding resistance between concrete footings and bedrock.

If necessary, sliding resistance can be supplemented by dowelling into bedrock or between concrete surfaces.

For design purposes, the following OHBDC capacities may be assumed for the bond between bedrock and grout.

Factored Bearing Capacity @ U.L.S. = 500 kPa
Bearing Capacity at S.L.S. Type II will not govern

The minimum dowel embedment should be 1m. Neither the structural strength of the dowel, nor the compressive strength of the grout should be exceeded. Also, the annular space around the dowel (to be grouted) should be in the order of 2 cm wide (between the dowel and the bedrock).

The capacity of dowels between concrete surfaces will be dependent on the strength of the concrete and the dowel.

Settlement Consideration

Total and differential settlement of the spread footing at the east abutment and embankment fill is expected to be less than 25mm. Most of this will take place immediately after the completion of the construction. No settlement is anticipated at the west abutment and at the pier location where the footing would be constructed on sound bedrock.

Frost Protection

At the east abutment a 1.8m frost cover is required. Frost protection is not required for footings on unweathered bedrock, such as at pier and west abutment locations. Frost protection requirements at the east abutment could be reduced if it could be ensured that groundwater will always be below footing level.

Dewatering

The proposed foundation at the pier location will be below the groundwater table. It will be either required to lower the groundwater below the excavation or other measures would have to be taken to construct the footing either in dry or without creating unbalanced hydrostatic pressure. It will be necessary to put a special provision in the contract that footing at the pier location is to be constructed without disturbing adjacent ground. Although construction procedures are the responsibility of the contractor the situation could be addressed by the following procedure.

Assuming that lanes at Highway 11 will be open during construction and considering roadway protection will be required to maintain traffic, a suitable scheme will be to drive sheet piles to the bedrock and utilize sheet piling for dewatering as well as shoring. Once the overburden material is removed above the bedrock, the concrete will be poured using a tremie seal to control inflow if necessary.

In any case, the contractor should submit his proposal for review a minimum of 10 working days prior to the construction.

Excavation

Rock excavation will be required for the construction of west abutment. Cut rock slopes will be stable with near vertical faces provided that blasting is carefully controlled. If advice on controlled blasting techniques are required, please contact this office.

Miscellaneous

The field work for this project was carried out under the supervision of C. Davidson, a student specialist.

The equipment used was owned and operated by Master Soil Investigation Ltd.

If there are any questions, or any explanations are required regarding this memo, please contact this office.

K. Ahmad, P. Eng.
Foundation Engineer

For

D. Dundas, P. Eng.
Senior Foundation Engineer