

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 121-87-00

DIST 9

HWY 416

STR SITE -

Proposed High Mast Light Poles  
Highway 416, Knoxdale Rd. to Baseline Rd.

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FOUNDATION INVESTIGATION REPORT  
For  
Proposed High Mast Light Poles  
Highway 416, Knoxdale Road to Baseline Road  
W.P. 121-87-00  
District 9, Ottawa

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INTRODUCTION

A request for foundation investigation was made by Eastern Region Structural Section for the design of high mast light poles for the proposed Highway 416 from Knoxdale Road to Baseline Road. A large number of foundation investigations have been carried out in the area before. The existing information was employed to estimate the subsurface conditions at most of the proposed pole locations and hence eliminate the need for field investigation in most cases.

A thorough desk study has been carried out to extract the relevant information. This report summarizes the information collected and includes the foundation recommendations pertaining to the design of the high mast light poles (HML) C4 to C11. Foundation investigation will be required on Pole #C1-C3 and we will forward our recommendations under separate cover once the field data are available. Proposed pole locations are shown in Figures 1 to 5 in the Appendix.

## DISCUSSION AND RECOMMENDATIONS

### General

Reference borehole numbers for each HML pole are tabulated in Table 1. Subsurface conditions at the location of the reference boreholes are shown on the record of borehole sheets in the Appendix. Groundwater levels may vary from the elevations shown in the record sheets due to seasonal fluctuations. Based on the subsoil information, the geotechnical design parameters are summarized in Table 2.

### Foundation

The design of caissons for the HML foundations shall be as per the "Procedures for the Design of High Mast Light Pole Foundations" prepared by the Structural Office, Procedures Section, dated January 1993.

The soils within 1.8 m of the finished grade should be neglected in the calculation for lateral resistance due to frost penetration. The finished grades of some of the HML poles is different from the existing ground surface. In these cases, the HML poles will be founded in a fill or a cut. The design of HML poles located in fills or cuts shall be as per the general guidelines given in a memo from the Foundation Design Section dated 1990 04 02. A copy of this memo is attached in this report for easy reference. It is recommended that the construction be closely monitored and any unforeseen subsoil conditions be reported to this office so that design may be reviewed to suit actual site conditions.

### Construction Considerations

For caisson construction, liners should be used to stabilize the sides during installation and concreting of the caissons, especially when excavation advances below the groundwater level in cohesionless materials. The founding base of the caisson should be pumped dry prior to concreting. Alternatively, tremie concrete

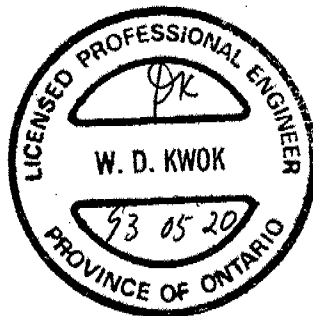
should be used for underwater concreting.

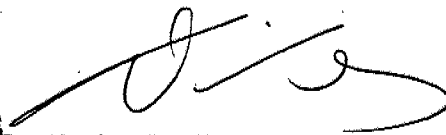
It should be noted that the glacial till stratum contains occasional boulders. Installation of caissons through glacial till stratum may encounter obstruction from boulders.

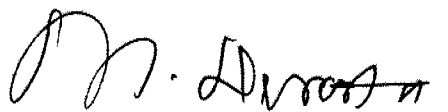
#### MISCELLANEOUS

This report was written by D. Kwok, Project Foundation Engineer, based on the investigation data extracted from various relevant foundation reports.

This report was reviewed by B. Iyer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



  
D. Kwok, P. Eng.  
Project Foundation Engineer

  
M. Devata, P. Eng.  
Chief Foundation Engineer

To: V. Boehnke  
Head, Structural Section  
Central Region

From: Foundation Design Section  
Room 315, Central Building

Re: High Mast Lighting Foundations  
on Cut and Fill Slopes

Date: 1990 04 02

Further to our meeting of February 26, 1990 and your subsequent minutes we have reviewed your proposal for high mast light foundations on slopes. Following are our comments on

- general implications for HML foundation on the slopes as opposed to in the median
- design implications for HML foundations on cut slopes

These comments are intended for planning purposes only. A foundation investigation would have to be initiated for each specific HML site. Since the foundation conditions will be variable, some refinement in foundation recommendations should be expected in the design phase of the project.

#### Slope Versus Median

There are a number of disadvantages in placing caisson foundations on slopes.

- The lateral resistance would be decreased due to the proximity of the caisson to the slope, inferior compaction near the slope and the reduction in passive resistance due to movement of the slope. These factors would contribute to deeper caissons.
- Access ramps would be required for caisson installation and permanent berms/benches would be required to increase lateral resistance and for maintenance access. These factors would increase property requirements and the complexity of grading.
- By not utilizing the full depth of the highway embankment and due to the implications for lateral resistance on slopes, caissons would be deeper thus increasing the risk of encountering artesian groundwater conditions. If artesian conditions are encountered, installation costs could be considerably higher and a drainage/filter system would have to be installed below frost level outletting to a permanent drain.

### Cut Slopes

The design parameters for HML foundations at the toe of cut slopes will require investigation on a site specific basis. If the caissons are located on a bench a minimum of 3 m from the toe of slope as indicated in your proposal there would be no implication for the caisson design. Since the proposed toe wall at the base of the cut slope would have to retain a considerable earth pressure, it would be expensive. Therefore we recommend deleting it from the design and grading the slopes at 2:1.

### Fill Slopes

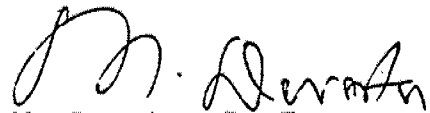
The implications for HML caissons on fill slopes are significant. The effects of settlement, slope movement, embankment compaction, and earth pressure on the caisson have been assessed resulting in the following recommendations.

Assuming that the proposed embankment geometry consists of an upper 4H:1V slope, 1.75 m high, then a 6 m berm, then 2H:1V slope:

- The design for caisson embedment can be calculated neglecting lateral resistance in the frost penetration zone but including lateral loads within the frost penetration zone.
- The caisson should be a minimum 3 m from the crest of the 2H:1V downslope.
- The properties of the fill will be site dependent but may involve a reduction of 10±% in strength parameters to account for uncertainties inherent in fill.
- The embankment should be preloaded prior to construction of the HML foundation in order to minimize settlement effects. The duration of the preload will be recommended on a site specific basis in the Foundation Report.
- The upper 60% of the embedment length within the fill (taken from frost penetration depth) should be disregarded for lateral resistance.

In conclusion, it is feasible to construct HML caissons on slopes as proposed. However, caissons would extend to a lower elevation and be more expensive. These costs should be compared to any savings that would result from locating HML's on the slopes instead of in the median.

If there are any questions, please advise.



M. Devata, P. Eng.  
Chief Foundation Engineer

MD/BI/DD/mmj

cc: R. Dorton  
B. Iyer  
P. Payer  
D. Dundas

## APPENDIX



W.P. 121-87-00

Table 1

REFERENCE BOREHOLE NUMBERS

HML Pole #	Ref. BH No.	Project No.	Orig. Grade	Final Grade
C-4	10	146-74-00	96.70	94.3
	12	146-74-00	96.70	
	CRA-5	146-74-00-2	88.53	
C-5	17-6	121-87-06	91.2	93.45
	10	146-74-00	97.6	
	CRA-5	146-74-00-2	88.53	
C-6	17-1	121-87-06	97.4	92.05
	5	146-74-00	98.1	
	CRA-4	146-74-00-2	95.71	
C-7	89-5	146-74-00-3	89.7	87.60
	89-17	146-74-00-3	95.3	
	89-18	146-74-00-3	97.1	
C-8	89-4	146-74-00-3	88.5	85.55
	89-5	146-74-00-3	89.7	
	9	146-74-00	88.6	
C-9	89-3	146-74-00-3	87.7	81.95
	89-21	146-74-00-3	88.1	
	90-W30	126-87-01(A)	87.4	
C-10	89-10	146-74-00-3	86.6	86.7
	89-11	146-74-00-3	87.0	
	90-W6	126-87-01(A)	86.6	
	90-W7	126-87-01(A)	86.9	
C-11	16-2	127-87-00(A)	85.4	78.60
	90-W20	126-87-01(A)	85.2	
	90-W21	126-87-01(A)	85.1	
	90-W15	126-87-01(A)	86.3	
	108	126-87-01	85.0	

Table 2  
REFERENCE BOREHOLE NUMBERS

HML Pole #	Final Grade	Elevation (m)	$\gamma$ (kN/m <sup>3</sup> )	$\phi$ (°)	$q_u$ (kPa)
C-4	94.30	92.50 - 76.00	20	35	---
C-5	93.45	91.65 - 89.70 89.70 - 76.00	*19 20	0 35	--- ---
C-6	92.05	90.25 - 79.10 79.10 - 73.30 73.30 - 71.70	20 22 25	38 40 0	--- --- 20000
C-7	87.60	85.80 - 80.60	20	38	---
C-8	85.55	83.80 - 82.00 82.00 - 73.10	19 20	- 35	120 ---
C-9	81.95	80.15 - 76.00 76.00 - 70.90	19 20	- 32	120 ---
C-10	86.70	84.90 - 76.00 76.00 - 74.10 Below 74.10	18 20 26	- 32 -	60 - 20000
C-11	78.60	76.80 - 73.20 Below 73.20	19 26	30 -	--- 20000

\* If the landfill material has been removed and replaced by compacted granular fill,  $\gamma = 20 \text{ kN/m}^3$  and  $\phi = 30^\circ$  may be used.

## 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
$C_a$	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
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

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

FORMER

RECORD OF BOREHOLE No 10

METRIC

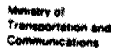
W P 146-74-00 LOCATION Co-ords. N 5 020 521.9; E 359 252.3 ORIGINATED BY RS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TR  
DATUM Geodetic DATE 84 05 16 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
97.6	Ground Surface												
0.0													
	Sand		1	SS	18		97						
	trace silt		2	SS	16		96						0 94 5 1
	Compact		3	SS	21		95						
			4	SS	22		94						
			5	SS	20		93						0 97 (3)
	dense		6	SS	38		92						
			7	SS	30		91						
			8	SS	29		90						
			9	SS	40		89						0 96 (4)
			10	SS	39		88						
			11	SS	17		87						0 97 (3)
	compact		12	SS	16		86						
							85						
	some silt						84						
							83						

Continued

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

Continued



**W.P. 121-87-00**

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

**+3, x5: Numbers refer to Sensitivity**

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

FORMER

RECORD OF BOREHOLE No 12

METRIC

W P 146-74-00 LOCATION Co-ords. N 5 020 485.6; E 359 175.3 ORIGINATED BY HS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
DATUM Geodetic DATE 84 05 18 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
96.7	Ground Surface																
0.0	Silty Clay (fill) trace sand trace of roots Stiff		1	SS	14												
95.0																	
1.7	Sand  trace silt		2	SS	10												
			3	SS	17												
	Compact		4	SS	42												0 96 (4)
			5	SS	40												
			6	SS	46												0 96 (4)
	Dense																
	Very Dense		7	SS	61												
	some silt																
87.1			8	SS	71												0 83 (17)
9.6	End of Borehole																
	* Note: Water level not established.																

OFFICE REPORT ON SOIL EXPLORATION

FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

CRA - 5

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW5-88

PROJECT NO.: 2396

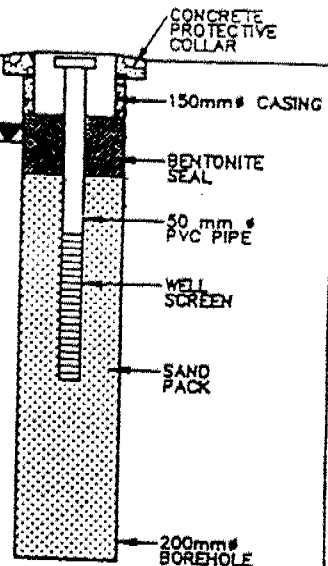
DATE COMPLETED: 26 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53				
1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.	87.63				
2.0	- wet					
3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		1SS	X	17
4.0	- siltier, not as dense			2SS	X	20
5.0	END OF HOLE • 5.18 m BGS.	83.35	<p>SCREEN DETAILS: Screened Interval: 85.18 to 86.71 AMSL Length -1.52m Diameter -50mm Slot # 10 Material - PVC</p>	3SS	X	15
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						
13.0						

## NOTES:

MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



2/05/88

FORMER

RECORD OF BOREHOLE No 17-6 1 OF 1 METRIC

W.P. 121-87-00 LOCATION Co-ords N5 020 683.4, E 359 216.4 ORIGINATED BY TS  
DIST 9 HWY 416 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY TS  
DATUM Geodetic DATE 88 11 28 CHECKED BY JP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
91.2	Ground Surface												
0.0	Sand Brown, Compact (Fill Material)		1	SS	10								
89.7			5	SS	40								
1.5	Sand with Occ. Silt seams		3	SS	32								
	Brown, Dense to Very Dense		4	SS	38								
			5	SS	68								
84.8			6	SS	21								
8.6	End of Borehole • Formerly BH 1 (WP 125-87-00) • 88 11 28												



FORMER

RECORD OF BOREHOLE No 10

METRIC

W P 146-74-00 LOCATION Co-ords. N 5 020 521.9; E 359 252.3  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger ORIGINATED BY HS  
DATUM Geodetic DATE 84 05 16 COMPILED BY IR  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
97.6	Ground Surface																
0.0																	
	Sand		1	SS	18												
	trace silt		2	SS	16												
	Compact		3	SS	21												
			4	SS	22												
			5	SS	20												
			6	SS	38												
			7	SS	30												
			8	SS	29												
			9	SS	40												
			10	SS	39												
			11	SS	17												
			12	SS	16												
82.5																	
15.1																	

