

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-12



Ontario

Ministry of
Transportation



INDEX

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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 (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING		MECHANICAL PROPERTIES OF SOIL				
S S	SPLIT SPOON	T P	THINWALL PISTON	m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
WS	WASH SAMPLE	O S	OSTERBERG SAMPLE	C_c	1	COMPRESSION INDEX
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE	C_s	1	SWELLING INDEX
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY	C_α	1	RATE OF SECONDARY CONSOLIDATION
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY	c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
T W	THINWALL OPEN	F S	FOIL SAMPLE	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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT
For
Regional Road #36 Proposed Crossing
Hwy. #401, City of Cambridge
W.P. 7-83-09, Site 33-151
District #3, Stratford

INTRODUCTION

This report contains the results of a site investigation carried out at the above mentioned site.

The field work for this project was carried out between 89 10 02 and 89 10 26, and comprised of ten sampled boreholes accompanied with Dynamic Cone Penetration Tests and coring of rock.

The boreholes were advanced to a maximum depth of 39.2 m below the existing ground level (El. 286.6) using continuous flight hollow stem auger and BX size diamond bit.

SITE DESCRIPTION

The proposed site is located at the crossing of Hwy. 401 and Regional Road #36 in the City of Cambridge.

The topography of the site with the exception of the existing interchange (fills) is relatively flat and landscaped terrain. Physiographically the area is located in the region known as the "Guelph Drumlin Field" and consist of granular type materials.

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site consists of granular (Granular 'A' or Granular 'B') fill underlain by natural soil predominantly composed of sand and silt, with virtually no gravel content. Despite the geological history of this area, glacial till was not encountered, except near terminal depth

in boreholes 8, 9 & 10. The natural soil is underlain by dolostone bedrock of the Guelph formation. For classification purposes, the soils encountered at this site can be divided into two different zones:

- a) Sand some silt and Gravel (Granular Fill)
- b) Layered Sand and Silt

The soils encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Boreholes sheets contained in the Appendix of this report. Three stratigraphical profiles are shown on Drawing No. 78309-A.* This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

Granular Fill

This fill which was placed to raise the finished grade of Hwy. 401 and the Regional Road #36 was encountered in all the boreholes, immediately below the existing ground level. The gradation tests carried out on representative samples are shown on Figure #1 in an envelope form. The gradation analyses indicate that this fill is predominantly composed of sand with varying proportions of silt and gravel sized particles. The natural moisture content of this fill varies from 3% to 16% with an average value of 9%. The Standard Penetration Test results indicate that this granular fill is in very loose to compact state of compaction (N-values 2 to 31 blows/30 cm). The thickness of this fill varies from 2.7 m to 8.5 m and extends to elevation 317.0±. In majority of the boreholes, a 0.3 m to 0.9 m thick organic silty layer was observed to separate the fill and the natural soil.

Layered Sand and Silt

The organic silty layer is underlain by this deposit. The gradation tests carried out on representative soil samples are shown on Figure #2 in an envelope form. The gradation analyses indicate that this deposit is

* DWG NO 2 OF THE CONTRACT DWG'S

predominantly composed of sand and silt, with virtually no gravel content. The natural moisture content of this deposit varies over a wide range (3% to 32%) depending on the sand and silt contents. The Standard Penetration Test results indicate that this stratum is in compact to very dense state of compaction (N-values 11 blows/30 cm to 84 blows/30 cm). In boreholes 2, 6 & 8, occasional boulders and cobbles were encountered near terminal depth (El. 292.0± to 299.0±).

Bedrock

Boreholes 8, 9 & 10 were taken into the bedrock and rock cores were obtained using BX-size diamond bits. The rock cores were examined by Mr. S.A. Senior, Geological Engineer and his description is included in the Appendix of this report.

The project area is underlain by dolostone bedrock of the Guelph Formation. The presence of boulders and cobbles immediately above the bedrock made the identification of weathered rock very difficult. However, in borehole 8, the thickness of weathered rock was observed to be about 1.83 m. The elevation of the unweathered rock is as follows:

<u>Borehole No.</u>	<u>Elevation</u>
8	289.8
9	289.1
10	290.7

The RQD values measured from BX size cores (0% to 7%) indicate that the bedrock up to the depth of drilling may be classified as very poor quality rock. However, in borehole 8, the rock quality was observed to improve (RQD = 68%) near terminal depth (El. 288.1).

Ground Water Conditions

The ground water level was encountered in all the boreholes with the exception of borehole 7, and was observed between 12.5 m and 19.6 m (El.

306.0± to 307.0±) below the existing ground level. The ground water elevation at each borehole location is as follows:

<u>Borehole No.</u>	<u>Elevation Metre</u>
1	307.2
2	307.0
3	305.6
4	306.0
5	306.3
6	306.5
8	307.2
9	305.9
10	306.3

The groundwater elevations indicated above are based on the observations made during drilling operations and the stabilized water level could not be established in a short period of time. In our opinion, the water table may be expected to rise above the elevations indicated.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. M. Hopper. The equipment used was owned and operated by Marathon Drilling Company Limited. This report was prepared by Mr. M. Vasavithasan and reviewed by Mr. P. Payer, Senior Foundation Engineer.

