

GEOCRES No:

4001-10

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 287-94-01 DIST 32
HWY 21 STR SITE 14-28

Hickory Creek Replacement Bridge

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GEOCRES 4001-10

DATE SEP 29 1997

FOUNDATION INVESTIGATION REPORT

For

Hickory Creek Replacement Bridge

W. P. 287 - 94 - 01; Site 14 - 28

Highway 21, District 32, Chatham

INTRODUCTION

This report contains the results of a foundation investigation carried out at the crossing of Highway 21 and Hickory Creek. The fieldwork was carried out between 1995 12 04 and 1995 12 08, and comprised of two sampled boreholes and Dynamic Cone Penetration Test adjacent to both of these holes.

Boreholes were advanced to maximum depth of 27.6 m (El. 183.9) below the existing highway shoulder level using a 82 mm I. D. continuous flight hollow stem auger as well as BW casing.

SITE DESCRIPTION

The site under investigation is located approximately 13 km north of Highway 402 at the crossing of Highway 21 and Hickory Creek in the Township of Forest, County of Lambton. The surrounding area is gently rolling and cultivated farmland. The width of the creek along the centreline of Highway 21 is about 10 m and the creek bed is approximately 3.5 m below the existing road level.

The topography of the site on the south side of the creek is generally flat, and on the north side, it may be classified as undulating with isolated flat area. Physiographically, the site is located in the region known as the " St. Clair Clay Plain ". Adjoining the St. Clair River in Lambton County are extensive clay plains covering several hundred square kilometres. The subsoil at this site is a clayey material deposited during the Wisconsin glacial stage of the Pleistocene Epoch. The

bedrock underlying the clayey soil is a black shale of Devonian and Missipian Age.

SUBSURFACE CONDITIONS

General

Generally uniform subsoil conditions were found to prevail over the project area. The underlying subsoil at this site consists of 1.9 m to 2.1 m stiff fill underlain by 22.0 m to 22.2 m stiff to hard clayey silt which overlies shale bedrock of the Kettle Point Formation. For classification purposes, the soils encountered at this site can be divided into three different zones.

- a) Embankment Fill
- b) Clayey Silt, Trace of Gravel
- c) Shale Bedrock

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. A stratigraphical section is shown on Drawing No. 2879401 - A. This drawing also shows the location and elevation of the borings. Description of the strata encountered are given below.

Embankment Fill

This fill which was placed to raise the finished grade of Highway 21 was encountered in both boreholes, and consists of 0.5 m to 0.7 m compact silty sand with gravel is underlain by 1.2 m to 1.6 m stiff (N - values 8 blows/0.3 m to 14 blows/0.3 m) clayey silt. This extends to elevations 209.6 to 209.4.

Clayey Silt, Trace of Gravel

The clayey fill is underlain by this clayey silt with trace of gravel. The thickness of this deposit varies from 22.0 m to 22.2 m and extends to elevation 187.4. The natural moisture content was observed to vary from 14.5% to 19.5% with an average value of 17.5%. The results of the Atterberg Limit Test are shown on Figure 1. The Standard Penetration Test values in this deposit vary over a wide range (N - values 13 blows/0.3 m to 41 blows/0.3 m). Based on these results, it may be classified as stiff to hard.

Shale Bedrock

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

The bedrock was encountered at about elevation 187.4. Based on the RQD values measured from BX cores, the quality of the bedrock may be described as poor to fair (RQD - values 49% to 58%). The bedrock at this site may be classified as slightly weathered to unweathered shale bedrock of the Kettle Point Formation.

Groundwater Conditions

The groundwater level measurements were taken in open boreholes during the investigation and was observed at elevations 209.4 and 195.6. The water level in the creek was observed at about elevation 208.5. Seasonal fluctuation of the groundwater level may be expected due to the influence of the creek. The groundwater level at each borehole is as follows:

<u>Borehole No.</u>	<u>Elevation</u>
1	195.6
2	209.4

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing structure at the crossing of Highway 21 and Hickory Creek to provide standard lane and shoulder widths. Two options are under consideration for the replacement bridge and these are as follows:

- 1) A single span 18.0 m long rigid frame reinforced concrete structure (Option 1).
- 2) A single span 18.0 m long structure consisting of reinforced concrete deck supported on CPCI girders and integral type abutments (Option 2).

In both options, the final profile grade will be set maximum of 600 mm higher than the existing grade, ie. approximately at elevation 212.3. The new structure will be constructed along the same horizontal alignment as the existing bridge.