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5; Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

**FORMER**

RECORD OF BOREHOLE No 10 Continued

**METRIC**

W P 146-74-00

LOCATION Co.ords. N 5 020 521.9; E 359 252.3

ORIGINATED BY HS

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY IR

DATUM Geodetic

DATE 84 05 16

CHECKED BY \_\_\_\_\_

[illegible]

\*3, x3: Numbers refer to Sensitivity

20  
15  $\pm$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

## FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

PROJECT NAME: BRUCE PIT

CRA - 5

PROJECT NO.: 2396

HOLE DESIGNATION: OW5-88

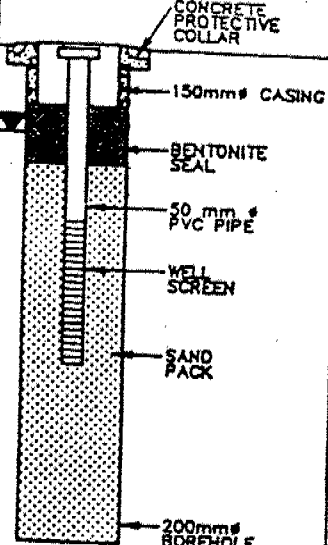
CLIENT: MTO

DATE COMPLETED: 26 APR 1988

LOCATION: AS PER PLAN

DRILLING METHOD: 108 mm ID HSA

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VOLUME
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53	 <p>CONCRETE PROTECTIVE COLLAR</p> <p>150mm# CASING</p> <p>BENTONITE SEAL</p> <p>50 mm # PVC PIPE</p> <p>WELL SCREEN</p> <p>SAND PACK</p> <p>200mm# BOREHOLE</p>			
- 1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.	87.63				
- 2.0	- wet			1SS	×	17
- 3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		2SS	×	20
- 4.0	- siltier, not as dense			3SS	×	15
- 5.0	END OF HOLE • 5.18 m BGS.	83.35				
- 6.0			<p><b>SCREEN DETAILS:</b>  Screened Interval:  85.18 to 86.71 AMSL  Length -1.52m  Diameter -50mm  Slot # 10  Material- PVC</p>			
- 7.0						
- 8.0						
- 9.0						
- 10.0						
- 11.0						
- 12.0						
- 13.0						

## NOTES:

MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



2/05/88

FORMER

RECORD OF BOREHOLE No 17-1

1 OF 1

METRIC

W.P. 121-87-00

LOCATION

Co-ords N5 020 689.5, E 359 118.5

ORIGINATED BY TS

DIST 9

HWY 416

BOREHOLE TYPE

HS AUGER, BW/AW Casing, Washboring, AQ Rock Core

COMPILED BY TS

DATUM Geodetic

DATE

80 12 17-20

CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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					
97.4	Ground Surface												
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel with traces of ash and wood (Fill Material) Brown, Very Soft to Firm		1	SS	6								
			2	SS	2								
			3	SS	2								
			4	SS	4								
92.1			5	SS	11								
5.3	Compact Dense to Very Dense		6	SS	9								
			7	SS	30								
			8	SS	39								
	Gravelly Sand trace Silt Brown		9	SS	52								
			10	SS	66								
			11	SS	43								
			12	SS	48								
			13	SS	40								
79.1			14	SS	34								
18.3	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Gray, Very Dense		15	SS	50								
73.3			16	RC	REC 6%								
24.1	Bedrock, Dolomite Gray, Medium Strong Unweathered		17	SS	17%								
71.7			18	RC	REC 100%								
25.7	End of Borehole												
	• 90 12 21												

FORMER			RECORD OF BOREHOLE No 5				METRIC				
W P 146-74-00		LOCATION Co-ords. N 5 020 688.8; E 359 110.3		ORIGINATED BY HS							
DIST 9 HWY 416		BOREHOLE TYPE Hollow Stem Auger		COMPILED BY IR							
DATUM Geodetic		DATE 84 05 15		CHECKED BY							
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	Wp W WL	WATER CONTENT (%)	GR SA SI CL
98.1	Ground Surface										
0.0	Landfill Silty Sand trace gravel		1	SS	15		98				
	Sand some silt trace gravel pieces of wire cable, rubber tires		2	SS	5		97				
	Loose to Compact		3	SS	14		96				
			4	SS	7		95				
92.9							94				
5.2	Sand with gravel some silt		5	SS	72		93				
			6	SS	38		92				
	Dense to Very Dense		7	SS	49		91				
			8	SS	100		90				
85.9							89				
12.2	End of Borehole						88				
	* Note: Groundwater Elevation assumed to be at the Elevation of Caving in the Open Borehole.						87				
							86				

OFFICE REPORT ON SOIL EXPLORATION

## FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

CRA - 4

PROJECT NAME: BRUCE PIT

PROJECT NO.: 2396

CLIENT: MTO

LOCATION: AS PER PLAN

HOLE DESIGNATION: OW4-88

DATE COMPLETED: 27 APR 1988

DRILLING METHOD: 108 mm ID HSA

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE			
				NUMBER	STATE	VALUE	HNU
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	95.707 95.71	CONCRETE PROTECTIVE COLLAR				
	REFUSE: decayed domestic garbage, plastic, wood, black, moist, compact.		150mm Ø CASING				
1.0			200mm Ø BOREHOLE				
2.0			CEMENT/BENTONITE GROUT				
3.0			50 mm Ø PVC PIPE				
4.0							
5.0							
6.0							
7.0	SP SAND: trace silt, compact, medium grained, uniform, massive, light gray-brown, moist, garbage odour.	89.46	BENTONITE SEAL	1SS	32	3	
8.0	- occasional thin seam of coarse sand	87.87		2SS	32	2	
9.0							
10.0	SM SAND: little silt, dense, fine grained, poorly graded, gray-brown, massive, very moist, garbage odour.	86.56	SAND PACK	3SS	29		
11.0			WELL SCREEN				
12.0	ML SILT: some sand, compact, layered, thin laminations of fine sand, wet, gray, slight garbage odour.	84.67		4SS	27		
13.0	SM SAND: little silt, fine grained, poorly graded, massive, compact, grey, wet, odourless.	83.15 82.91		5SS	17		
	END OF HOLE @ 12.80 m BGS. * - HNU READING FROM SAMPLE HEAD SPACE		SCREEN DETAILS: Screened Interval: 84.73 to 87.78 AMSL Length - 3.05m Diameter - 50mm Slot # 10 Material - PVC				

## NOTES:

MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



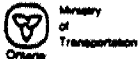
WATER FOUND



STATIC WATER LEVEL



5/05/88



POLE NO C7

W.P. 121-87-00

## FORMER

## RECORD OF BOREHOLE No 89-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 917; E 359 045 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing COMPILED BY A.C.  
DATUM Geodetic DATE May 30, 1989 CHECKED BY A.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
89.7	Ground Surface																
0.0	Topsoil																
0.2	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11												
			2	SS	6												
87.0	Very Stiff Grey Brown		3	SS	4												
2.7	Silty clay and clayey silt, trace gravel and sand		4	SS	2												
			5	SS	WH*												
			6	TW	WH*												
84.1	Firm to Stiff Grey																
5.6	Sand, fine to coarse, trace gravel, trace to some silt		7	SS	31												
			8	SS	18												
81.6	Compact to Very Dense Grey Brown		9	SS	>100												
8.1	Sand, trace gravel, trace to some silt, some silty fine sand		10	SS	105												
80.6	seams occasional cobble																
9.1	Very Dense Grey Brown																
	End of Borehole																
	*Sank under weight of hammer																

\*3, \*5: Numbers refer to 20  
Sensitivity 15-5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXAMINATION

FORMER

RECORD OF BOREHOLE No. 89-17

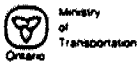
METRIC

W.P. 146-74-00-3 LOCATION Co-ords N 5 020 864; E 359 112 ORIGINATED BY L.C.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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	20 40 60 80 100	20 40 60 80 100					
95.3	Ground Surface															
0.1	Silty sand						95									
94.8	Brown															
0.5	Probably silty clay, some sand, trace gravel						94									
93.3	Grey Brown															
2.0	Probably sand and gravel, trace silt, occasional cobble						93									
91.6							92									
3.7	Sand, fine to medium and fine to coarse, trace gravel and silt						91									
			1	SS	33		90									
			2	SS	35		89									
87.7	Dense Grey Brown						88									
7.6	Sand and gravel, trace silt, occasional cobble		3	SS	60/150 mm		87									
							86									
85.5	Very Dense Grey to Dense Brown		4	SS	44											
9.8	End of Borehole															
	* Note: Water level not established						85									

OFFICE REPORT ON SOIL EXPLORATION





POLE NO C7

W.P. 121-87-00

FORMER			RECORD OF BOREHOLE No. 89-18				METRIC					
W P 146-74-00-3		LOCATION Co-ords N 5 020 817; E 359 130		ORIGINATED BY A.C.								
DIST 9 HWY 416		BOREHOLE TYPE Hollow Stem Auger		COMPILED BY A.C.								
DATUM Geodetic		DATE July 10, 1989		CHECKED BY A.C.								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
97.1	Ground Surface											
0.0	Topsoil											
0.1	Silty Sand											
96.5	Brown											
0.6	Silty Clay (weathered crust)											
95.9	Gray Brown											
1.2	Probably sand, some gravel, occasional cobble											
90.1	Brown		1	SS	74							
7.0	Sand, fine to coarse, trace gravel and silt		2	SS	35							
88.4	Dense Grey Brown											
8.7	Sand, fine to medium and fine to coarse, trace gravel, trace to some silt		3	SS	34							
85.8	Dense Grey Brown		4	SS	30							
11.3	End of Borehole											
	* Note: Water level not established											

FORMER			RECORD OF BOREHOLE No 89-4				METRIC					
W P 146-74-00-3		LOCATION Co-ords N 5020 995; E 359 010		ORIGINATED BY R.B.								
DIST 9 HWY 416		BOREHOLE TYPE Hollow Stem Auger		COMPILED BY A.C.								
DATUM Geodetic		DATE May 29, 1989		CHECKED BY A.C.								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
88.5	Ground Surface											
0.0	Topsoil											
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	9							
86.2	Very Stiff Grey Brown		2	SS	7							
2.3	Silty clay, some sand and silty sand seams		3	SS	2							
			4	SS	WH*							
	Stiff Grey		5	SS	2							
82.1	Sand, some gravel, trace silt		6	SS	2							
6.4	Silty clay, trace sand and silty sand seams		7	SS	1							
6.6	Stiff Grey		8	SS	2							
80.1	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand layers		9	SS	16							
8.4	Very loose Grey and to Compact Grey Brown		10	SS	42							
78.3	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams		11	SS	25							
10.2	Compact to Dense Grey and Grey Brown											
Continued												

FORMER

RECORD OF BOREHOLE No 89-4 Continued METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 995; E 359 010 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 29, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued																
	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams.					Well Screen 75											
	Compact Grey sand to Dense Grey Brown					74											
73.1			12	SS	>100												
15.4	End of Borehole Auger Refusal																
	*Sank under weight of hammer																

UNITED REPORT ON SOIL EXAMINATION

FORMER

RECORD OF BOREHOLE No 89-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 917: E 359 045 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing COMPILED BY A.C.  
DATUM Geodetic DATE May 30, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
89.7	Ground Surface																
0.0	Topsoil																
0.2	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11												
	Very Stiff	Grey Brown	2	SS	6												
87.0			3	SS	4												
2.7	Silty clay and clayey silt, trace gravel and sand		4	SS	2												
			5	SS	WH*												
	Firm to Stiff	Grey	6	TW	WH*												
84.1																	
5.6	Sand, fine to coarse, trace gravel, trace to some silt		7	SS	31												
			8	SS	18												
	Compact to Very Dense	Grey Brown	9	SS	>100												
81.6																	
81	Sand, trace gravel, trace to some silt, some silty fine sand seams occasional cobble		10	SS	103												
80.6																	
9.1	Very Dense End of Borehole	Grey Brown															
	*Sank under weight of hammer																



FORMER			RECORD OF BOREHOLE No 9				METRIC						
W P 146-74-00			LOCATION Co-ords. N 5 020 929.6; E 358 976.7				ORIGINATED BY HS						
DIST 9 HWY 416			BOREHOLE TYPE Hollow Stem Auger & Cone Test				COMPILED BY IR						
DATUM Geodetic			DATE 84 05 15				CHECKED BY						
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100					
88.6	Ground Surface												
0.0													
	Silty Clay		1	SS	4								
	some sand		2	SS	4								
	Stiff												
			3	TM	PH								
			4	SS	4								
	Occasional Silt and Sand Seams		5	SS	3								
82.2			6	SS	4								
6.4	Heterogeneous Mixture Silty Clay with sand trace gravel												
	Firm to Stiff		7	SS	13								
			8	SS	7								
78.4													
10.2	Sand some silt		9	CS									
77.9													
10.7	End of Borehole												

+3, x5: Numbers refer to  
Sensitivity20  
15 5 (%) STRAIN AT FAILURE  
10



## FORMER

## RECORD OF BOREHOLE No 90 - W30

METRIC

W P 126-87-01(A)