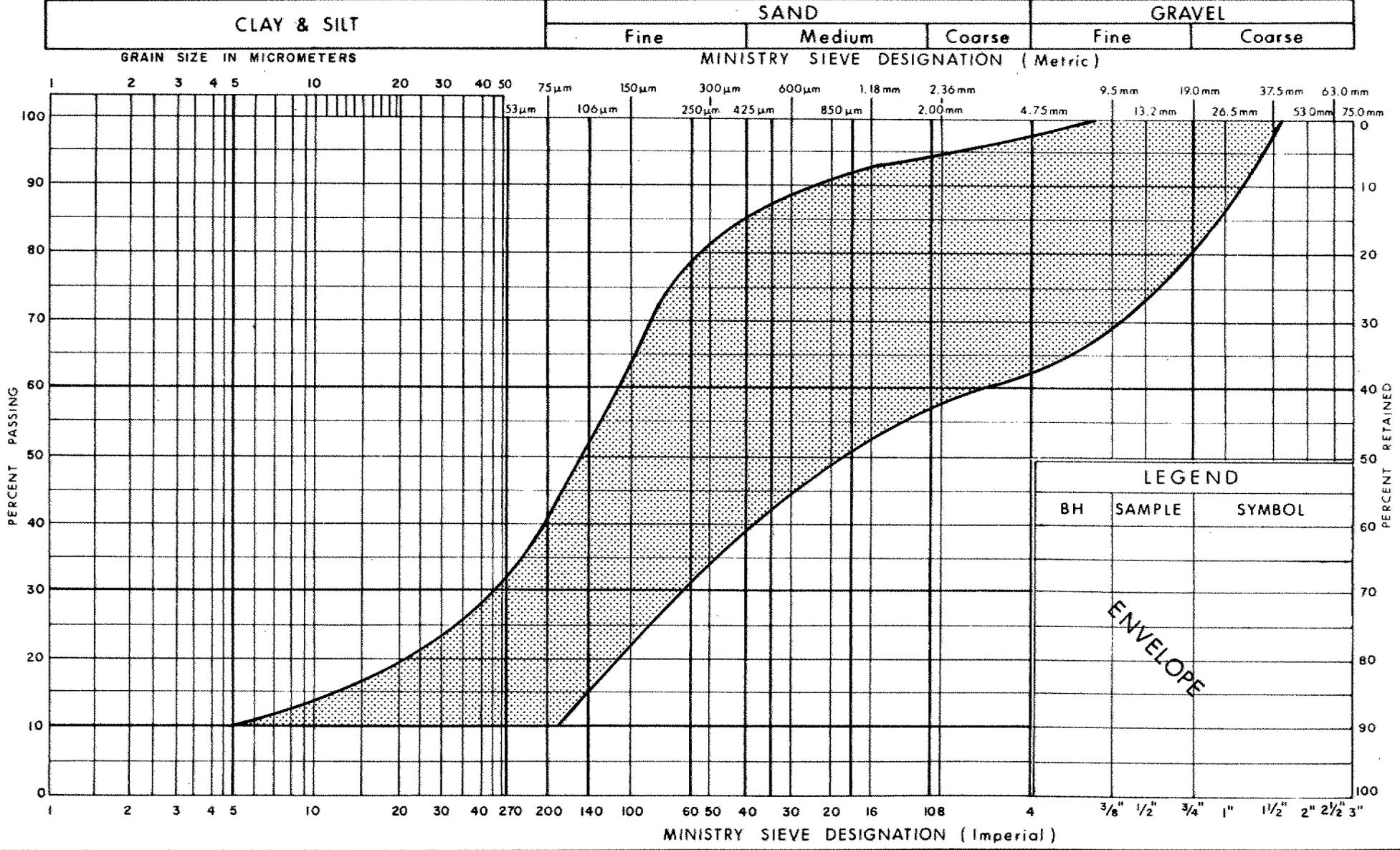


M. Vasavithasan
 M. Vasavithasan, P. Eng.
 Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL

ENVELOPE



GRAIN SIZE DISTRIBUTION
SAND & GRAVEL SOME SILT (FILL)

FIG No 1
W P 7-83-09

ROCK CORE DESCRIPTION
WP 7-83-09

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	39	35.48-35.53	100	0	35.48-39.22	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; slightly weathered to unweathered; close to extremely close spaced fractures.
	41	35.53-35.79	95	0		
	42	35.70-36.27	50	0		
	43	36.27-36.53	100	0		
	44	36.53-36.70	86	0		
	45	36.70-37.74	95	0		
	46	37.74-39.22	100	68		
9	32	34.90-35.20	-	-	34.90-36.58	OVERBURDEN , boulders, cobbles
	33	35.20-36.25	-	-		
	34	36.25-37.16	42	0	36.58-37.16	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; moderately to slightly weathered; very close spaced fractures.
10	19	27.61-29.13	40	-	27.61-29.26	OVERBURDEN , boulders, cobbles
	20	29.13-30.66	93	7	29.26-30.66	DOLOSTONE , light grey; medium grained, vuggy; medium strong rock; slightly weathered to unweathered; very close spaced fractures.

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated in zones of poor core recovery)

Logged by: SAS, Soils and Aggregates Section.

RECORD OF BOREHOLE No 1

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 433.9, E 239 242.2 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 02 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	Wp	W	Wl			10 20 30
319.7	Ground Level													
0.0	Silty Sand to Sandy Silt Very Loose to Compact (Fill)	[Strat Plot]	1	SS	24								8 56 (36)	
			2	SS	13									
			3	SS	5									
			4	SS	4									
			5	SS	8									
317.1			6	SS	2									
2.6	Sandy Silt to Silty Sand Compact to Very Dense	[Strat Plot]	7	SS	12								0 29 (71)	
			8	SS	18									
			9	SS	28									
			10	SS	28									
			11	SS	22									
			12	SS	26									
			13	SS	21									
			14	SS	24									
			15	SS	22									
			16	SS	22									
			17	SS	45									
			18	SS	53									
			19	SS	18									
			20	SS	29									
			21	SS	17									
301.1	22	SS	32											
18.6	End of Borehole												0 16 (84)	

+3, x5: Numbers refer to Sensitivity
 20
 15 - 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 427.5, E 239 234.8 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.); BW Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 02 to 89 10 03 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40						60
319.6	Ground Level														
0.0	Silty Sand to Sandy Silt, Trace of Gravel, Very Loose to Compact	X	1	SS	3									8 65 24 3	
			2	SS	7										
			3	SS	15										1 48 (51)
			4	SS	6										
			5	SS	3										
			6	SS	2										
316.4			(Fill)		7	SS	8								
3.2	Sandy Silt to Silty Sand, Compact to Dense	.	8	SS	15										
			9	SS	20										
			10	SS	26										
			11	SS	31										
			12	SS	31										
			13	SS	30										
			14	SS	23										
			15	SS	24										
			16	SS	30										
			17	SS	58										0 8 (92)
			18	SS	27										
			19	SS	39										
			20	SS	16										
			21	SS	50										
	Occasional Boulders		22	RC											
			23	SS	58										
295.1			24	SS	62								0 91 (9)		
24.5	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity
 20
 15 → 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 426.4, E 239 209.1 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Generic DATE 89 10 03 to 89 10 04 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W _p	W	W _L		
319.3	Ground Level												
0.0	Topsoil	⊗	1	SS	7								
	Sand, Some Silt, Trace of Gravel, Loose to Compact	⊗	2	SS	5								
		⊗	3	SS	10								17 63 15 5
		⊗	4	SS	12								
316.6	(Fill)	⊗	5	SS	19								
2.7	Organic Silt. Loose	⊗	6	SS	17								
		⊗	7	SS	6								
		⊗	8	SS	8								3 47 (50)
		⊗	9	SS	31								
		⊗	10	SS	29								
		⊗	11	SS	22								0 23 (77)
		⊗	12	SS	29								
		⊗	14	SS	34								
		⊗	15	SS	31								
		⊗	16	SS	35								
		⊗	17	SS	29								
		⊗	18	SS	30								
		⊗	19	SS	26								
		⊗	20	SS	36								
		⊗	21	SS	45								
		⊗	22	SS	84								0 8 (92)
		⊗	23	SS	29								
		⊗	24	SS	17								
		⊗	25	SS	24								3 3 (94)
302.2	End of Borehole												
17.1	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 4

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 426.0, E 239 218.8 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 04 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L			10 20 30
320.0	Ground Level													
0.0	Sand, Some Silt and Gravel, Loose to Compact (Fill)	[Strat Plot]	1	SS	6									
			2	SS	16									
			3	SS	11									
			4	SS	11									
317.2			5	SS	26									
			6	SS	67									
2.7	Organic Silt, Some		7	SS	5									
316.3	Sand, v. Loose to Loose		8	SS	2									
3.6	Silty Sand to Sandy Silt, Compact to Dense	[Strat Plot]	9	SS	3									
			10	SS	29									
			11	SS	29									
			12	SS	24									
			13	SS	30									
			14	SS	21									
			15	SS	32									
			16	SS	40									
			17	SS	51									
			18	SS	23									
			19	SS	17									
			Occasional Cobbles	[Strat Plot]										
298.4			RC	REC										
			21	SS	17									
			22	SS	44									
21.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE

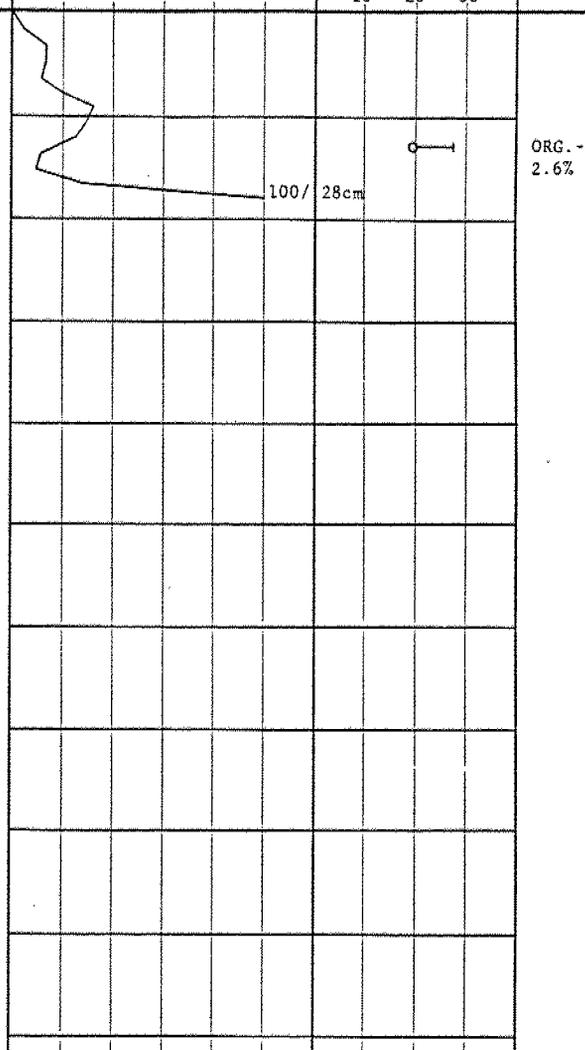
RECORD OF BOREHOLE No 5

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 388.2, E 239 244.8 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 05 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40
320.0	Ground Level													
0.0	Topsoil		1	SS	4									
0.5	Sand, Some Silt and Gravel, Very Loose to Compact (Fill)	[X]	2	SS	9									
			3	SS	7									
			4	SS	14									
			5	SS	21									
317.3			6	SS	13									
			7	SS	1									
2.7	Clayey Silt, Very Soft	[X]	8	SS	13									
	Sand, Some Silt and Gravel Compact to Dense	[X]	9	SS	55									
315.6			10	SS	19									
4.4	Silty Sand to Sandy Silt, Compact to Dense	[X]	11	SS	21									
			12	SS	33									
			13	SS	36									
			14	SS	27									
			15	SS	25									
			16	SS	23									
			17	SS	29									
			18	SS	32									
			19	SS	36									
			20	SS	49									
			21	SS	41									
			22	SS	42									
			23	SS	11									
			24	SS	41									
298.4	End of Borehole		25	SS	55									

OFFICE REPORT ON SOIL EXPLORATION



³, x⁵: Numbers refer to Sensitivity 20 15 ± 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.4, E 239 242.9 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 05 to 89 10 06 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60						80
320.0	Ground Level															
0.0	Sand, Some Silt and Gravel, Very Loose to Compact (Fill)	[Strat Plot]	1	SS	16											
			2	SS	12											
			3	SS	7											
			4	SS	4											
			5	SS	20											
			6	SS	31											
317.3	Silty Sand, Trace of Organic, Compact	[Strat Plot]	7	SS	11										21 48 26 5	
2.7			8	SS	10											
316.4	Silty Sand to Sandy Silt, Compact to Dense	[Strat Plot]	9	SS	27											
3.6			10	SS	34											
			11	SS	63											
			12	SS	33											
			13	SS	14											
			14	SS	27											
			15	SS	24											
			16	SS	25											
			17	SS	39											
			18	SS	43											
			19	SS	20											
			20	SS	18											
			21	SS	14											
			22	SS	71											
	23	SS	50													
	24	RC														
	25	RC														
291.7	Occasional Boulders	[Strat Plot]	26	SS	68									0 47 53		
28.3	End of Borehole													0 2 (98)		

OFFICE REPORT ON SOIL EXPLORATION

*3, x⁵: Numbers refer to Sensitivity
 20 15 5 (% STRAIN AT FAILURE)

RECORD OF BOREHOLE No 7

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 454.4, E 239 216.1 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 10 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60						80
325.6	Shoulder Level		1	SS	75											
0.0	Asphalt		2	SS	23											
	Sand With Silt, Some Gravel, Compact to Dense (Fill)	[Strat Plot]	3	SS	16											
			4	SS	15											
			5	SS	28											
			6	SS	27											
			7	SS	27											
			8	SS	20											
			9	SS	21											
			10	SS	12											
			11	SS	5											
			12	SS	14											
			13	SS	30											
			14	SS	37											
			15	SS	43											
			16	SS	32											
			17	SS	21											
			18	SS	38											
316.9					19	SS	26									
8.7			End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 8

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 448.6, E 239 227.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 11 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT. PLT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			N ^o VALUES	20						40
325.8	Ground Level													
0.0	Sand Some Silt and Gravel, Loose to Compact (Fill)		1	SS	10									
			2	SS	16									
			3	SS	16									
			4	SS	5									31 59 (10)
			5	SS	20									
			6	SS	18									
			7	SS	15									
			8	SS	12									
			9	SS	11									
			10	SS	19									
320.9		Sand, Some Organic Silt & Gravel, Compact		11	SS	14								
4.9			12	SS	16									11 49 (40)
			13	SS	19									2 84 (14)
			14	SS	35									
			15	SS	31									
			16	SS	15									
			17	SS										
			18	SS	12									5 55 34 (6)
			19	SS	18									
			20	SS	22									0 68 (32)
			21	SS	30									
		22	SS	29									0 28 (72)	
		23	SS	31										
		24	SS	27										
		25	SS	37										
		26	SS	38										
		27	SS	43										
		28	SS	59									0 11 (89)	
		29	SS	27										
		30	SS	16									0 1 (99)	
		RC	REC											
	Occasional Boulders		31	BX	90%									
			32	SS	54									
295.6														
30.2														

Continued

+³, x⁵: Numbers refer to 20 15 ± 5 (%) STRAIN AT FAILURE Sensitivity

Continued

RECORD OF BOREHOLE No 8

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 448.6, E 239 227.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 11 to 89 10 12 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60					
295.6	Continued														
30.2	Silty Sand to Sandy Silt, Dense to Very Dense		33	SS	103	28cm									
	Occasional Boulders		34	RC BXL	40%										
			35	SS	7L										
291.7															
34.1	Weathered Unweathered Dolostone Bedrock		36	RC BXL	25										
			*												
			45	RC BXL	99%										
			46	RC BX	97%										
286.6															
39.2	End of Borehole														
	* Note Sample														
			No.	Type	Rec.	RQD									
			37	RC	40%	0									
			38	RC	80%	0									
			39	RC	100%	0									
			41	RC	95%	0									
			42	RC	50%	0									
			43	RC	100%	0									
			44	RC	86%	0									

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity 20
 15-5 (% STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 9

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 366.4, E 239 245.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), Casing NX COMPILED BY PM
 DATUM Geodetic DATE 89 10 17 to 89 10 23 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80						100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE
295.5	Continued Occasional Boulders		30	SS	32													
30.2																		
					31	SS	64											
					32	RC	50%											
					33	RC	12%											
289.1					34	RC BX	REC 43%											
288.5	Dolostone Bedrock															RQD = 0		
37.2	End of Borehole																	

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.8, E 239 219.4 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 24 to 89 10 25 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80						100
320.0	Ground Level															
0.0	Silty Sand to Sandy Silt, Compact to Dense	1	SS	15												
		2	SS	45												
		3	SS	15												
		4	SS	26												
		5	SS	4												7 50 37 6
		6	SS	12												0 12 (88)
		7	SS	19												
		8	SS	32												
		9	SS	21												
		10	SS	14												
		11	SS	26												
		12	SS	34												
		13	SS	17												
		14	SS	21												
		15	SS	45												
		16	SS	14												
		17	SS	28												
	18	SS	86/													
	19	RC BX	REC 42%													
290.7	Occasional Boulders															
29.3	Dolostone Bedrock	20	RC BX	REC 96%												
289.3																
30.7	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

+ 3, x 5; Numbers refer to Sensitivity 15-5 (%) STRAIN AT FAILURE

RQD = 7%



Ministry of
Transportation and
Communications

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

FOUNDATION INVESTIGATION REPORT
For
Regional Road #36 Proposed Crossing
Hwy. #401, City of Cambridge
W.P. 7-83-09, Site 33-151
District #3, Stratford

INTRODUCTION

This report contains the results of a site investigation carried out at the above mentioned site to provide information for the design and construction of the bridge, retaining wall and approaches.

The field work for this project was carried out between 89 10 02 and 89 10 26, and comprised of ten sampled boreholes accompanied with Dynamic Cone Penetration Tests and coring of rock.

The boreholes were advanced to a maximum depth of 39.2 m below the existing ground level (El. 286.6) using continuous flight hollow stem auger and BX size diamond bit.

SITE DESCRIPTION

The proposed site is located at the crossing of Hwy. 401 and Regional Road #36 in the City of Cambridge.