The existing bridge is a single span rigid frame cast-in-place reinforced concrete structure. The clear span between the face of the abutments is about 13.0 m. The Structural Drawing dated August 22, 1934 indicates that the existing bridge is supported on 1.75 m wide spread footing placed at about elevation 207.3.

The approach embankment as well as the structure appear in very good condition. However, spalling of concrete has been noticed at few locations.

Structure Foundation

Option 1

Considering the subsoil conditions at this site, it is recommended that the abutments for the proposed structure be supported on spread footings placed at elevation 207.2. The footings may be designed assuming the following bearing pressures.

Factored Bearing Resistance at U. L. S = 400 kPa

Bearing Resistance at S. L. S = 250 kPa

The allowable bearing pressure (SLS) recommended above is based on the assumption that the footings will not be placed at a level higher than the elevation 207.2. The total settlement for this bearing pressure is not expected to exceed 25 mm.

The sliding resistance may be estimated based on effective angle of internal friction neglecting the effective shear strength of the founding soil. An unfactored coefficient of friction value of $\tan 26^\circ$ may be assumed for the estimate.

Spread footings in this area should have a minimum of 1.2 m earth cover to protect against frost penetration.

Option 2

The integral type abutments may be supported on HP 310 x 110 steel H - piles driven to bedrock which will be encountered approximately at elevation 187.4. Piles may be designed assuming a factored axial geotechnical resistance at U.L.S. of 1600 kN. Axial resistance at S.L.S. will not govern, because the loads required to produce detrimental settlement of the structure will be much larger than the recommended value for the factored axial resistance at U.L.S.

This option may require determination of contraflexure point and for this purpose, coefficient of horizontal subgrade reaction value of 30,000 kN/m³ may be assumed from El. 208 to El. 187.4. Considering the span of the integral abutments type structure (13 m), preaugered holes filled with loose sand may not be required.

The pile tips may be reinforced with driving shoes as per MTO Standard DD - 3301 to protect from damage during driving.

Lateral Earth Pressure

Earth pressure should be computed as per Section 6. 7. 4. 5 of the O. H. B. D. C., and the coefficient of earth pressure at rest shall be used for rigid and unyielding walls. The granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

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

Approach Embankment

The proposed finished grade of the replacement bridge is expected to be 600 mm higher than the existing grade. No major instability problems are anticipated for the approach embankment constructed with 2 horizontal to 1 vertical side slope. The fill should consist of well compacted acceptable material. The topsoil as well as any spongy or soft area observed within the base width of the embankment should be removed before placing the fill.

Other Considerations

In view of the impervious nature of the subsurface conditions at this site, no major dewatering problems are anticipated at the abutment locations. Any minor seepage or surface run-off into the excavation may be readily handled by pumping from the sump. Care shall be exercised during construction to prevent any flow of water from the river in to the excavation.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Vasavithasan, Foundation Engineer. The equipment used was owned and operated by London Soil Test Limited. This report was prepared by M. Vasavithasan, Foundation Engineer and reviewed by Tae C. Kim, Senior Foundation Engineer.