LOCATION Co-ords N 5 021 128; E 359 039

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY AC

DATUM GEODETIC

DATE July 15, 1990

COMPILED BY RN

CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
87.4	Ground Surface													
0.0	Topsoil													
0.2	Silty clay, some fine sand seams (weathered crust)					*								
85.3	Grey Brown						86							
2.1	Silty clay, some fine sand seams, trace to some fine gravel						84							
	Grey						82							
							80							
							78							
							76							
74.1			1	SS	7									
13.3	Sand, fine to coarse, trace silt						74							
	Loose Grey		2	SS	PM									
72.4														
15.0														

Continued

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity20  
15 5 (%) STRAIN AT FAILURE  
10

FORMER

RECORD OF BOREHOLE No 90 - W30

METRIC

W P 126-87-01(A)

LOCATION Co-ords N 5 021 128; E 359 039

ORIGINATED BY AC

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY RN

DATUM GEODETIC

DATE July 15, 1990

CHECKED BY RA

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 x LAB VANE

20 40 60 80 100

PLASTIC LIMIT

Wp

NATURAL MOISTURE CONTENT

W

LIQUID LIMIT

Wl

WATER CONTENT (%)

20 40 60

UNIT WEIGHT

Y

REMARKS  
&  
GRAIN SIZE  
DISTRIBUTION  
(%)

GR SA SI CL

ELEV  
DEPTH

DESCRIPTION

STRAT PLOT

NUMBER

TYPE

'N' VALUES

72.4

Continued

15.0

Sand, fine to coarse,  
trace silt

3

SS

PH

72

70.9

Loose Grey

16.5

End of Borehole  
Refusal to Auger  
Probable Bedrock

70

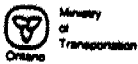
\* Note: Water level not  
established

68

OFFICE REPORT ON SOIL EXPLORATION

\*3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



POLE NO C9

W.P. 121-87-00

## FORMER

## RECORD OF BOREHOLE No 89-3

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 078; E 358 972  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger ORIGINATED BY R.B.  
DATUM Geodetic DATE May 25, 1989 COMPILED BY A.C.  
CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)			
87.7	Ground Surface													
0.0	Topsoil													GR SA SI CL
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	7									
	Very Stiff to Stiff Grey Brown		2	SS	5									
84.7			3	SS	1									
3.0	Silty clay, some silty sand and sand seams		4	SS	1									
	Stiff Grey		5	SS	1									
			6	SS	1									
79.8			7	SS	2									
7.9	Clayey silt, trace gravel and sand		8	SS	4									11 10 48 31
			9	SS	3									
			10	SS	1									
	Very Stiff to Stiff Grey		11	SS	3									
75.9			12	SS	7									
11.8	Silty sand, fine to medium, trace gravel, some silty clay seams		13	SS	16									
74.8	Compact Grey													
12.9	Sand, fine to coarse, some silt, trace gravel		14	SS	11									4 71 (25)
			15	SS	41									
73.0	Compact to Dense Grey													
14.7	End of Borehole Auger Refusal													

+3, x5: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE





**FORMER**

RECORD OF BOREHOLE No 90 - W6

**METRIC**

W D 126-87-01(A)

LOCATION Co-ords N 5 021 199; E 358 915

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY PH

DATUM \_\_\_\_\_ GEODETIC \_\_\_\_\_

DATE JULY 3, 1990

COMPILED BY RN

CHECKED BY AW

[illegible]

+3, x5: Numbers refer to Sensitivity

20  
13  $\diamond$  5 (%) STRAIN AT FAILURE  
10

FORMER

RECORD OF BOREHOLE No 90 - W7

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 181; E 358 923  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core  
DATUM GEODETIC DATE July 9, 1990  
ORIGINATED BY BB  
COMPILED BY RN  
CHECKED BY RN

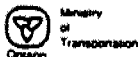
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE R <sub>20T</sub>					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.9	Ground Surface																
86.4	Topsoil																
86.4	Fill - silty sand																
0.5	Silty clay, some fine sand seams (weathered crust)																
84.6	Grey Brown		1	SS	5												
2.3	Silty clay, some sand seams																
84.1	Firm Grey																
78.8			2	SS	PM												
8.1	Silty sand, some fine to medium gravel Grey																
8.7	Silty clay, some sand seams																
75.8	Grey		3	SS	PM												
11.1	Sand and silt, some gravel and clay (glacial till)																
74.1	Very stiff Grey		4	SS	PM												
12.8	Dolomitic limestone, some shale partings, some coarse sandstone layers, occasional calcite inclusions, trace pyrite		5	SS	18												
71.9			6	RC BXL	* Rec-100% RQD-82%												
15.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

\* REC: Recovery  
RQD: Rock Quality Designation

\* 3, \* 5: Numbers refer to  
Sensitivity

20  
15 \* 5 (%) STRAIN AT FAILURE  
10



POLE NO C10

W.P. 121-87-00

## FORMER

RECORD OF BOREHOLE No. 89-10

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 206; E 358 886 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 21, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)					
86.6	Ground Surface																
0.0	Topsoil																
0.2	Probably Silty Clay																
							86										
							85										
							84										
							83										
82.2	Grey Brown to Grey																
4.4	Silty clay, trace gravel, occasional silty sand seam		1	SS	1		82										
81.1	Grey						81										
5.5	Sandy silt to silty sand, some gravel and clay		2	SS	14		80										
							79										
			3	SS	2		78										
77.9	Very Loose Grey																
8.7	Silty clay, some sand, trace gravel		4	SS	1		77										
76.4	Grey																
10.2	Probably silty sand						76										
75.9																	
10.7	End of Borehole						75										
	* Note: Water level not established																

3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

[illegible]

**FORMER**

## RECORD OF BOREHOLE No 108

METRIC

w p 126-87-01

LOCATION Coords N 5 021 301.1; E 358 935.3

ORIGINATED BY RH

DIST 9 HWY 416

BOREHOLE TYPE Hollow stem auger, BX rock core

COMPILED BY RH

DATUM Geodetic

DATE November 8, 9, 1989

CHECKED BY JSB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE (MPa)	FAST MIT	NATURAL WATER CONTENT (%)	UNIT WEIGHT  Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT. PLT.	NUMBER	TYPE	'N' VALUES*			20 40 60 80 100		SHEAR STRENGTH (kPa)			Wp W WL	20 40 60
								20 40 60 80 100		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL * LAB VANE			Wp W WL	20 40 60
85.0	Ground Surface					28/12/89								
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	8		84							
			2	TW	PH		83	10+						
	CI-CH (Marine Deposit)		3	TW	PH		82	12						
							81	+						
	Firm, becoming soft with depth		4	TW	PH		80	12+						
			5	TW	PH		79							
77.4	Gray						78	15						
7.6	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy SM-ML (Till)		6	TW	PH		77							
			7	SS	3		76							
							75							
73.5	Very loose to loose Dark Gray		8	SS	9		74							
11.5	Limestone bedrock with frequent dolomite beddings, very strong, fresh, vertical joints at approx. 13-m depth, filled with calcite.		9	RC BXL	REC 100%		73				27.3	RQD = 65%		
71.1	Gray		10	RC BXL	REC 94%		72					RQD = 42%		
13.9	End of borehole													
*For RC samples, numbers represent Core Recovery.														

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples,  
numbers represent  
Core Recovery.

\*3, x5: Numbers refer to Sensitivity

**FORMER**

## RECORD OF BOREHOLE No 90 - W15

**METRIC**

W P 126-87-01(A)

LOCATION Co-ords N 5 021 316; E 358 894

ORIGINATED BY AC

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY RN

DATUM \_\_\_\_\_ GEODETIC \_\_\_\_\_

DATE JUNE 29, 1990

CHECKED BY *EW*

[illegible]

+3, x5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

FORMER

RECORD OF BOREHOLE No 90 - W20

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 351; E 358 946 ORIGINATED BY AC  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE JUNE 29, 1990 CHECKED BY A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
85.2	Ground Surface																
0.0	Fill - mixture of sand and gravel, occasional cobble.					*											
84.1																	
83.7	Topsoil						84										
1.5	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown																
80.6							82										
4.6	Silty clay, occasional silty fine sand seams  Grey																
							80										
							78										
							76										
							74										
73.8																	
11.4	Sandy silt, some gravel and clay (glacial till)																
72.7	Grey																
12.5	End of Borehole Refusal to Auger Probable Bedrock  NOTE: * Water level not established						72										



FORMER

RECORD OF BOREHOLE No 90 - W21

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 328; E 358 956  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core  
 DATUM Geodetic DATE July 12 and 13, 1990  
 ORIGINATED BY PH  
 COMPILED BY RN  
 CHECKED BY RN

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
85.1	Ground Surface															
0.0	Topsoil															
0.2	Silty clay, some silty fine sand layer (weathered crust)															
	Very stiff to stiff		1	SS	11		84									
	Grey Brown		2	SS	7		Native Backfill									
82.2			3	SS	1											
2.9	Silty clay, some silty fine sand layer		4	SS	PM		82									
	Firm		5	SS	PM											
	Grey		6	SS	PM											
			7	SS	PM											
76.6			8A	SS	PM											
8.5	Silty clay, some silty fine sand layers, trace gravel		8B	SS	PM											
75.6			9	SS	2											
9.5	Sandy silt to clayey silt, some clay and gravel (glacial till)		10	SS	1											
	Very loose															
	Grey															
73.1																
12.0	Dolomitic Limestone Bedrock, fresh, some shale partings, some coarse sandstone seams, occasional calcite inclusions, trace pyrite		11	RC BXL	Rec- 100% RQD- 93%											
70.4																
14.7	End of Borehole															