The topography of the site with the exception of the existing interchange (fills) is relatively flat and landscaped terrain. Physiographically the area is located in the region known as the "Guelph Drumlin Field" and consist of granular type materials.

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site consists of granular (Granular 'A' or Granular 'B') fill underlain by natural soil predominantly composed of sand and silt, with virtually no gravel content. Despite the geological history of this area, glacial till was not encountered, except near terminal depth

in boreholes 8, 9 & 10. The natural soil is underlain by dolostone bedrock of the Guelph formation. For classification purposes, the soils encountered at this site can be divided into two different zones:

- a) Sand some silt and Gravel (Granular Fill)
- b) Layered Sand and Silt

The soils encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Boreholes sheets contained in the Appendix of this report. Three stratigraphical profiles are shown on Drawing No. 78309-A. This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

Granular Fill

This fill which was placed to raise the finished grade of Hwy. 401 and the Regional Road #36 was encountered in all the boreholes, immediately below the existing ground level. The gradation tests carried out on representative samples are shown on Figure #1 in an envelope form. The gradation analyses indicate that this fill is predominantly composed of sand with varying proportions of silt and gravel sized particles. The natural moisture content of this fill varies from 3% to 16% with an average value of 9%. The Standard Penetration Test results indicate that this granular fill is in very loose to compact state of compaction (N-values 2 to 31 blows/30 cm). The thickness of this fill varies from 2.7 m to 8.5 m and extends to elevation 317.0±. In majority of the boreholes, a 0.3 m to 0.9 m thick organic silty layer was observed to separate the fill and the natural soil.

Layered Sand and Silt

The organic silty layer is underlain by this deposit. The gradation tests carried out on representative soil samples are shown on Figure #2 in an envelope form. The gradation analyses indicate that this deposit is

predominantly composed of sand and silt, with virtually no gravel content. The natural moisture content of this deposit varies over a wide range (3% to 32%) depending on the sand and silt contents. The Standard Penetration Test results indicate that this stratum is in compact to very dense state of compaction (N-values 11 blows/30 cm to 84 blows/30 cm). In boreholes 2, 6 & 8, occasional boulders and cobbles were encountered near terminal depth (El. 292.0± to 299.0±).

Bedrock

Boreholes 8, 9 & 10 were taken into the bedrock and rock cores were obtained using BX-size diamond bits. The rock cores were examined by Mr. S.A. Senior, Geological Engineer and his description is included in the Appendix of this report.

The project area is underlain by dolostone bedrock of the Guelph Formation. The presence of boulders and cobbles immediately above the bedrock made the identification of weathered rock very difficult. However, in borehole 8, the thickness of weathered rock was observed to be about 1.83 m. The elevation of the unweathered rock is as follows:

<u>Borehole No.</u>	<u>Elevation</u>
8	289.8
9	289.1
10	290.7

The RQD values measured from BX size cores (0% to 7%) indicate that the bedrock up to the depth of drilling may be classified as very poor quality rock. However, in borehole 8, the rock quality was observed to improve (RQD = 68%) near terminal depth (El. 288.1).

Ground Water Conditions

The ground water level was encountered in all the boreholes with the exception of borehole 7, and was observed between 12.5 m and 19.6 m (El.

306.0± to 307.0±) below the existing ground level. The ground water elevation at each borehole location is as follows:

<u>Borehole No.</u>	<u>Elevation Metre</u>
1	307.2
2	307.0
3	305.6
4	306.0
5	306.3
6	306.5
8	307.2
9	305.9
10	306.3

The groundwater elevations indicated above are based on the observations made during drilling operations and the stabilized water level could not be established in a short period of time. In our opinion, the water table may be expected to rise above the elevations indicated.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to widen the existing bridge along the Regional Road #36 at the Hwy. 401 crossing to provide exit from Hwy. 401 as well as entry facility to Hwy. 401. These facilities will require construction of a retaining wall in front of the north abutment, and piers and abutments for the bridge widening.

The piers and abutments of the existing bridge are supported on approximately 7.6 m long HP 310 x 79 driven piles founded at about elevation 309.0±.

Structure Foundation

Considering the type of soils encountered at this site, shallow foundation may not be feasible. In addition, if displacement type driven piles such as closed end pipe are used, the vibrations created by the pile driving may cause some disturbance to the existing foundation. However, low displacement piles such as steel H-piles may be used to support the piers and abutments. If steel H-piles are selected, it should be driven at least 3 times the flange width away from the existing piles. The following bearing capacity values are recommended for the steel H-piles.

	<u>Pile Tip Elevation</u>	
	<u>309 m</u>	<u>305 m</u>
Factored Capacity at U.L.S.	230 kns.	510 kns.
Capacity at S.L.S. Type II	200 kns.	300 kns.

Alternatively, the proposed structures may (piers and abutments) be supported on caissons founded at about elevation 309.0±. The following bearing capacity values are recommended for the design of the caissons.

<u>Centre Pier</u>	<u>Pile Diameter in Metre</u>	
	0.76	1.00
Factored Capacity at U.L.S.	1160 kN	2000 kN
Capacity at S.L.S. Type II	700 kN	1200 kN

<u>North and South Piers and Abutments</u>	<u>Pile Diameter in Metre</u>	
	0.76	1.00
Factored Capacity at U.L.S.	1520 kN	2640 kN
Capacity at S.L.S. Type II	900 kN	1550 kN

If caisson size in between 0.76 m and 1.0 m is selected, the bearing capacity values may be interpolated from the above recommendations.

If caissons are constructed below ground water level, loosening of the founding soil could be anticipated. The soil is highly susceptible to conditions of unbalanced hydrostatic head and seepage forces and is likely to 'boil' and become unstable under such conditions. The Contractor shall maintain the stability of the soil in the sides and bases of the holes for the caissons at all times from commencement of their construction to the placing of concrete.

Some differential settlement is expected to take place between the new and the existing structures. In view of this, it is advisable to provide either a 'slip' or 'isolation' joint between the existing and the new structures.

If caissons are selected to support the piers and abutments, the construction of pile-cap may be eliminated by taking the caissons to the underside of the bridge deck.

Retaining Wall

Considering the removal and backfilling of large volume of fill material and construction difficulties, tangent piles (drilled-in-place concrete piles) with anchors may be used instead of concrete retaining wall. We

understand that there are machineries available in the construction industry to construct large diameter drilled-in-place concrete piles under limited head-room facility. With this in view, the option of tangent pile wall with soil anchors is recommended.

The presence of granular fill and the silty sandy soil encountered at this site will require liner for the construction of tangent pile wall. Considering the limited space the liner will have to be lowered in short lengths.

The soil anchors may be constructed using hollow-stem auger or cased hole and grout injected under pressure while the hollow-stem auger or casing is withdrawn.

If the cement grout is injected under pressure, a maximum bond stress value of 75 kPa is recommended for the design of the soil anchors.

For aesthetic purposes, the wall may be covered with concrete pannels.

Alternatively, the retaining wall may be constructed using the following construction sequence.

- 1) Close Regional Road #36 for traffic during construction.
- 2) Remove embankment fill on both side of the north abutment simultaneously to elevation 317±, and on the south side of the south abutment to about elevation 324±.
- 3) After excavation, wire brush clean the exposed piling of all dirt and loose scale, inspect for damage and apply sufficient coat of coal tar paint to avoid transfer of any down-drag load during compaction of backfill.
- 4) Construct caissons using drilled-in-place concreting.

- 5) Construct pile cap and retaining wall.
- 6) Compact the backfill on both side of the abutment simultaneously.

Earth pressure should be computed as per 6.1.2.2 of the code. In the case of retaining wall and abutments, an unyielding foundation condition may be assumed for the earth pressure computations. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

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

Approach Embankment

A maximum fill height of about 7 m may be expected at this crossing. The subsoil conditions at this site is not expected to create any stability problems for the approach embankments constructed with 2 horizontal to 1 vertical slopes. The fill material should consist of well compacted acceptable material. The topsoil as well as any spongy or soft areas observed within the base width of the embankment, should be removed before placing the fill.