M. Vasavithasan

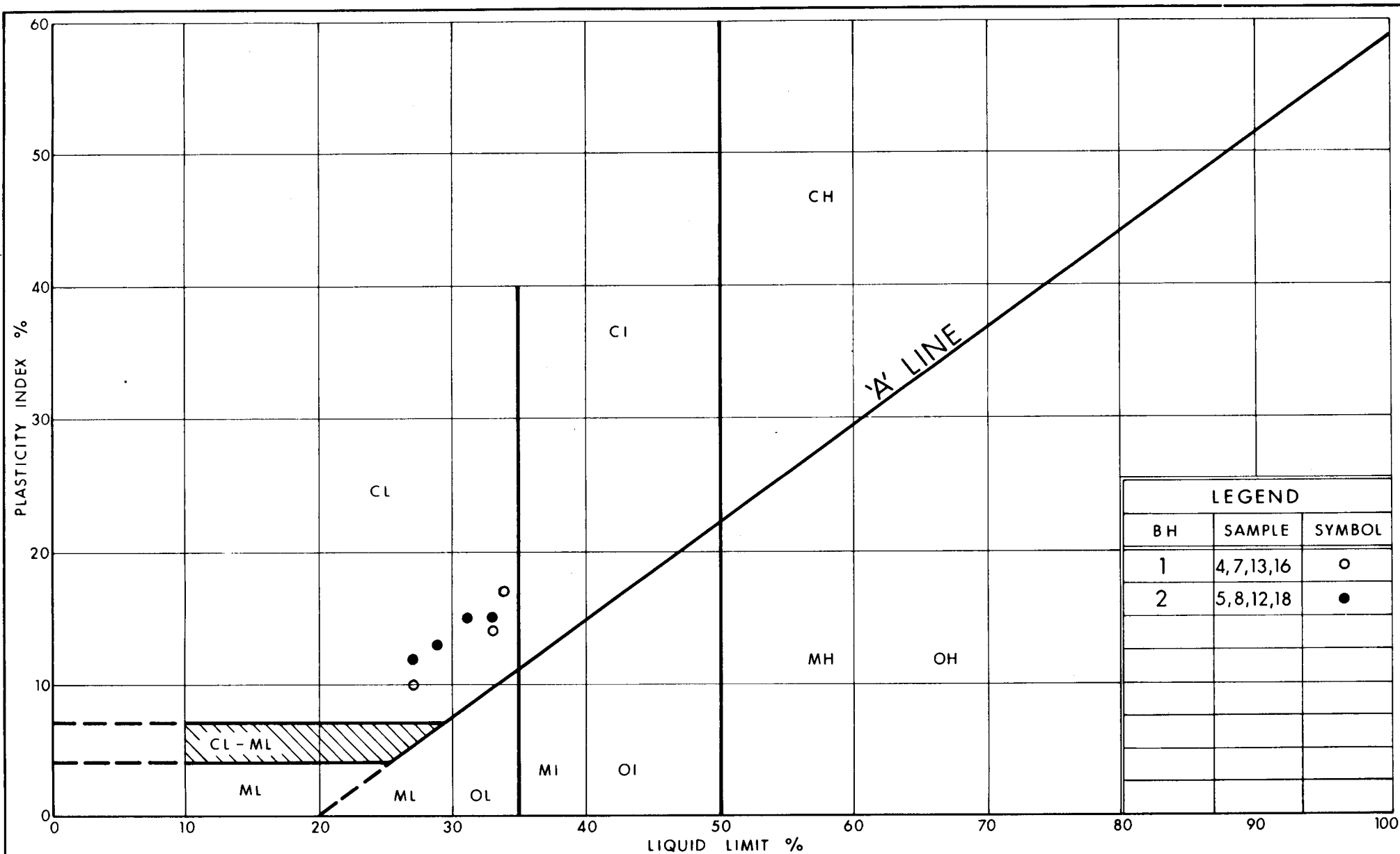
M. Vasavithasan, P. Eng.
Foundation Engineer



Tae C. Kim

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

APPENDIX



Ministry of
Transportation
Ontario

PLASTICITY CHART CLAYEY SILT

FIG No 1

W P 287 -94 -01

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 287 - 94 - 01 LOCATION CO - ORDS; N 4 771 674.1, E 345 447.2 ORIGINATED BY M V
DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 1995 12 06 & 07 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _P	W	W _L		
211.5	Ground Surface													
0.0	SILTY SAND, With Gravel (Fill)													
0.7	CLAYEY SILT, Trace of Gravel, Stiff		1	SS	9									
209.6	(Fill)		2	SS	14									
1.9			3	SS	11									
			4	SS	19									
			5	SS	20									
			6	SS	16									
			7	SS	18									
			8	SS	19									
			9	SS	20									
			10	SS	24									
			11	SS	30									
			12	SS	25									
			13	SS	30									
			14	SS	24									
			15	SS	24									
			16	SS	41									
187.4			17	RC BX	REC 57%									
24.1	Highly Weathered		18	RC BX	REC 98%									
183.9	Unweathered SHALE BEDROCK													
27.6	End of Borehole													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 287 - 94 - 01 LOCATION CO - ORDS; N 4 771 647.9, E 345 435.4 ORIGINATED BY M V
DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 1995 12 04 & 05 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
211.5	Hwy. 21 Shoulder													
0.0	SILTY SAND, With Gravel (Fill)													
0.5	CLAYEY SILT, Tr. of Gravel, Tr. of Organics, Stiff		1	SS	13									
209.4	(Fill)		2	SS	8									
2.1	Layers of Silty Sand & Organics		3	SS	5									
			4	SS	8									
			5	SS	13									
			6	SS	15									
			7	SS	15									
			8	SS	14									
			9	SS	13									
			10	SS	18									
			11	SS	20									
			12	SS	21									
	CLAYEY SILT, Trace of Gravel, Stiff to Hard		13	SS	21									
			14	SS	27									
			15	SS	23									
			16	SS	33									
			17	SS	32									
			18	SS	27									
187.4			19	RC BX	REC 78%									
186.9	SHALE BEDROCK													ROD = 52%
24.6	End of Borehole													