\*Rec = Recovery  
 RQD = Rock Quality Designation

+3, x5: Numbers refer to  
 Sensitivity

20  
 15 + 5 (%) STRAIN AT FAILURE  
 10

FORMER

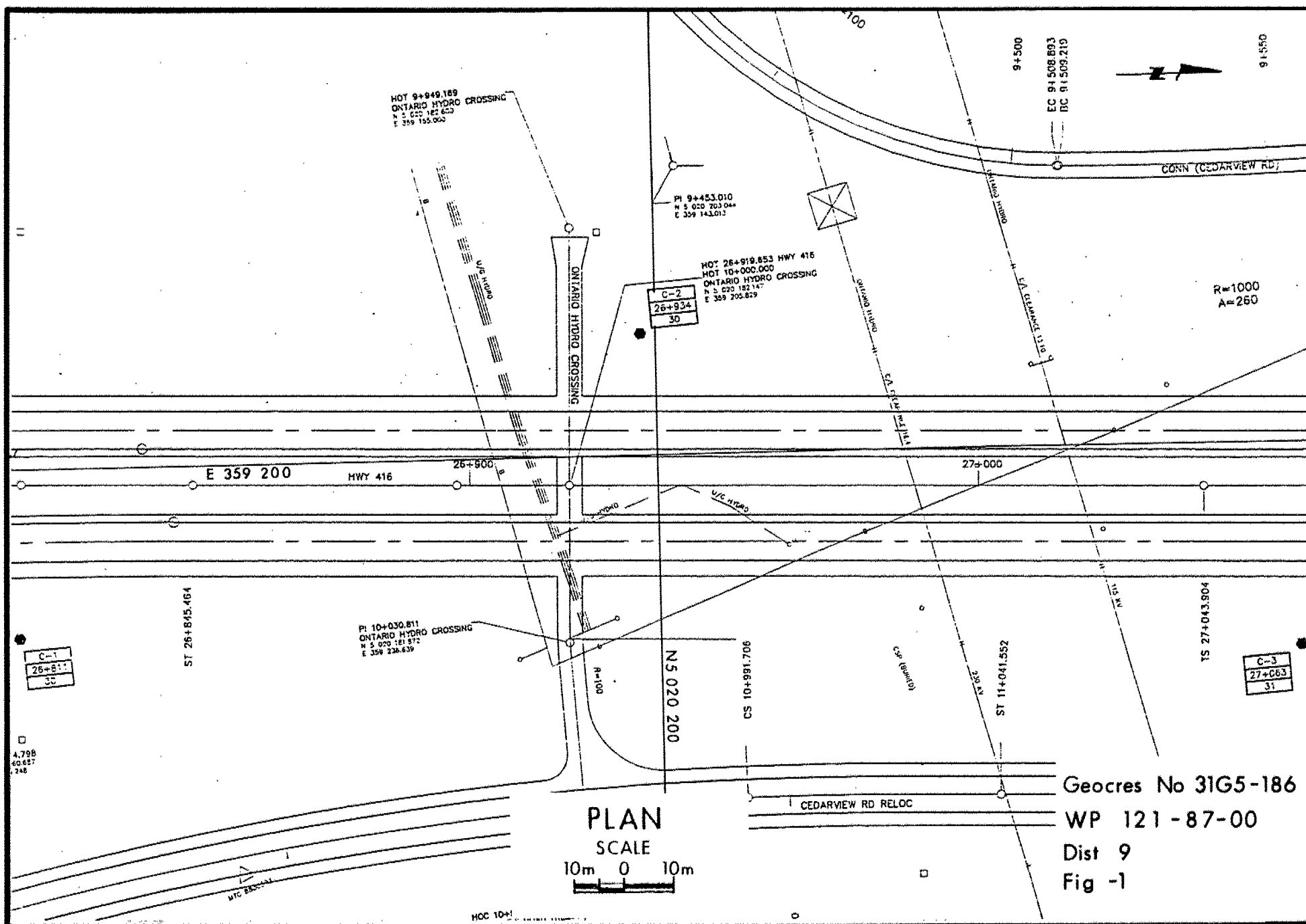
RECORD OF BOREHOLE No 16-2

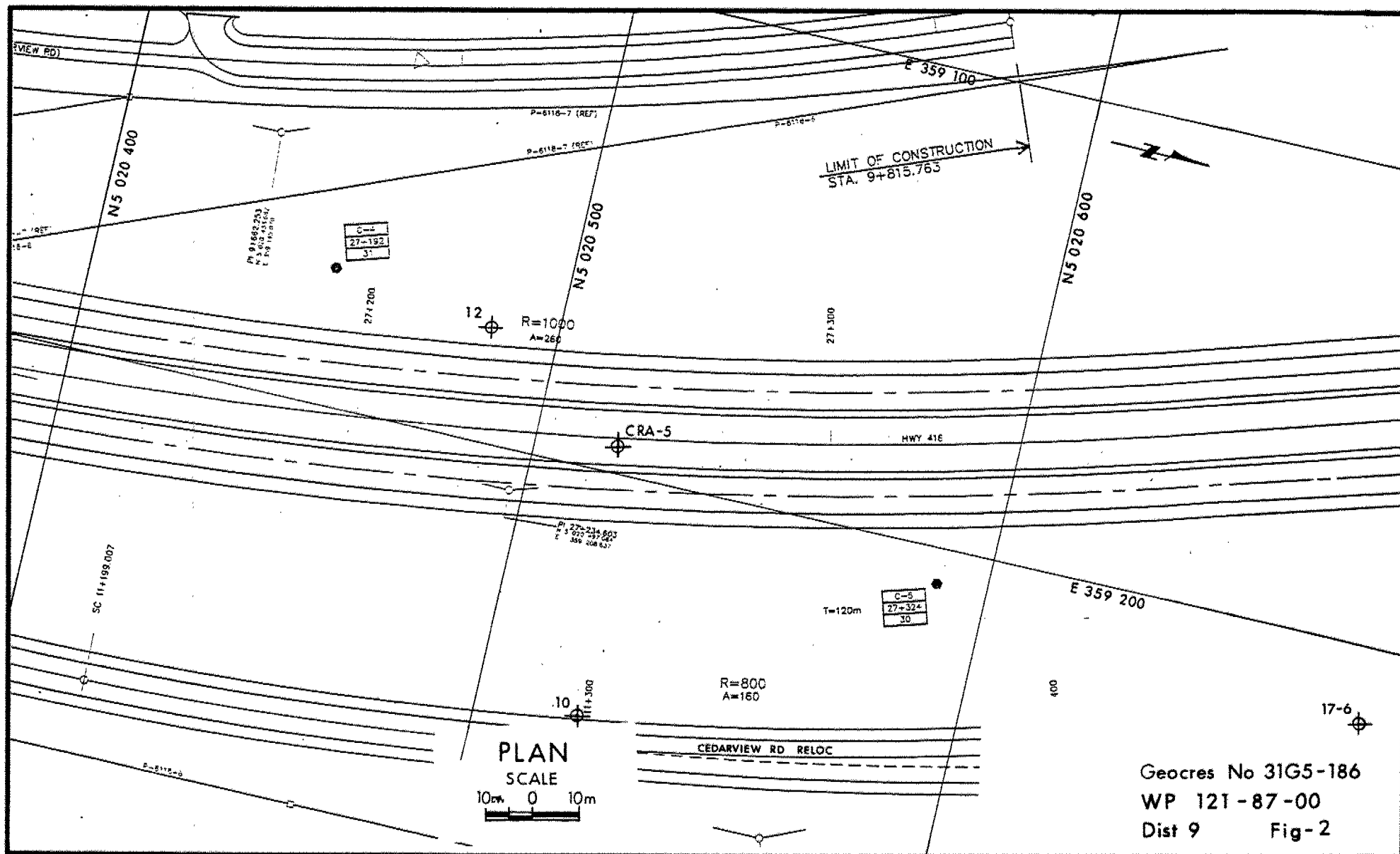
METRIC

W P 127-87-00A LOCATION Co-ords: N 5 021 337.2; E 358 935.0  
DIST 9 HWY 416 BOREHOLE TYPE HS Auger & Cone Test ORIGINATED BY JW  
DATUM Geodetic DATE 89 08 03 COMPILED BY JW  
CHECKED BY

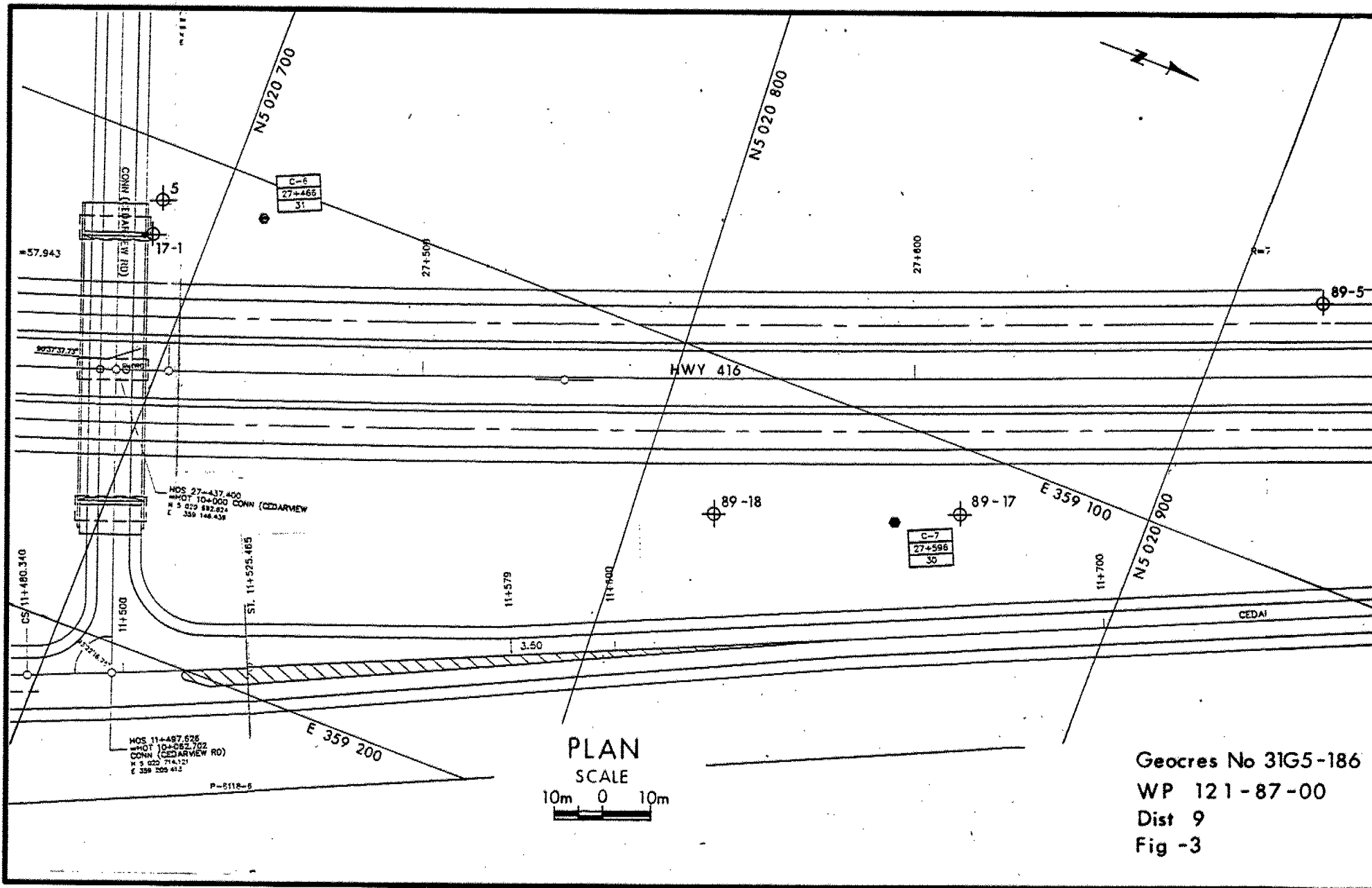
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	Wp	W	W <sub>L</sub>		
85.4	Ground Level													
0.0	Silty Clay to Clayey Silt Grey, Occ. Sand Seams Stiff Firm		1	SS	12		84							
			2	SS	8									
			3	SS	4		82							
			4	TW	PH									
			5	TW	PH		80						19.8	0 2 59 39
			6	TW	PH		78						18.1	0 17 58 25
			7	TW	PH									
76.7														
8.7	Het. Mixture of Silt, Sand and Gravel (Glacial Till)		8	SS	2		76							
			9	SS	1									
73.2							74							
12.2	End of Borehole Refusal to Auger (Probable Bedrock or Boulder)													

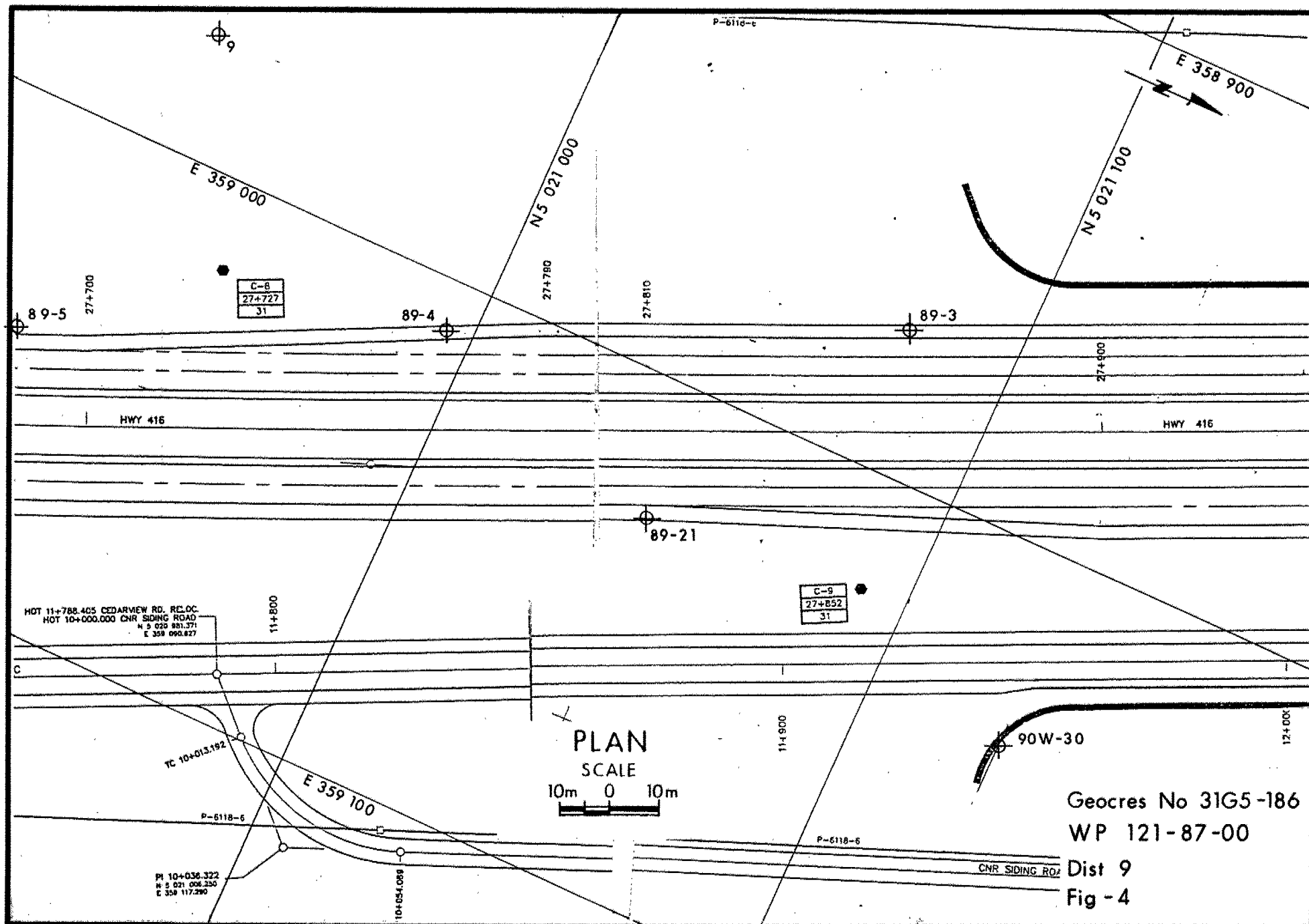
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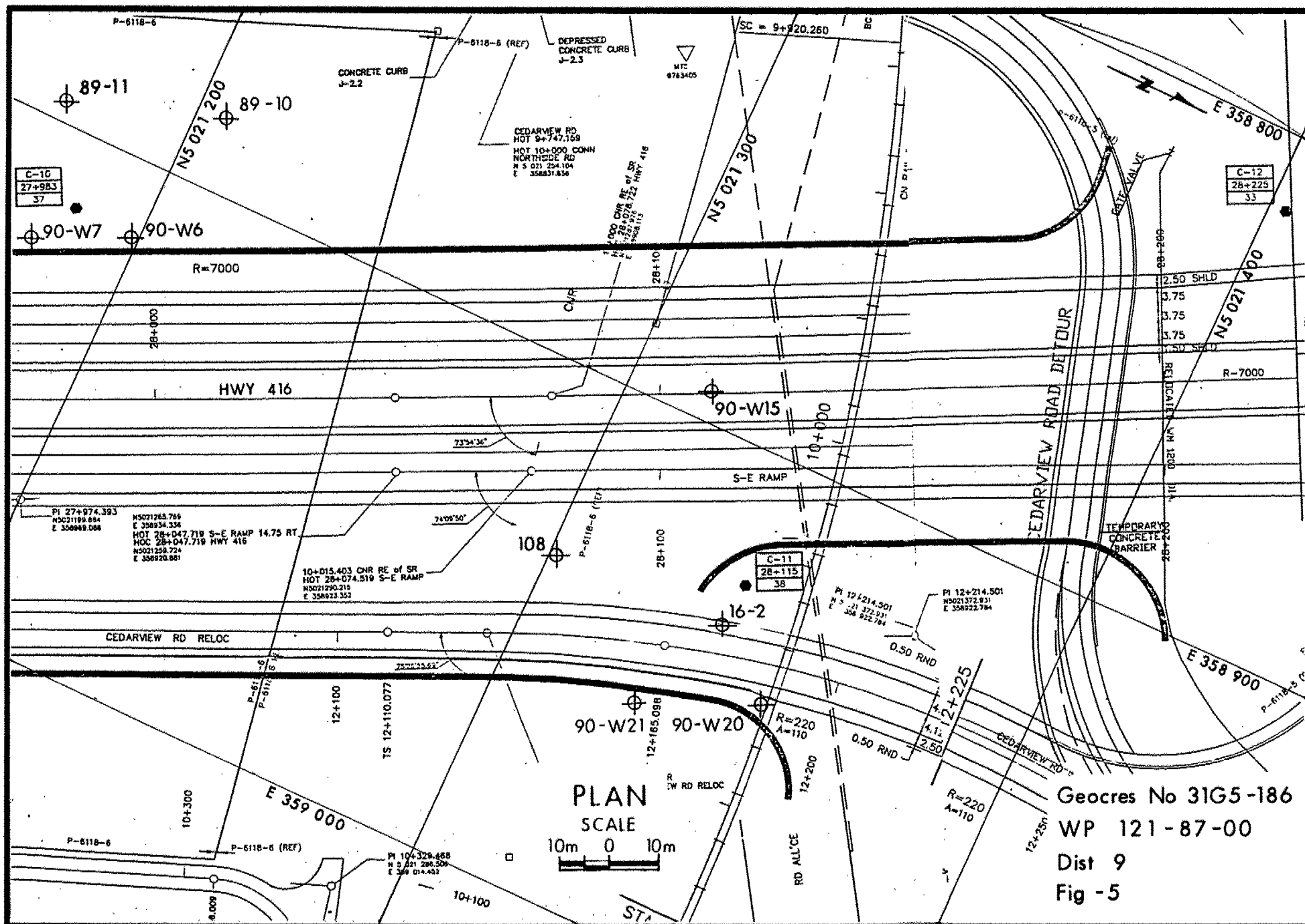