Other Considerations

The pile caps should have a minimum of 1.2 m earth cover for frost protection. Ground water problems are not anticipated within the proposed founding level of the caisson.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. M. Hopper. The equipment used was owned and operated by Marathon

Drilling Company Limited. This report was prepared by Mr. M. Vasavithasan and reviewed by Mr. P. Payer, Senior Foundation Engineer.



M. Vasavithasan

M. Vasavithasan, P.Eng.
Foundation Engineer

M. Devata

M. 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 (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

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

STRESS AND STRAIN

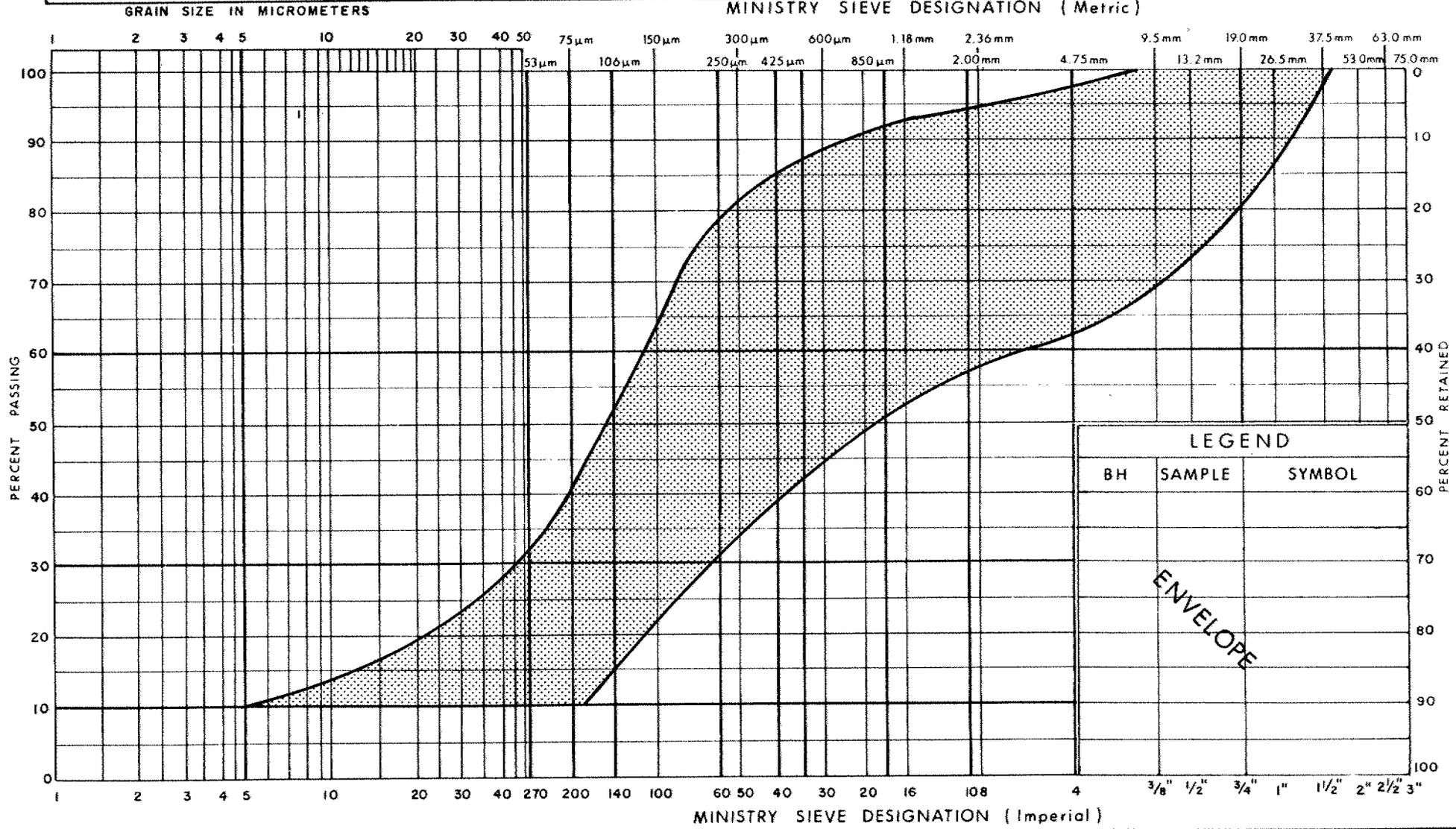
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

PHYSICAL PROPERTIES OF SOIL

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

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



**GRAIN SIZE DISTRIBUTION
SAND & GRAVEL SOME SILT (FILL)**

FIG No 1
W P 7-83-09

ROCK CORE DESCRIPTION
WP 7-83-09

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	39	35.48-35.53	100	0	35.48-39.22	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; slightly weathered to unweathered; close to extremely close spaced fractures.
	41	35.53-35.79	95	0		
	42	35.70-36.27	50	0		
	43	36.27-36.53	100	0		
	44	36.53-36.70	86	0		
	45	36.70-37.74	95	0		
	46	37.74-39.22	100	68		
9	32	34.90-35.20	-	-	34.90-36.58	OVERBURDEN , boulders, cobbles
	33	35.20-36.25	-	-		
	34	36.25-37.16	42	0	36.58-37.16	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; moderately to slightly weathered; very close spaced fractures.
10	19	27.61-29.13	40	-	27.61-29.26	OVERBURDEN , boulders, cobbles
	20	29.13-30.66	93	7	29.26-30.66	DOLOSTONE , light grey; medium grained, vuggy; medium strong rock; slightly weathered to unweathered; very close spaced fractures.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated in zones of poor core recovery)

Logged by: SAS, Soils and Aggregates Section.

RECORD OF BOREHOLE No 1

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 433.9, E 239 242.2 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 02 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60						80
319.7	Ground Level															
0.0	Silty Sand to Sandy Silt Very Loose to Compact (Fill)	[Strat Plot]	1	SS	24										8 56 (36)	
			2	SS	13											
			3	SS	5											
			4	SS	4											
317.1			5	SS	8											
			6	SS	2											
2.6	Sandy Silt to Silty Sand Compact to Very Dense	[Strat Plot]	7	SS	12										0 29 (71)	
			8	SS	18											
			9	SS	28											
			10	SS	28											
			11	SS	22											
			12	SS	26											
			13	SS	21											
			14	SS	24											
			15	SS	22											
			16	SS	22											
			17	SS	45											
			18	SS	53											0 31 (69)
			19	SS	18											
			20	SS	29											0 61 (39)
			21	SS	17											
301.1			22	SS	32											0 16 (84)
18.6	End of Borehole															

RECORD OF BOREHOLE No 2

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 427.5, E 239 234.8 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.): BW Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 02 to 89 10 03 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40						60	80
319.6	Ground Level															
0.0	Silty Sand to Sandy Silt, Trace of Gravel, Very Loose to Compact	X	1	SS	3									8 65 24 3		
			2	SS	7											
			3	SS	15											1 48 (51)
			4	SS	5											
			5	SS	3											
			6	SS	2											
316.4			(Fill)		7	SS	8									
3.2	Sandy Silt to Silty Sand, Compact to Dense	.	8	SS	15											
			9	SS	20											
			10	SS	26											
			11	SS	31											
			12	SS	31											
			13	SS	30											
			14	SS	23											
			15	SS	24											
			16	SS	30											
			17	SS	58											0 8 (92)
			18	SS	27											
			19	SS	39											
			20	SS	16											
	Occasional Boulders	B	22	RC												
			23	SS	58											
			24	SS	62											0 91 (9)
24.5	End of Borehole															