ROCK CORE DESCRIPTION
WP 287-94-01

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	18	24.61-26.14	57	49	24.61-27.56	SHALE (bituminous), black, with interbedded greenish grey SILTSTONE (5%); very fine grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	19	26.14-27.56	98	58		
2	20	24.10-24.64	78	52	24.10-24.64	SHALE (bituminous), black, with interbedded greenish grey SILTSTONE (21%); very fine grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to dipping, 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

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

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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

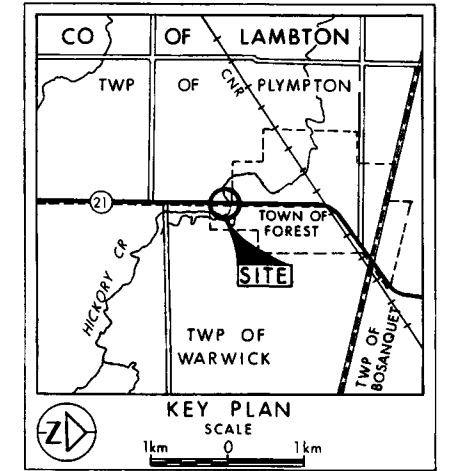
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 287-94-01

HICKORY CREEK
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1995 12

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	211.5	4 771 674.1	345 447.2
2	211.5	4 771 647.9	345 435.4