Geocres No 31G5-186  
 WP 121-87-00  
 Dist 9 Fig-2









# **Golder Associates Ltd.**

CONSULTING ENGINEERS

REPORT TO  
MINISTRY OF TRANSPORTATION ONTARIO

ENGINEERING STUDY  
PROPOSED CUT AND RAILWAY UNDERPASS  
HIGHWAY 416  
DISTRICT NO. 9 (OTTAWA)  
NEPEAN ONTARIO

W.P. 121 - 87 - 00

**Distribution:**

14 copies - Ministry of Transportation Ontario,  
Toronto, Ontario

2 copies - Golder Associates Ltd.,  
Mississauga, Ontario

August, 1990

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## 1.0 INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Golder Associates Ltd. (GA) to carry out an engineering study along the proposed Highway 416 adjacent to the Lynwood subdivision in Nepean, Ontario (see Site Location Plan, Figure 1). Highway 416 is to enter the Ottawa area as a six lane highway along the route of and just east of Cedarview Road, in the city of Nepean. It is planned to carry Highway 416 under the main CNR tracks which are immediately south of Baseline Road. The vertical alignment results in a cut of about 11 m at the railway, with the cut depth gradually decreasing towards the south as the highway approaches existing grade south of Bell High School at the top of an escarpment area. This cut section is adjacent to the Lynwood Subdivision. North of the railway track the ground surface falls off relatively quickly and the cut depth also decreases. This report presents the results for the study and also incorporates the discussion and comment during various meetings between MTO and GA, and between MTO, GA and FENCO.

## 2.0 TERMS OF REFERENCE

The scope of work for this project was outlined in Golder Associates' proposal to MTO, dated April 12, 1990.

After an assessment of available data on the shear strength parameters of the silty clay, the feasibility of the deep cuts along Highway 416 near the railway crossing is to be examined. The use of a diaphragm wall as a means of retaining the soil in the deeper sections of the cut (and also decreasing the volume of excavated clay to be wasted) is also to be examined. Considering the harsh climate of the Ottawa area, means to protect the wall from frost action are to be considered in this study. The earth pressure distribution required for the wall design is to be

included in the study as well as drainage concerns. The study would address whether competent contractors are available to construct this wall and at what approximate cost.

The excavation of clay to the depths proposed will probably involve a two stage dig. The study is to comment on excavation methodology and on procedures that would be required to provide trafficability to construction equipment operating on the surface of the clay. The study is to comment on the difficulties of transportation and disposal of the sensitive clay.

### 3.0 LIST OF DATA REVIEWED

- o Geotechnical and Groundwater study. Proposed Highway 416. Cedarview Road Corridor Near the Lynwood Subdivision. W.P. 146-74-00-3 District 9 (Ottawa) Nepean, Ontario (Golder Associates Report to MTO, Report No. 891-2208). January, 1990.
- o Foundation Investigation. Proposed Jock River Bridges, Highway 416. W.P. 128-87-07/08 District 9 (Ottawa), Nepean, Ontario (Golder Associates Report to MTO, Report No. 891-2251). September, 1989.
- o Geotechnical Investigation. Proposed Diaphragm Walls and Stability of Cuts at Highway 416. W.P. 126-87-01-A District 9 (Ottawa), Nepean, Ontario (Golder Associates Report to MTO, Report No. 901-2256). August, 1990.
- o Foundation Investigation for Bridge Structure. Proposed Highway 416 and CNR Subway. District No. 9, Ottawa, WP 126-87-01, Site 3-544 (Acres Report to MTO). February, 1990.
- o Foundation Investigation Report. Geocon Limited, Consulting Engineers. Proposed Highway 7 and 15 Underpass, District 9 (Ottawa) - W.P. 908-64.
- o MTO Borehole data, 1966 and 1984.
- o Golder Associates in-house data regarding experience of local slopes.
- o Golder Associates Report No. 901-2115 on Pump Test. (In preparation).

#### 4.0 SUBSURFACE CONDITIONS

The subsurface conditions in the study area, along the route of the proposed Highway 416, generally consist of sensitive silty clay of variable thickness overlying discontinuous deposits of silty sand and gravel which, in turn, overlies dolomitic limestone bedrock. In some areas, a layer of glacial deposit composed of sandy silt and clay and gravel follows the silty clay layer, and this glacial till layer overlies bedrock. The ground water level measured in standpipes sealed in the overburden and the bedrock indicates a general pattern of underdrainage.

The locations of boreholes put down in the area of deeper cut are shown on Figure 2, the borehole location plan. The boreholes were put down during current (1990) geotechnical investigations carried out by GA, and during previous investigations by MTO, GA and Acres. The soil profiles along section A-A (west of centreline of highway alignment) and B-B (east of centreline of highway alignment) are shown on Figures 3A and 3B, respectively. The subsoil conditions generally consist of a relatively deep deposit of sensitive silty clay, the upper layer of which is grey-brown and weathered, the lower layer being grey in colour and unweathered; this is followed by granular glacial and fluvial deposits which overlie dolomitic limestone bedrock. The bedrock profile was determined by boreholes where coring was carried out and inferred by boreholes which were augered to refusal. Boreholes were spaced generally at 20 m intervals. In general, the bedrock surface is relatively level, ranging from Elevation 71 m to Elevation 76 m across the site. Karst structures were not encountered at the borehole locations, though localized occurrence of such conditions has been reported in the Ottawa area. The soil

and rock conditions defined in the current investigations are consistent with the results of previous investigations.

During service clearance for drilling in the current 1990 investigations, a gas, a sanitary and 1,220 mm diameter watermain lines were reported in the general area of the deep cut section. The approximate locations for these lines are shown on Figure 2.

#### **5.0 ASSESSMENT OF UNDRAINED SHEAR STRENGTH FOR USE IN DESIGN**

Data concerning undrained shear strengths of the clay at the site and in the general area have been obtained by GA, MTO and Acres. The variation(s) of undrained strength,  $S_u$ , with elevation are plotted in Figures 4, 5 and 6, based on Acres data, MTO and GA Lynwood data, and GA Jock River data respectively.

A composite plot for all of the data is shown on Figure 7, which indicates the variation of  $S_u$  with elevation; from the  $S_u$  data, a design profile is delineated. This  $S_u$  profile comprises a strong top layer followed by a thin soft layer of 20 kPa and a thick lower layer of 30 kPa.

#### **6.0 ASSESSMENT OF EFFECTIVE STRESS PARAMETERS FOR USE IN DESIGN**

The Mohr circles for consolidated undrained triaxial tests with pore pressure measurements carried out by Acres are shown on Figure 8, which indicates an interpretation of the strength envelope  $\phi'$  of  $23^\circ$  in the normally consolidated stress range. For the average stress range appropriate for 5 m to 15 m slope cuts, a strength envelope of  $\phi' = 25^\circ$  to  $26^\circ$  can be drawn, together with a cohesion intercept,  $C'$ , which varies from about 0 to 12 kPa. This interpretation

for the effective stress parameters is shown in Figure 9. For purposes of analysis, a value of 5 kPa was used for  $c'$ .

#### 7.0 LOCAL EXPERIENCE WITH SIMILAR CUT SLOPES

A synthesis of some local experience with safe slope cuts in sensitive soft clays is illustrated in Figure 10, which plots  $\gamma H/S_u$  (where  $\gamma$  = total unit weight of soil, and  $H$  = height of slope cut) against the slope angle  $\beta$ . Tabulated slope data on which data in Figure 10 are based, are shown in Table 1.

On the basis of these data, a boundary limit can be set to represent "safe local slopes" in terms of strength, height and slope angle. However local experience has also shown that surface sloughing can occur even in "safe" areas, if the slope surface is steeper than  $26^\circ$ .

#### 8.0 DETERMINATION OF SAFE CUT SLOPE

The stability of a proposed slope cut of 2.5(H):1(V) ( $\beta = 22^\circ$ ) is examined below. Design analyses are based on the design strength parameters previously determined.

##### 8.1 Undrained Analysis

The results of slip circle analysis for 7 m and 11 m slopes, using the design profile in Figure 7 are shown on Figures 11 and 12 respectively. For a cut slope of 11 m, the calculated factors of safety,  $F$ , for the cases of no surcharge and an applied rail surcharge of 75 kPa are 1.4 and 1.05 respectively. The calculated factors of safety are shown on Table 2. These calculated values of  $F$  may be compared with the local slope data on Figure 10 and the "calculated" safety factor,  $F$ , can thus be calibrated to

derive an "operational value",  $F'$ , which correlates with observational data. From Figure 10, the operational factor of safety,  $F'$ , for a 7 m cut is thus about 1.5. For an 8 m cut it is about 1.3 to 1.5 and, for a deeper cut of 11 m, it reduces to about unity.

## 8.2 Effective Stress Analysis

The results of effective stress analyses using the parameters derived from Figure 9, namely  $C' = 5$  kPa and  $\phi' = 26^\circ$ , are shown on Figure 13. These parameters are consistent with local failures at the toe of steep slopes due to high  $r_u$  values (where  $r_u$  = ratio of pore pressure to total vertical pressure) where  $F$  approaches unity. The phreatic surface and potential slip surfaces suggest an average pore pressure ratio,  $r_u$  of about 0.3 over the entire slope with a local  $r_u$  of 0.5 at the toe. Computed factors of safety range from 1.3 for a 5 m to 6 m cut, to 1.2 for a 10 m to 11 m cut, and to 1.1 or less for 15 m cut. Reference to the normalized slope data shown on Figure 10, indicates that these effective stress analyses are consistent with the slope experience reflected in Figure 10.

## 8.3 Recommended Slope

Based on this assessment it is considered that both temporary and final cuts of between 7 m and 8 m can be safely excavated at side slopes of 2.5(H):1(V), which fits within established precedents in this area. For design, it is recommended that the final cuts be restricted to a maximum depth of 7.5 m, using side slopes of 2.5(H):1(V).

The drainage system in the slope is essential for long term stability and erosion protection. Treatment of the slope



surface for erosion protection should be provided by a granular cover consisting of a 0.5 m thick layer of gravel, cobble, or fine rockfill, overlying 0.5 m of concrete fine aggregate (sand). Drainage within the slope may be provided using conventional counterfort drains at 10 m centres and at least 1.8 m deep below surface grade to prevent freezing of the drains. Trenching should be carried out continuously, being backfilled immediately with concrete fine aggregate (sand).

#### 9.0 MODIFICATIONS TO CUT SLOPES

Cuts within Leda clay deeper than 7.5 m at 2.5 (H):1(V) are beyond most precedent data and will require flatter side slopes or modifications to the slopes to ensure stability. Accordingly, the maximum depth of cut in clay for this project should be 7.5 m. This critical height corresponds to the distance from ground surface to the maximum excavated level, namely, the ditch invert (Refer to inset in Figure 10). Various possible modifications of cut slopes through the use of berms and partial retaining walls have been examined; the intent being to steepen the cut slopes without reducing stability. Both upper walls and toe walls have been examined, but are considered to be unsuitable options for the site. An upper wall will have to be founded in the soft clay layer; a toe wall requires a substantial initial excavation at the toe of the slope, thereby reducing the overall stability of the slope during construction; a toe wall for a deep slope cut will have also to be relatively massive, and to be effective, must be founded on bedrock. Thus both of these types of modifications are not recommended. As an alternative, it is recommended that consideration be given to replacing the cut slope with a vertical wall, as discussed below.