+3, x⁵: Numbers refer to 20
15 → 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 388.2, E 239 244.8 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 05 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80						100
320.0	Ground Level																
318.5	Topsoil		1	SS	4												
0.5	Sand, Some Silt and Gravel, Very Loose to Compact (Fill)		2	SS	9												
			3	SS	7												
			4	SS	14												
			5	SS	21												
317.3			6	SS	13												
			7	SS	1												
2.7	Clayey Silt, Very Soft		8	SS	13												
315.6	Sand, Some Silt and Gravel Compact to Dense		9	SS	55												
			10	SS	19												
4.4	Silty Sand to Sandy Silt, Compact to Dense		11	SS	21												
			12	SS	33												
			13	SS	36												
			14	SS	27												
			15	SS	25												
			16	SS	23												
			17	SS	20												
			18	SS	32												
			19	SS	36												
			20	SS	49												
			21	SS	41												
			22	SS	42												
			23	SS	11												
			24	SS	41												
208.4	End of Borehole		25	SS	55												
21.6																	

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.4, E 239 242.9 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 05 to 89 10 06 CHECKED BY

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE			N VALUES	20 40 60 80 100						WATER CONTENT (%) 10 20 30
320.0	Ground Level													
0.0	Sand, Some Silt and Gravel, Very Loose to Compact (Fill)		1	SS	16									
			2	SS	12									
			3	SS	7									
			4	SS	4									
			5	SS	20									
317.3			6	SS	31								21 48 26 5	
2.7	Silty Sand, Trace of Organic, Compact		7	SS	11									
316.4			8	SS	10									
3.6	Silty Sand to Sandy Silt, Compact to Dense		9	SS	27									
			10	SS	34									
			11	SS	63									
			12	SS	33									
			13	SS	14									
			14	SS	27									
			15	SS	24									
			16	SS	25									
			17	SS	39									
			18	SS	43									
			19	SS	20									
			20	SS	18									0 47 53
			21	SS	14									0 2 (98)
			22	SS	71									
	23	SS	50											
	24	RC												
	25	RC												
291.7	Occasional Boulders		26	SS	68									
28.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to 15-25 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 454.4, E 239 216.1 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 10 10 CHECKED BY _____

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100						WATER CONTENT (%)	10
125.6	Shoulder Level		1	SS	75														
0.0	Asphalt		2	SS	23														
	Sand With Silt, Some Gravel, Compact to Dense (Fill)		3	SS	16													3 60 (37)	
			4	SS	15														2 63 (35)
			5	SS	28														
			6	SS	27														
			7	SS	27														
			8	SS	20														
			9	SS	21														
			10	SS	12														
			11	SS	5														16 39 (45)
			12	SS	14														
			13	SS	30														
			14	SS	37														
			15	SS	43							100	29	cm					8 45 (47)
			16	SS	32														
			17	SS	21														7 67 (26)
			18	SS	38														
116.9				19	SS	26													
8.7		End of Borehole																	

OFFICE REPORT ON SOIL EXPLORATION

+3, x5; Numbers refer to 20
15 ÷ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 448.6, E 239 227.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 11 to 89 10 12 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
295.6	Continued															
30.2	Silty Sand to Sandy Silt, Dense to Very Dense	S S S	33	SS	103/28cm											
	Occasional Boulders		34	RC	40%											
291.7			35	SS	71											
34.1	Weathered Unweathered Dolostone Bedrock	S S S	36	BXL	25											
			*													
			45	RC	REC	96%										
			46	BX	97%											
286.6																
39.2	End of Borehole															
* Note Sample																
No.	Type	Rec.	RQD													
37	RC	40%	0													
38	RC	80%	0													
39	RC	100%	0													
41	RC	95%	0													
42	RC	50%	0													
43	RC	100%	0													
44	RC	86%	0													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 366.4, E 239 245.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), Casing NX COMPILED BY PM
 DATUM Geodetic DATE 89 10 17 to 89 10 23 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40	60
325.7	Ground Level														
0.0	Sand, With Gravel, Some Silt, Loose to Compact (Fill)	X	1	SS	7										
			2	SS	13										33 53 (14)
			3	SS	10										
			4	SS	12										
			5	SS	17										
			6	SS	15										
			7	SS	12										28 44 (28)
			8	SS	8										
			9	SS	10										
			10	SS	10										19 48 (33)
			11	SS	6										
			12	SS	26										
			13	SS	29										
			14	SS	28										
			15	SS	24										37 49 (14)
			16	SS	26										
317.2	Organic Silt		17	SS	10										
8.5	Silty Sand to Sandy Silt, Compact to Very Dense	.	18	SS	54										
			19	SS	80										63 30 (7)
			20	SS	47										
			21	SS	25										
			22	SS	25										0 81 (19)
			23	SS	20										
			24	SS	24										
			25	SS	40										
			26	SS	97										1 29 (70)
			27	SS	23										
			28	SS	24										0 1 88 11
	29	SS	109												
295.5															
30.2															

Continued

*3, x5; Numbers refer to 20
15 & 5 (%) STRAIN AT FAILURE

Continued



RECORD OF BOREHOLE No 9

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 366.4, E 239 245.6 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), Casing NX COMPILED BY PM
 DATUM Geodetic DATE 89 10 17 to 89 10 23 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80						100
295.5	Continued	Occasional Boulders	30	SS	32												
30.2																	
					31	SS	64										
					32	RC	50%										
289.1			33	RC	12%												
288.5	Dolostone Bedrock		34	RC BX	REC 43%										RQD = 0		
37.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10

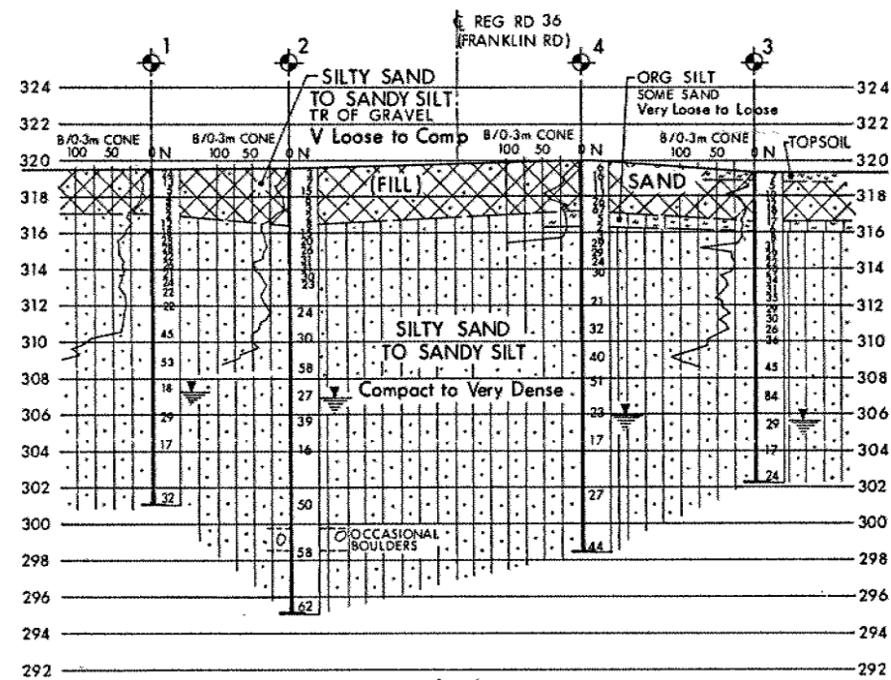
METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.8, E 239 219.4 ORIGINATED BY MH
 DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 89 10 24 to 89 10 25 CHECKED BY _____