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 GC 2.01 of OPS Gen Cond

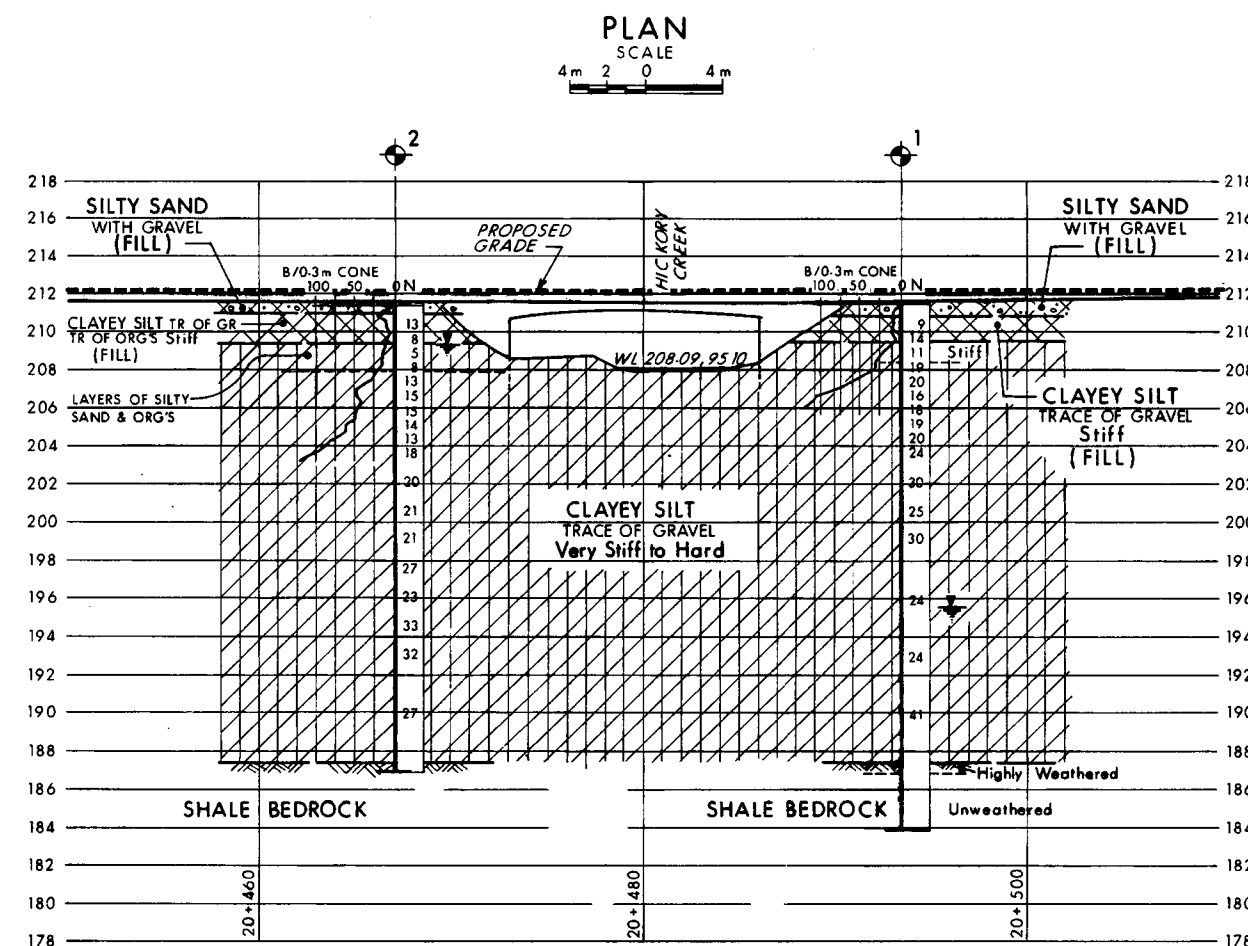
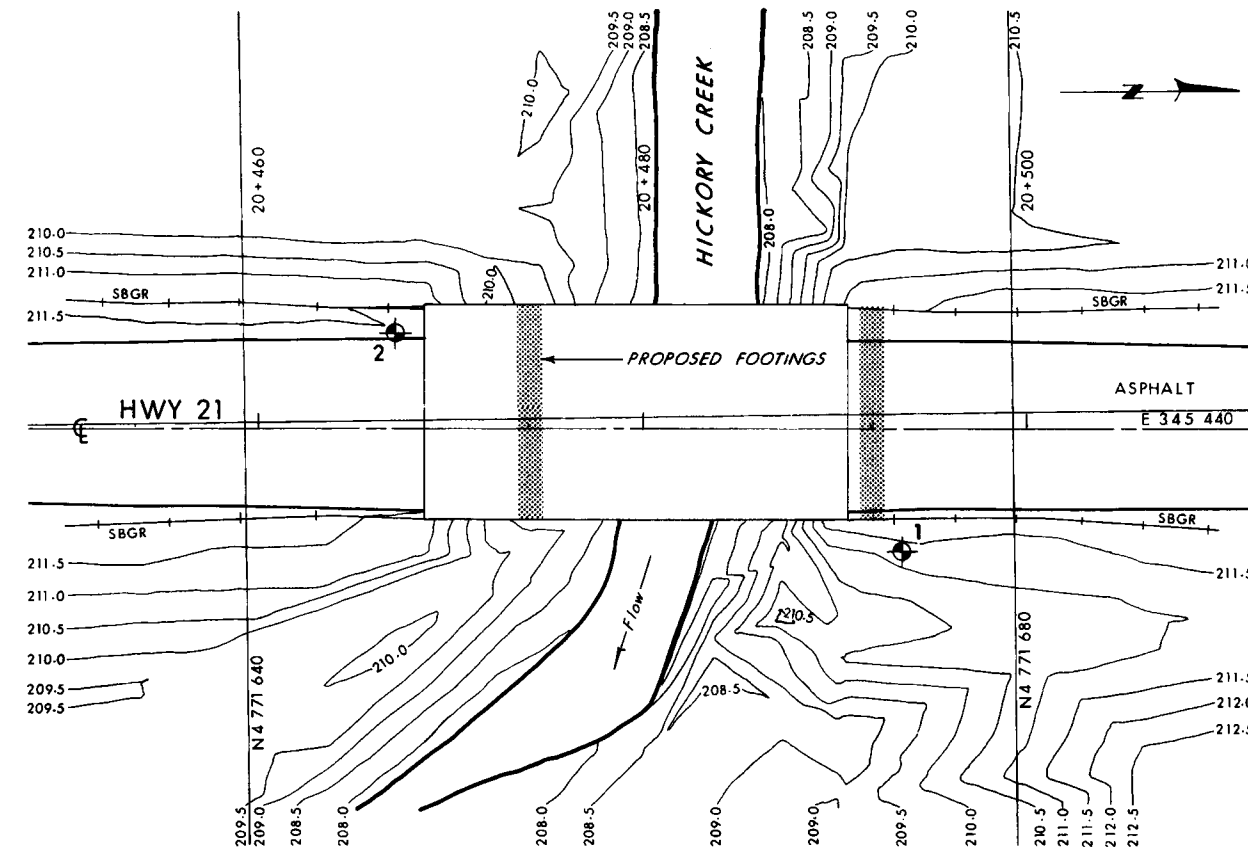
REV.	DATE	BY	DESCRIPTION

Geocres No 4001-10

HWY No 21			DIST 32
SUBM'D MV	CHECKED <input checked="" type="checkbox"/>	DATE 1997 09 04	SITE 14-028
DRAWN DT	CHECKED <input checked="" type="checkbox"/>	APPROVED	DWG 2879401-A



REF No E-177-21-1, 97-06



PROFILE HWY 21