#### 10.0 REPLACEMENT OF SLOPE BY VERTICAL DIAPHRAGM WALLS

Adequate precedents for permanent anchored walls exist. Case histories of the construction and behaviour of such anchored walls are documented in the literature, and confirmed by our experience with diaphragm walls.

To replace cut slopes deeper than 7.5 m, vertical diaphragm walls with tie backs are recommended. The site conditions are favourable for such a retaining system. Bedrock is at a relatively shallow depth so that vertical walls could be taken to rock and inclined tie backs could also be anchored in rock. A further advantage is that concrete walls taken to rock can be incorporated into the design of railway bridge abutments, if required.

At locations where the cut depth is marginal, namely, at or only slightly exceeding 7.5 m, the following may be considered:

- o Raising the road grade to reduce the required depth of cuts;
- o flattening the slope to 3.5(H):1(V) to increase stability should space permit;
- o removing soil at the top of the slope for a distance of 15 m to 20 m behind the crest to reduce height of slope; and,
- o constructing a mid-height berm.

Where soil is removed from the top of slope, the depth of excavation preferably should not exceed 0.5 m, so as to leave as much stiff clay crust as possible. The option for constructing a mid-height berm is not desirable since construction and equipment traffic will disturb the soft clay berm.

### 10.1 Design Earth Pressure(s)/Anchor Loads

The prediction of lateral earth pressures for this type of construction involves assumptions concerning both the soil parameters and the method of construction. Estimates of the possible range of lateral pressures to be expected, based on established prior experience, is illustrated in Figure 14. Possible envelopes of wall loading, based on both rectangular and triangular earth pressure distributions and on possible hydrostatic pressures are shown in the figure. (Note: Recorded observations and data for tied back walls show wide variations in loading. However, since in practically all cases the anchors were pre-stressed to approximately the design loads, the measurements only indicate that the design loads were not exceeded).

Taking the long term loading conditions into account, a lateral coefficient of earth pressure of 0.5 should be used in design. Possible design loadings are illustrated in Figure 14 for a cut with 10 m depth. For the wall loadings estimated, tie back anchor loads of the order of 500 kN to 1,000 kN are possible, depending on the pattern and number of anchors used. Such anchor loads can readily be developed by anchorage within the dolomitic limestone bedrock at the site. Some design parameters are presented in Appendix A.

### 10.2 Wall/Tie Back Arrangement

Deep excavations in soft to firm clays are subject to base heave failure if the foundation soil is overstressed in shear. Based on the shear strength data, vertical deep cuts at the site would be subject to basal instability if founded in the soft to firm clay layer. However, if rigid

walls are extended below the bottom of the clay cut, the wall stiffness reduces the tendency for the clay to be displaced toward the excavation and consequently inhibits heave. In areas where the vertical wall cut is to be located, the stratigraphy generally consists of soft to firm clay overlying a layer of loose sandy silt till, unsuitable for use as a founding stratum. It is, therefore, necessary to extend walls, a minimum of 0.5 m below the surface of the dolomitic limestone to unweathered rock.

Provided that the wall is rigid and good workmanship is maintained, horizontal deformations during construction should be modest and less than 0.5 per cent of the depth of excavation. Adequate rigidity is normally obtained by using a concrete wall thickness of 0.7 m and sufficient reinforcement to give a wall stiffness approaching 1,000 MN m<sup>2</sup>/m of wall.

A typical tie back diaphragm wall system is shown on Figure 15. In this example, the diaphragm wall shown (Part(a) of Figure 15) is supported by four levels of rock anchors, a row of anchors being installed at the toe of the wall for stability in preference to excavating for deep embedment in bedrock. Where the cut extends below bedrock due to road pavement requirements, the wall section may be founded in rock and provided with a rock-bench set-back as shown on part(b) of Figure 15.

To inhibit corrosion, it is recommended that all tie backs be double-proofed. This is now standard practice for anchors and experience to date has been good.

### **10.3 Provision of Frost Protection**

Nepean is in an area with a Freezing Index of about 1000 degree (Centigrade) days with a possible depth of frost penetration of 1.8 m. Where concrete diaphragm walls are used, insulation is required to prevent freezing of frost susceptible soils behind the walls which could induce excessive lateral forces due to frost action. It is suggested that Styrofoam SM, or equivalent, be used as insulation, with a minimum thickness of 150 mm being provided behind the wall facing.

### **10.4 Availability of Contractors/Costs**

In our opinion, there are adequate numbers of contractors who are experienced in construction of this kind of wall system.

Recent contracts in Toronto and Ottawa suggest that a unit cost of about \$1000 to \$1100 per square metre of wall face is a reasonable estimate for costing in 1991 dollars. (This figure assumes minimal chiselling of the wall into bedrock and includes the cost of tie backs, insulation and facing panels. A cost surcharge may need to be added for contractors' mobilization to Ottawa).

### **11.0 GROUND WATER CONTROL**

Ground water control will be essential during construction and positive permanent under-drainage will be needed below the final pavement. To maintain stability of the base of the cuts, drainage of slope faces and at the toe of the slopes should be directed to a permanent longitudinal drainage system. It is likely that pumping with adequate controls will be required during construction.

The proposed highway cut will be carried out through sand and gravel, and through silty clay underlain, in areas, by pervious sandy deposits. To facilitate construction of the roadway through the pervious deposits, the ground water level will have to be lowered to below the level of the bottom of the excavation, so as to allow construction and excavation in the dry. Where the bottom of the excavation is underlain by impervious silty clay which is, in turn, underlain by a pervious stratum under hydrostatic pressure, basal heave or a "blow" may occur if the net hydrostatic pressure on the bottom of impervious stratum is greater than the weight of the overlying soil. To prevent basal heave and disturbance of the sensitive clay, the piezometric pressure of the bottom pervious layer must be lowered.

#### 11.1 Temporary Dewatering

The piezometric water levels in the lower deposits and bedrock, immediately beneath the base of the open cuts and within diaphragm walls, should at all times during excavation and following completion of excavation, be below the level of the base. The water level in the lower deposits and bedrock should be maintained at this lowered level throughout the construction period of the structure and until a permanent under-drainage system is installed and operating.

It is recommended that a "performance specification" be used in that only the results which must be achieved by the temporary dewatering system are specified; the type of dewatering system to be installed at the site being the responsibility of the contractor.

The design, installation and maintenance of the temporary dewatering system should be the responsibility of the contractor, but the system installed at the site should be acceptable to the Engineer/MTO and should meet certain minimum requirements. Consequently, the contractor should be instructed to submit a detailed description of the proposed temporary dewatering system for approval at least 2 weeks before he intends to begin installation of the system. The system should be designed to lower and maintain the piezometric water level in the bedrock and lower pervious deposits to below the base(s) of excavation at all stages of excavation. The system should be designed and installed by a recognized company or person experienced in the design and operation of dewatering systems.

The bedrock and lower pervious deposits will recharge if pumping is stopped. Furthermore, because a large part of the base of the excavation is within granular soil which may "pipe", if subjected to any appreciable upward seepage force, standby pumps and alternative power sources should be available at the site.

To enforce the performance specification, piezometric levels below the base must be monitored during excavation and throughout the period that the temporary construction excavation will be open. The drawdown should be monitored by means of piezometers and by standpipes. The location of piezometers or standpipes will depend on the locations at which wells or well-points are installed and consequently can only be selected after the contractor's particular dewatering system has been approved. Provision should be made in the specifications for installing monitoring piezometers on at least 50 m centres within the area of the excavation bottom. All of these piezometers need not be installed initially, but could prove to be necessary should

the drawdown pattern beneath the area of the excavation bottom be erratic. These piezometers should be installed near the toe of the temporary excavation side slopes so that they will not be covered by the structure and thus be destroyed during construction.

### **11.2 Permanent Dewatering**

In the long term, it is necessary to control the ground water inflow in the slopes and prevent buildup of hydrostatic pressure below the roadway.

The underdrainage system for permanent dewatering may consist of continuous embedded horizontal drains along the length of the roadway together with vertical relief wells, as required. Such wells could be located within the east and west ditches of the roadway cut in the deep sections.

Details of the permanent drainage system can best be defined after assessment of the pump test data (Report 901-2115, in preparation).

### **12.0 COMMENTS ON ROADWAY EXCAVATION AND CONSTRUCTION**

Two stage excavation will likely be required where the depth of the cut is about 7 m to 8 m; where the depth reduces to about 6 m, the excavation could readily be carried out in one stage.

All the excavation should be planned using large hydraulic shovel(s) with trucks for haulage. No heavy equipment should be permitted to operate within 1.5 m of the final subgrade. Any excavation equipment must be fitted with a smooth excavation blade. Conventional excavator buckets



with teeth will cause unnecessary and excessive disturbance to the subgrade.

In general, the soft clays are weak for road subgrade and require sub-excavation and replacement with granular material. The sands and till are suitable for road subgrades and do not require sub-excavation. Localized loose granular native soils may require compaction by a few passes of a roller.

Temporary slopes may be cut to a maximum depth of 7.5 m; excavations below this depth, such as for the construction of pavement subbase and base courses, should only be carried out in strips of 5 m perpendicular to the slope which are then immediately backfilled. No storage of equipment or stockpiles should be permitted at the head of slopes.

As a possible example for consideration, it is suggested that, where the subgrade is more than about 1 m below the ground surface in frost susceptible soils such as silty clay or silty fine sand, the subgrade be protected against frost penetration with at least 50 mm of high strength polystyrene insulation installed beneath the subbase. The insulation should be underlain by a levelling layer of granular material where required. Insulation sheets should all be overlapping or ship-lapped. With insulation, the total pavement thickness may possibly be somewhat reduced.

The placement of granular material should follow excavation. The lowest lift of granular material should be placed in a thickness of at least 0.75 m to allow haulage vehicle access, although thinner lifts have been used in the past. The subgrade must be properly shaped and graded to promote drainage to the sub-drains.

Based on the water content and Atterberg limit data available, most of the silty clay and clayey silt will not be suitable for use as engineered fill; however, the weathered silty clay within about 1.0 m of ground surface can be considered for use in embankment fill construction. Since these soil types are sensitive to changes in water content and wetting, earthwork using the native weathered silty clay may only be carried out during consistent dry weather. Re-use of this weathered material may not be practical economically, since it would involve two stage excavation. The wet, weathered silty clay and the grey silty clay, although sensitive to disturbance, should remain intact ("solid") throughout haulage and disposal and could probably be piled to a low height at the disposal site ("liquid-like" spoil is not expected). Haulage and spreading equipment will probably not be able to travel on any of the excavated, disturbed, wet clay material until the material has had a considerable drying period. Even then, only a bulldozer could operate on the fill; a thick granular road would have to be constructed on the clay to enable haulage vehicle access.

### **13.0 COMMENTS ON BRIDGE FOUNDATIONS AND CONSTRUCTION**

The bridge abutment for the CNR at the crossing may consist of a relieving platform with caissons founded in bedrock. It is recommended that caissons be embedded at least 0.5 m in bedrock and provided with sockets in unweathered good rock. Recommended geotechnical design parameters are given in Appendix A. A typical section showing a configuration of the bridge abutment and tie back wall system at the CNR crossing is shown in Figure 16.

For the temporary excavations required for the construction of bridge piers, where the total excavation is greater than

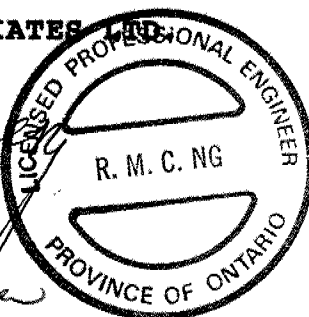
7.5 m, it is recommended that, to maintain stability, the section shown in Figure 17 be specified for construction. Temporary slope protection should be provided to the exposed clay face.

During construction the existing railway tracks will be temporarily diverted. An outline of possible sequence of construction events follows:

- o Construct diaphragm walls north of existing rail track.
- o Relocate tracks to north of existing tracks. (Railway tracks supported on native ground).
- o Dismantle existing (old) tracks.
- o Construct the remaining diaphragm walls.
- o Construct caisson supported platform at the crossing section (see Figure 16).
- o Install dewatering systems and monitoring piezometers.
- o Begin excavation south of relocated (new) track after pre-drainage of site is in progress.
- o Install tie back anchors as excavation proceeds.
- o Install additional dewatering units as required.
- o Construct bridge piers for the permanent track crossing. (See Figure 17).
- o Relocate rail tracks to the bridge piers.
- o Dismantle temporary tracks and begin excavation north of permanent tracks.
- o Construct permanent dewatering system and highway pavement structure.

**14.0 SUMMARY AND CONCLUSIONS**

- o From a review of available geotechnical data and subsurface information gathered in our 1990 field investigation, an assessment of undrained shear strength and effective stress parameters for use in design is made.
- o Based on the strength data and our experience with similar cut slopes in clay, it is considered that slopes at 2.5(H):1(V) can be excavated safely to 7.5 m depth.
- o The results of undrained and effective stress stability analyses carried out using the design profile and interpreted effective stress parameters respectively are consistent with data regarding local slopes.
- o Cuts in Leda clay deeper than 7.5 m at 2.5(H):1(V) are beyond most precedent data and require modifications to ensure stability. Alternatives were examined and replacement of slope by a tie back diaphragm wall is considered the most feasible, effective system, for the given site condition.
- o Groundwater control is essential during construction and permanent underdrainage system below the final pavement is necessary to maintain stability of the base of cut. Drainage of slope faces is also needed. Groundwater monitoring by piezometers are necessary during and after construction.