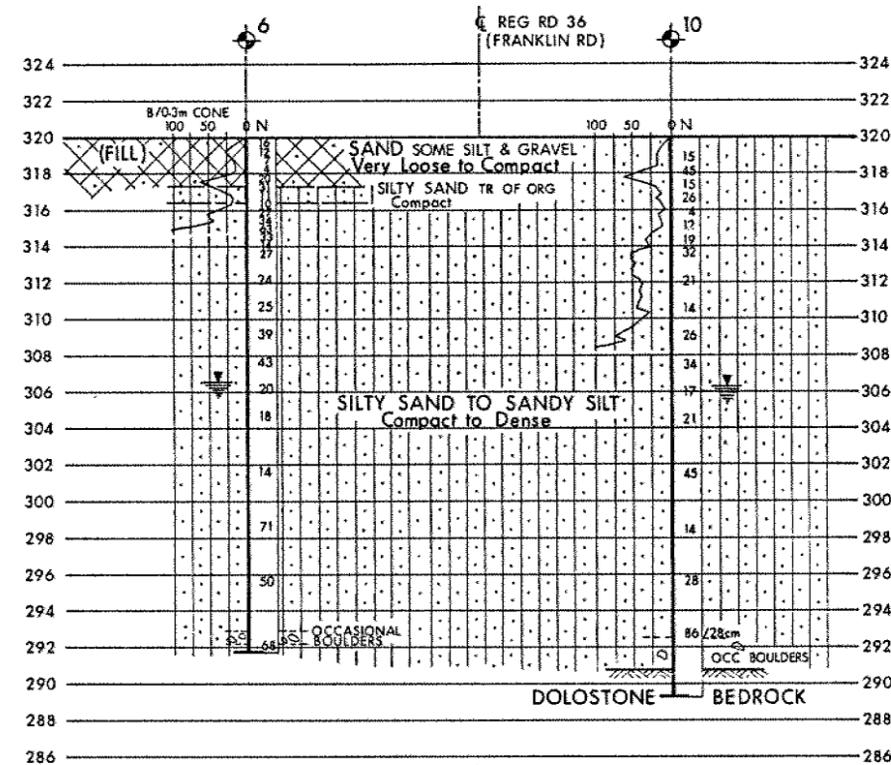
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W _n	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20						40
320.0	Ground Level													
0.0			1	SS	15									
	Silty Sand to Sandy Silt, Compact to Dense		2	SS	45									
			3	SS	15									
			4	SS	26									
			5	SS	4									7 50 37 6
			6	SS	12									
			7	SS	19									0 12 (86)
			8	SS	32									
			9	SS	21									
			10	SS	14									
			11	SS	26									
			12	SS	34									
			13	SS	17									
			14	SS	21									
			15	SS	45									
			16	SS	14									
			17	SS	28									
			18	SS	86/	28cm Bouncing								
	Occasional Boulders		19	BX	42%									
				RC	REC									
290.7														
29.3	Dolostone Bedrock		20	BX	96%									
				RC	REC									
289.3														
30.7	End of Borehole												RQD = 7%	

OFFICE REPORT ON SOIL EXPLORATION

3, x 5; Numbers refer to 15 x 5 (%) STRAIN AT FAILURE

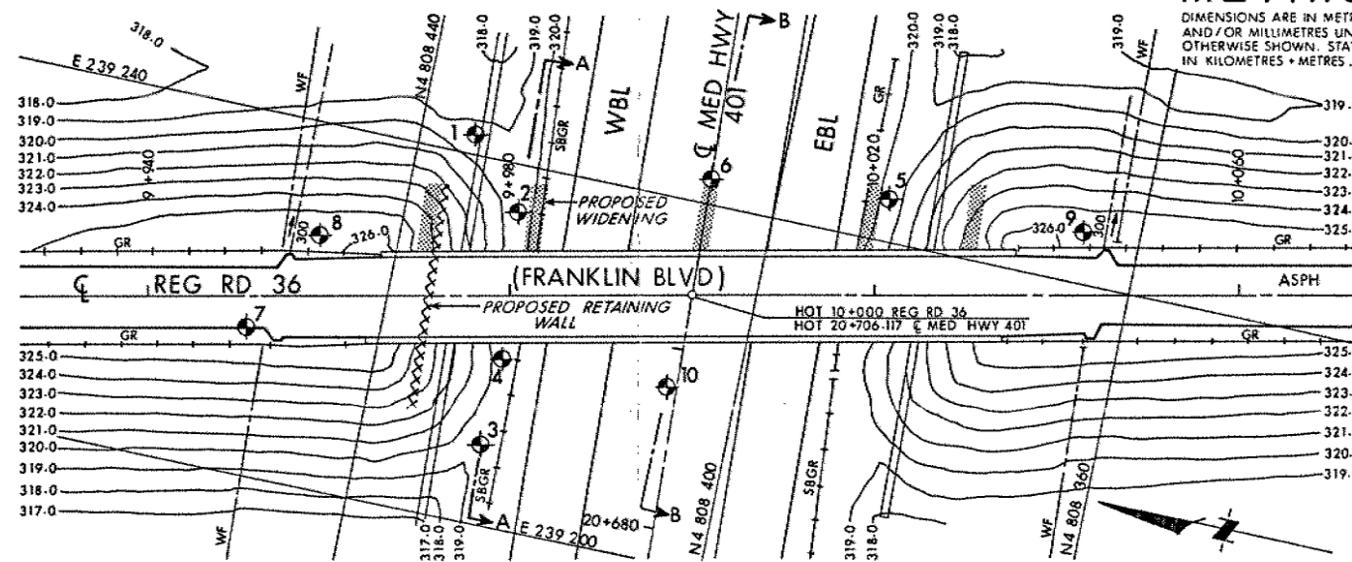
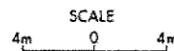


A-A

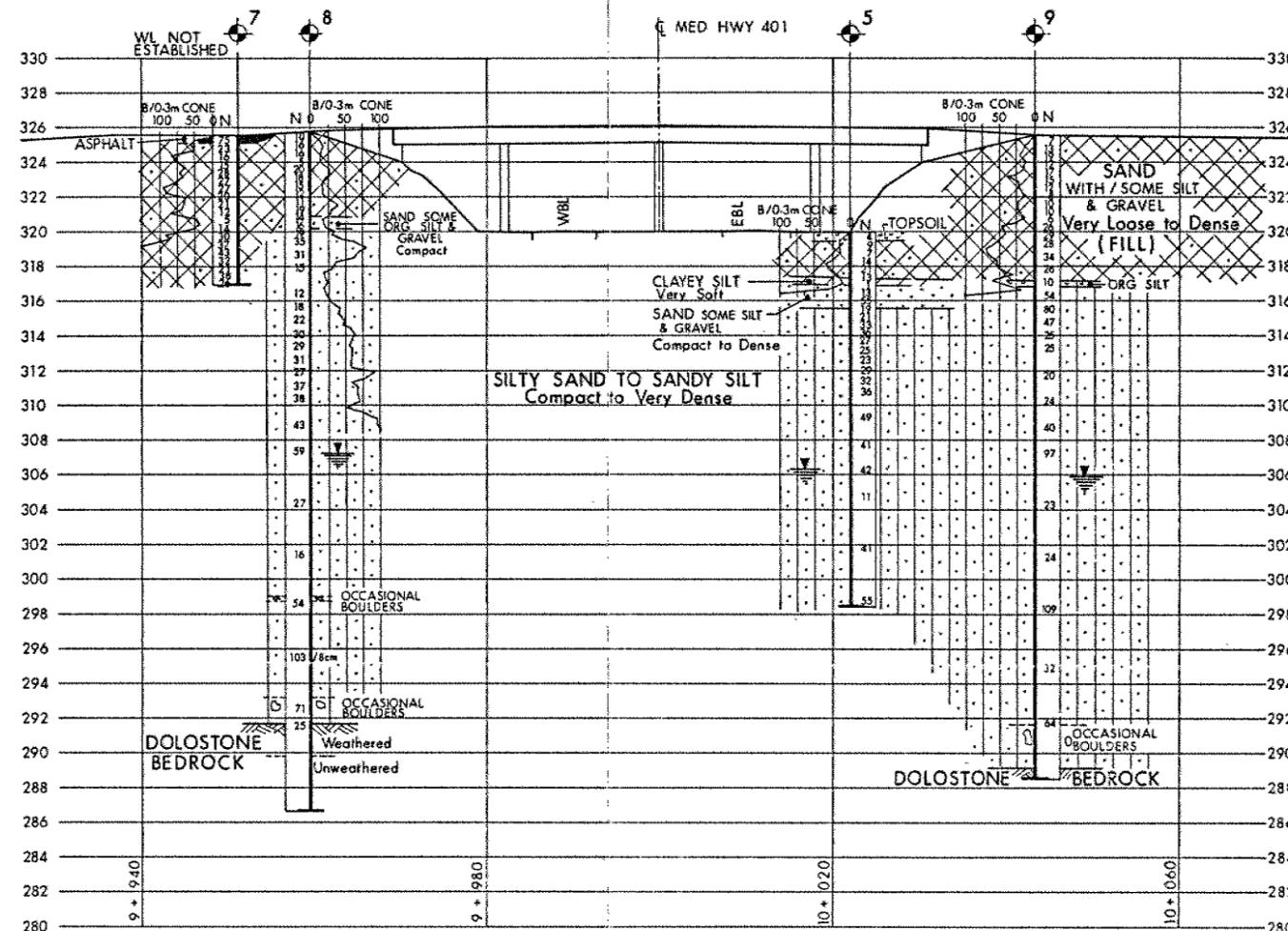
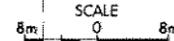