**GOLDER ASSOCIATES LTD.**  
R. Ng, P.Eng.  
for V. Milligan, P.Eng.

RMN/VM/dh

**TABLE 1**  
**SUMMARY DATA FOR EXISTING LOCAL EXPERIENCE**

	LOCATION	SLOPE HEIGHT H (m)	SLOPE ANGLE $\beta$ (deg) H:V		UNDRAINED STRENGTH Su (kPa)	REMARK OR REFERENCE
1	Heron Road at CN Beachburg Overpass-Confederation Heights	6	21.8	2.5H:1V	40 to 50	3.5 m weathered crust overlying firm grey silty clay.
2	Billings Bridge Transitway Station	7.5	21.8 to 26.6 ----- 27.8	2.5H:1V to 2H:1V ----- 1.9H:1V (some sloughing occurred)	70	(GA Report 821-2039) 6.4 m weathered crust overlying low plasticity grey silty clay.
3	Hunt Club Road, Underpass at CP Prescott Railway	5	18.4	3H:1V	24 to 43	(GA Report 73748) 2 m weathered crust overlying stiff grey silty clay
4	Orleans Blvd. Cut South of St. Joseph Blvd.	5	26.6 or flatter	2H:1V or flatter	25 to 30	(GA Report 821-2279) 2.3 m of sand overlying highly plastic firm grey silty clay
5	Prestone Drive Access Rd. - South of St. Joseph Blvd.	9 to 12 -----	18.4 -----	3H:1V -----	50 to 60	(GA Report 752160, 871-2254) weathered crust over silty clay -----
5a		5.5	32	Average 1.6H:1V		Quarried rock retaining wall
6	Highway 7 and 15 Underpass	9.2	26.6 ----- 18.4	2H:1V (in the top stiffer grey brown clay layer) ----- 3H:1V	35 to 100	(Geocon Report WP908-64) Fill underlain by 4.5 to 7 m stiff to firm silty clay overlying silt till overlying rock.
7	Duford St. Access Road	H<9.1 H=12.2 H=15.2	26.6 21.8 18.4	2H:1V 2.5H:1V 3H:1V	-----	(GA Report 69783) Recommended side slope angles to enhance slope stability

TABLE 2

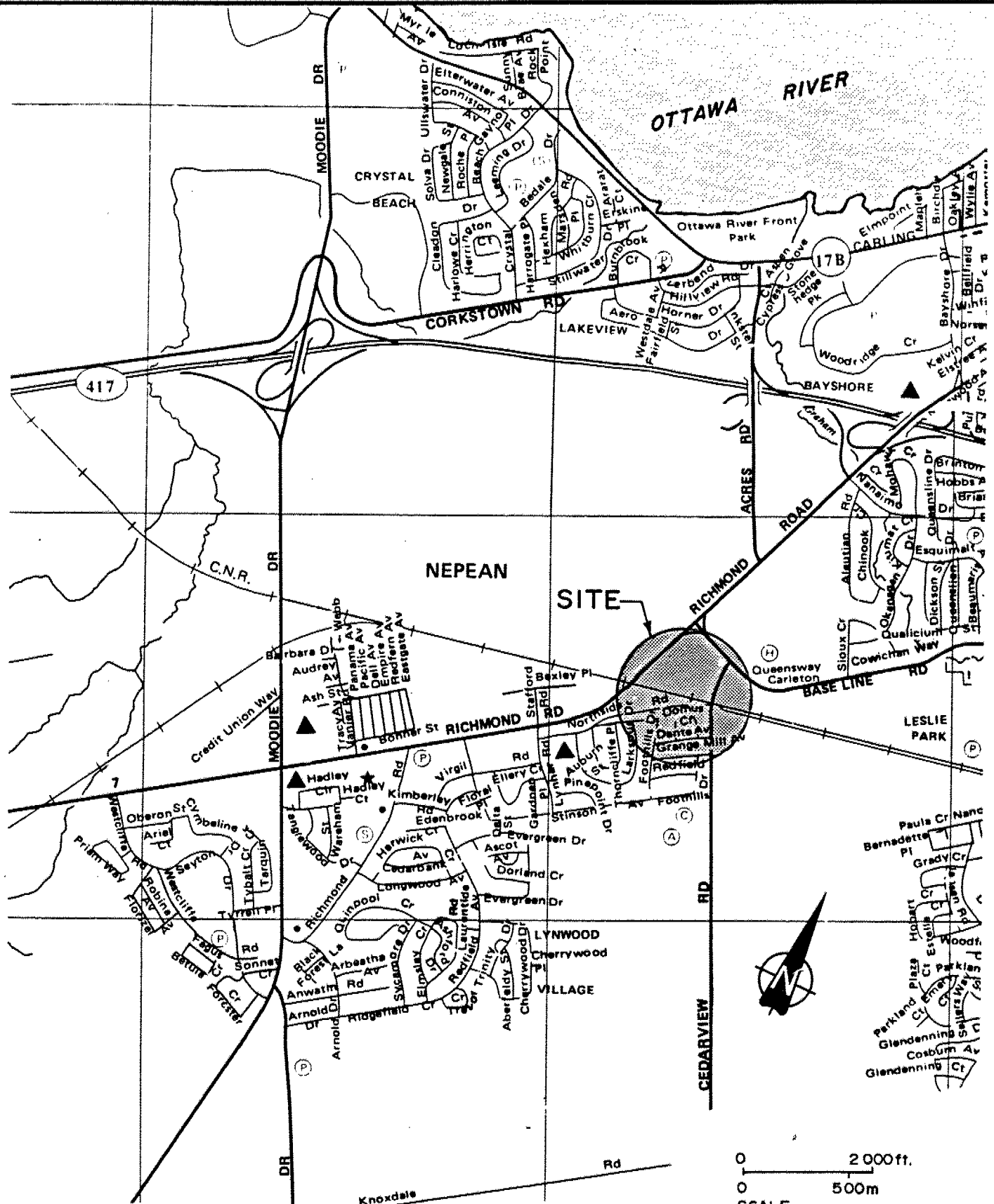
ASSESSMENT OF UNDRAINED ANALYSIS\*

H (m)	Calculated F (based on Field Vane $S_u$ )	Operational F' ( $S_u$ reduced by 0.7)	Remark
11	1.4	~1	See Figures 10, 12
8	2.0	~1.3 to 1.5	F' interpolated from Figure 10 for 22° slope
7	2.2	~1.5	See Figures 10, 11

\* See figures 10, 11 and 12 for undrained analyses and normalized undrained slope data.

# SITE LOCATION PLAN

FIGURE 1



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Chkd. *[Signature]*

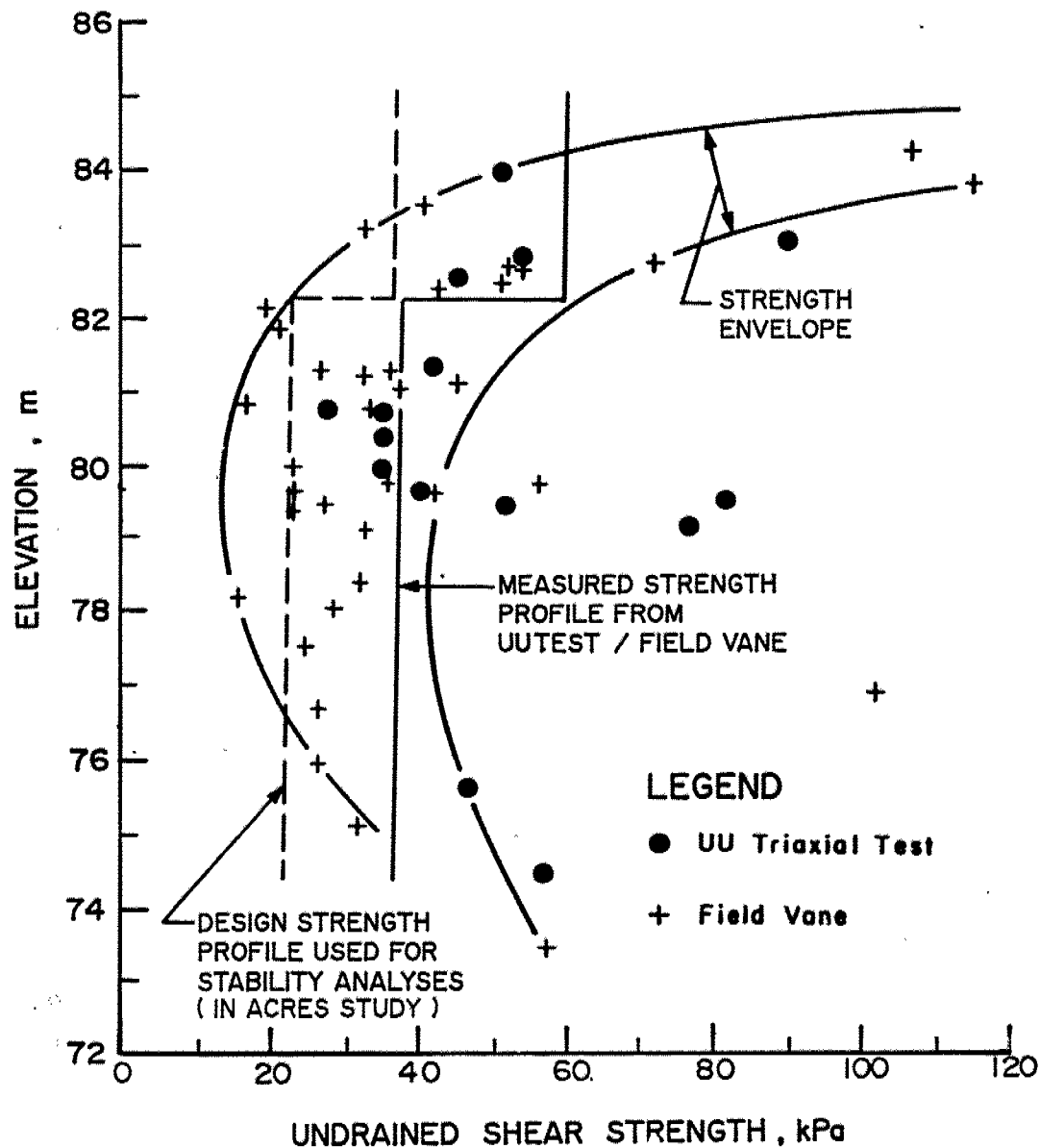
FORM PRODUCED JUNE 1985

# OVERSIZE DRAWING(S)



Su VS ELEVATION AND DESIGN PROFILE  
(ACRES UU TEST AND VANE DATA)

FIGURE 4.



SOURCE : ACRES REPORT TO MTO  
WP 126 - 87 - 01  
FIGURE No. 1

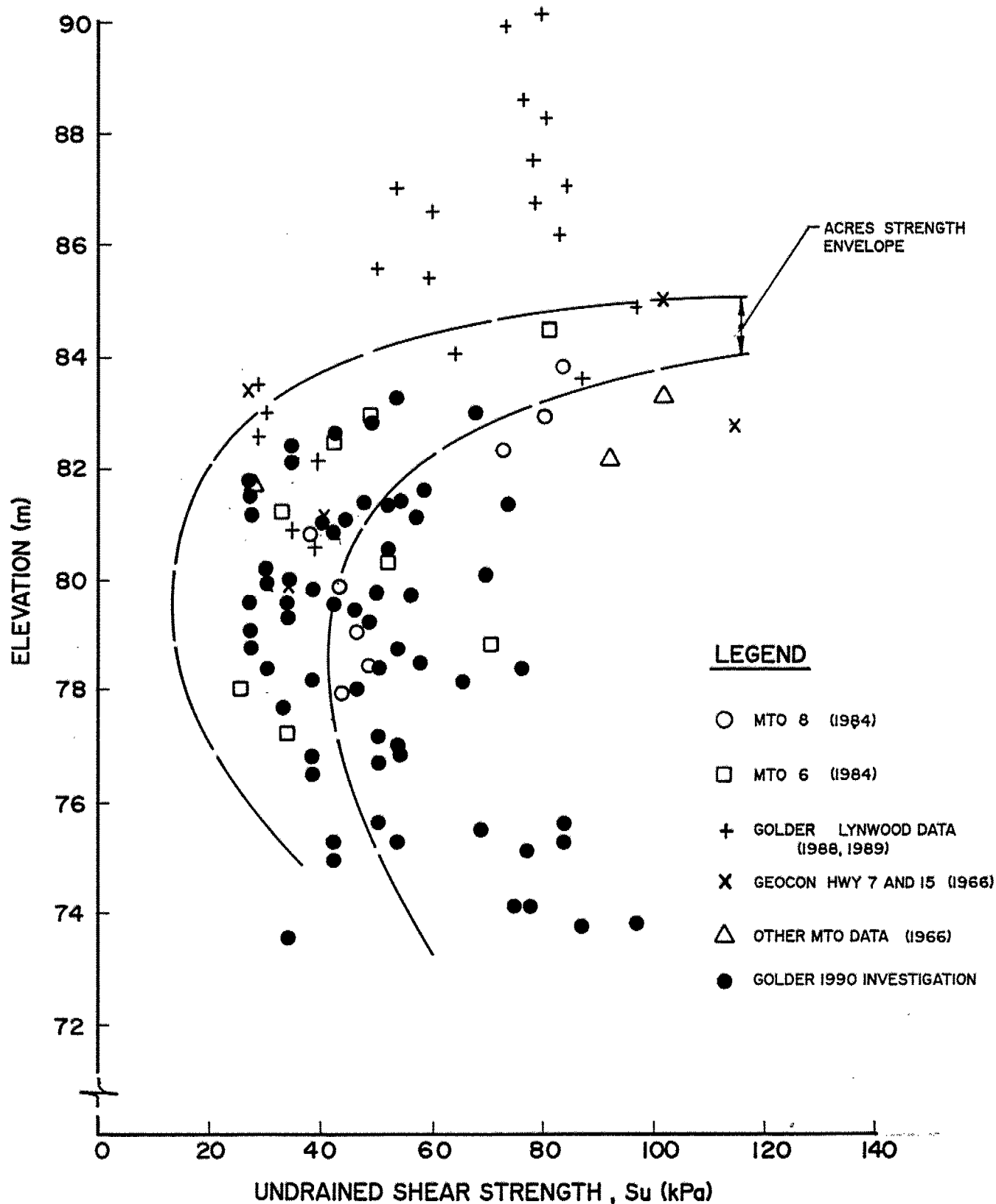
Date JUNE 12, 1990.  
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# Su VS ELEVATION ( MTO / GOLDER LYNWOOD VANE DATA )

FIGURE 5 .