B-B

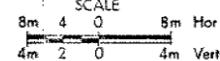
SECTIONS



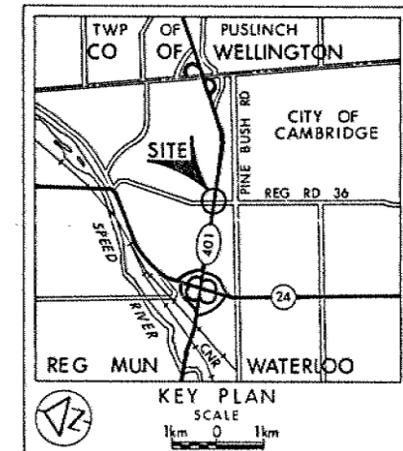
PLAN



PROFILE REG RD 36



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



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 89 10

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	319.7	4 808 433.9	239 242.2
2	319.6	4 808 427.5	239 234.8
3	319.3	4 808 426.4	239 209.1
4	320.0	4 808 426.0	239 218.8
5	320.0	4 808 388.2	239 244.8
6	320.0	4 808 407.4	239 242.9
7	325.6	4 808 454.4	239 216.1
8	325.8	4 808 448.6	239 227.6
9	325.7	4 808 366.4	239 245.6
10	320.0	4 808 407.8	239 219.4

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

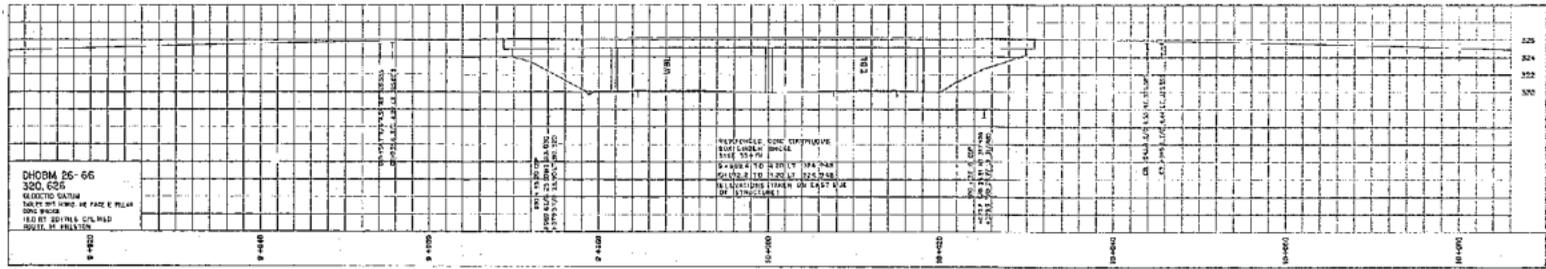
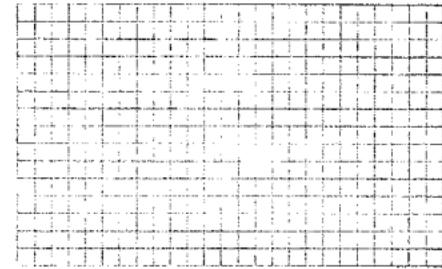
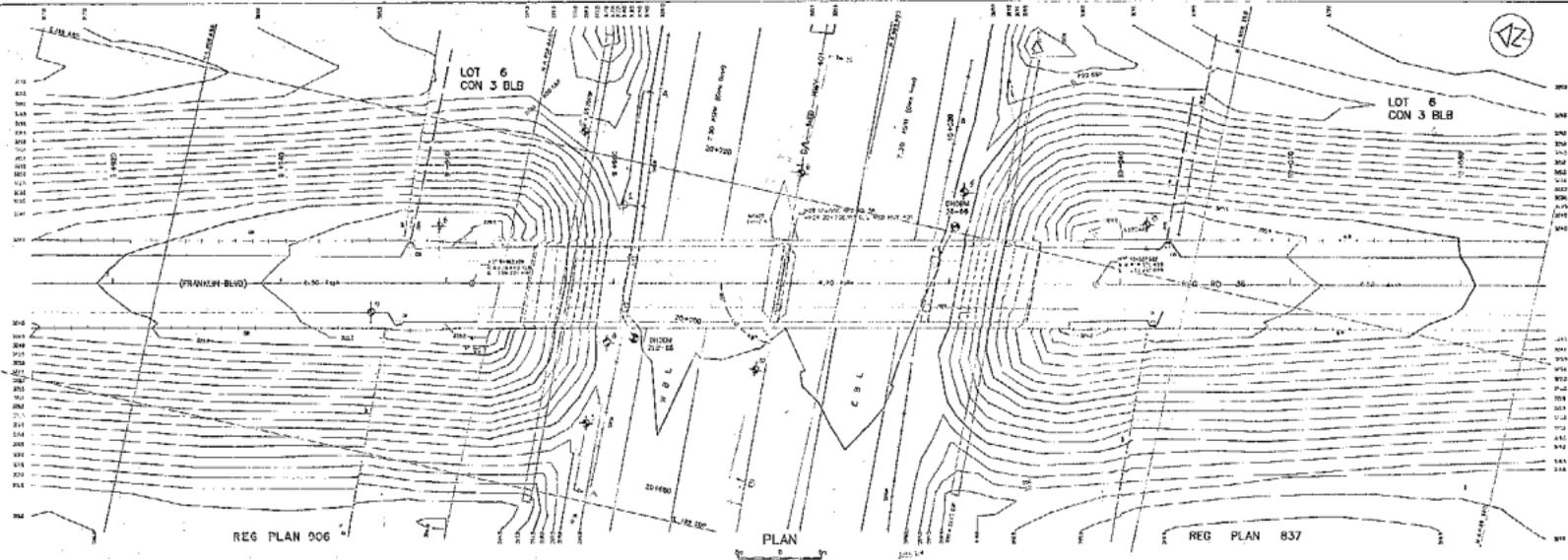
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 40P8-104

HWY No 401	DIST 3	
SUBM'D BY CHECKED	DATE 90 01 17	SITE 33-151
DRAWN BY CHECKED	APPROVED	DWG 78309-A

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



PROFILE OF REG RD 36



KEY PLAN

DATE	REVISIONS AND ADDITIONS		
MINISTRY OF TRANSPORTATION ENGINEERING AND RIGHT OF WAY OFFICE SURVEYS AND PLANS SECTION			
BRIDGE SITE PLAN AT REG RD 36 OVER KING'S HIGHWAY 401			
LOT 6 CON 3 BLB	CITY OF WATERLOO REG 100-1000		
SCALE AS SHOWN 1" = 40' 2" = 80'	DISTRICT 4-BURLINGTON	REGION 100-NORTHWESTERN PLAN E/W 164-401 E/W 164-401	
SURVEY 88-08		PLAN 88-08	
SHE 30-131		PLAN E-164-401-1	