Date JUNE 13, 1990.

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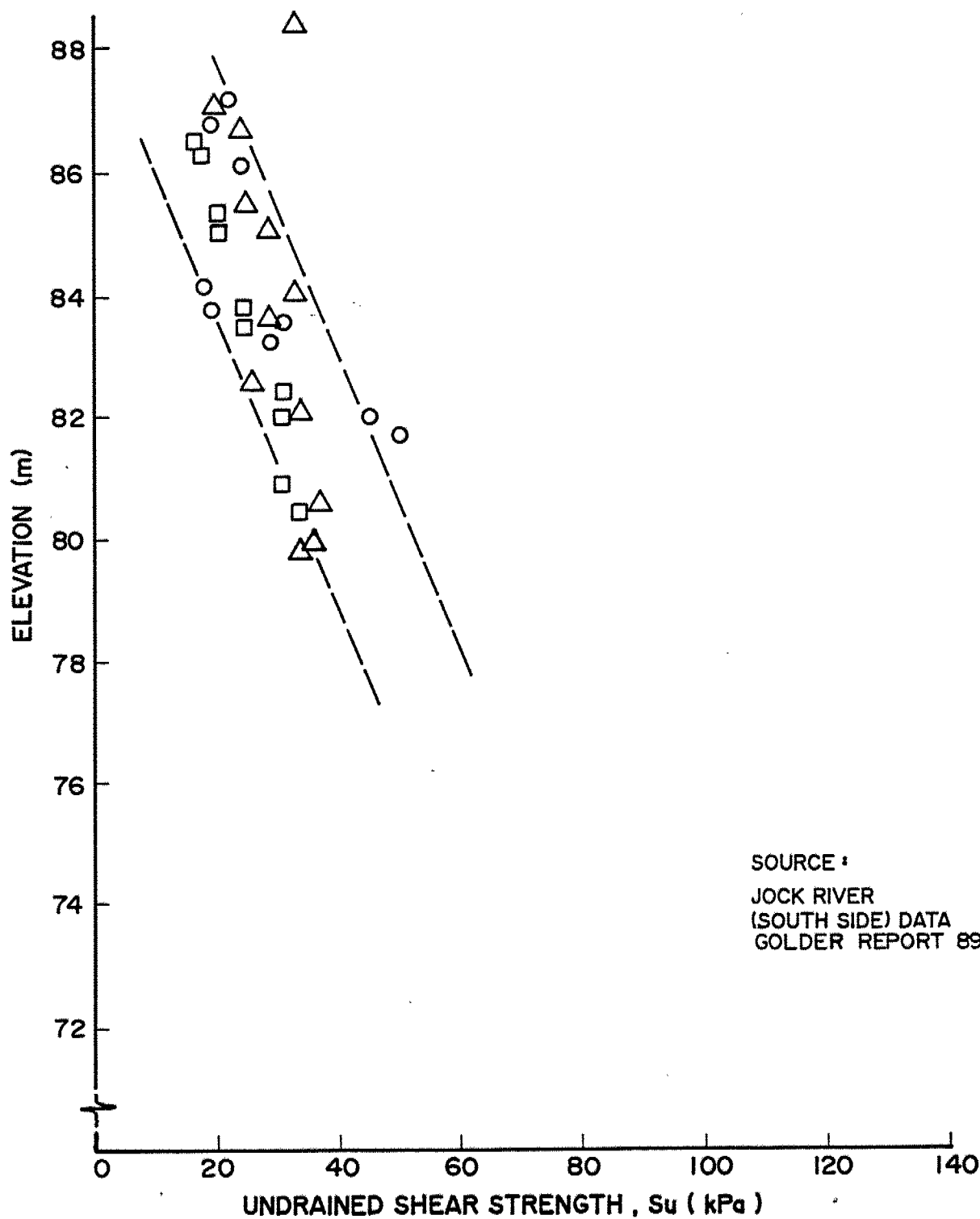
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Chkd. *[Signature]*

Su VS ELEVATION  
( GOLDER DATA ON JOCK RIVER )

FIGURE 6 .



SOURCE :  
JOCK RIVER  
(SOUTH SIDE) DATA  
GOLDER REPORT 891-2251

Date JUNE 13, 1990

Project 901 - 1339

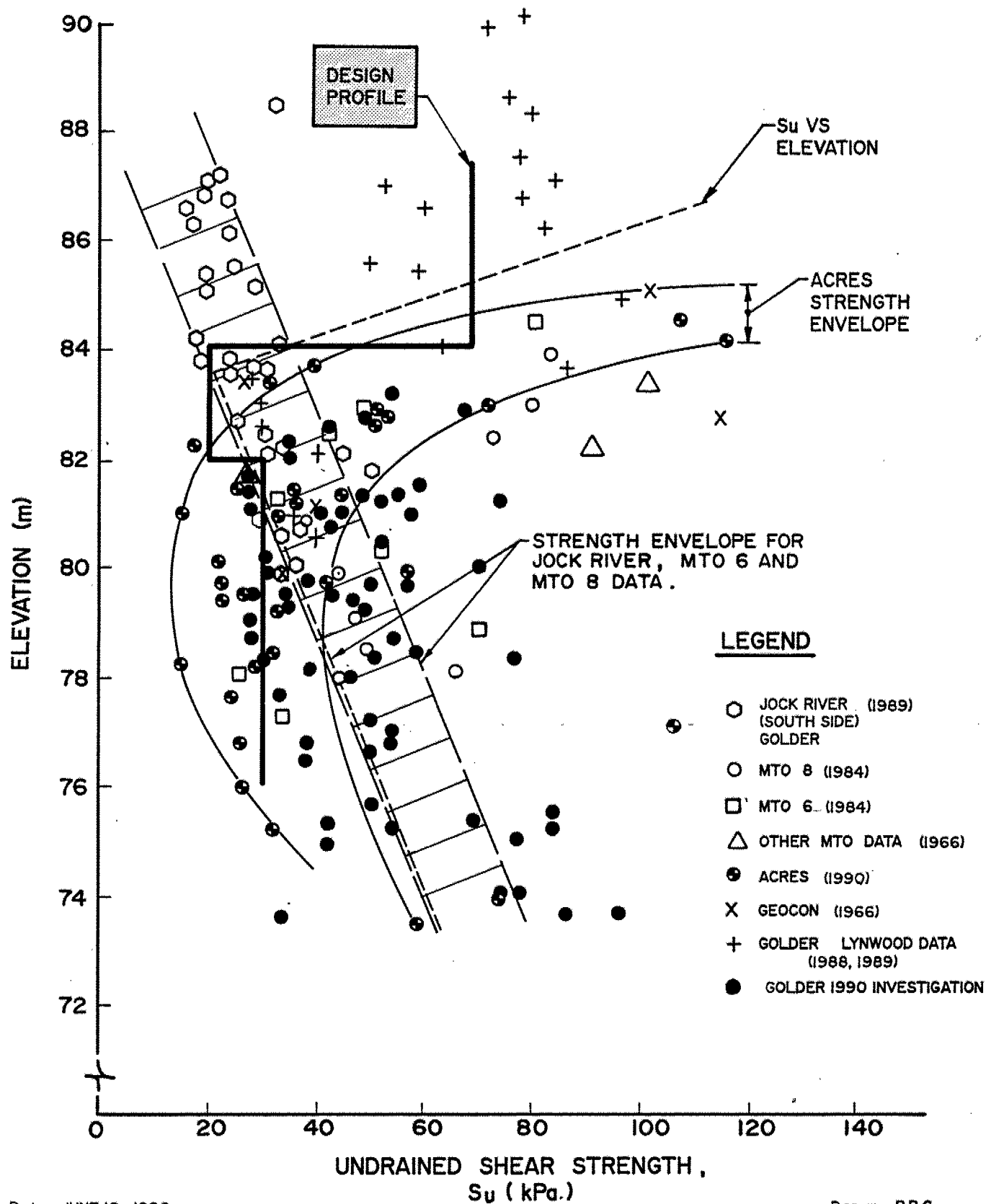
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# COMPOSITE PLOT OF ALL $S_u$ DATA AND DESIGN PROFILE

FIGURE 7.



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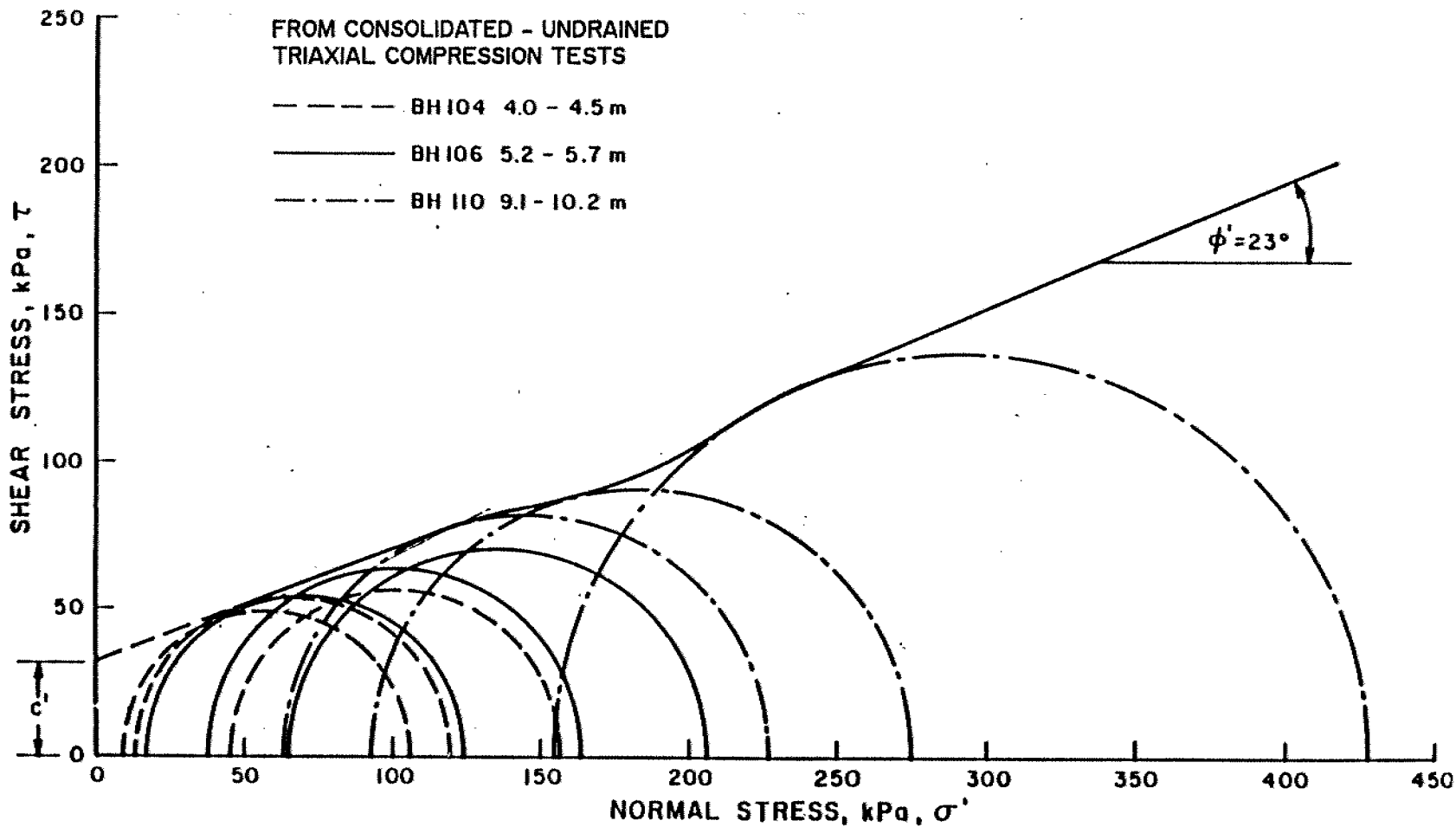
Drawn R.B.C.

Chkd. *RH*

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MOHR CIRCLES AND ENVELOPE  
( ACRES INTERPRETATION )

FIGURE 8.



SOURCE : ACRES REPORT TO MTO  
WP 126 - 87 - 01  
FIGURE No. 2

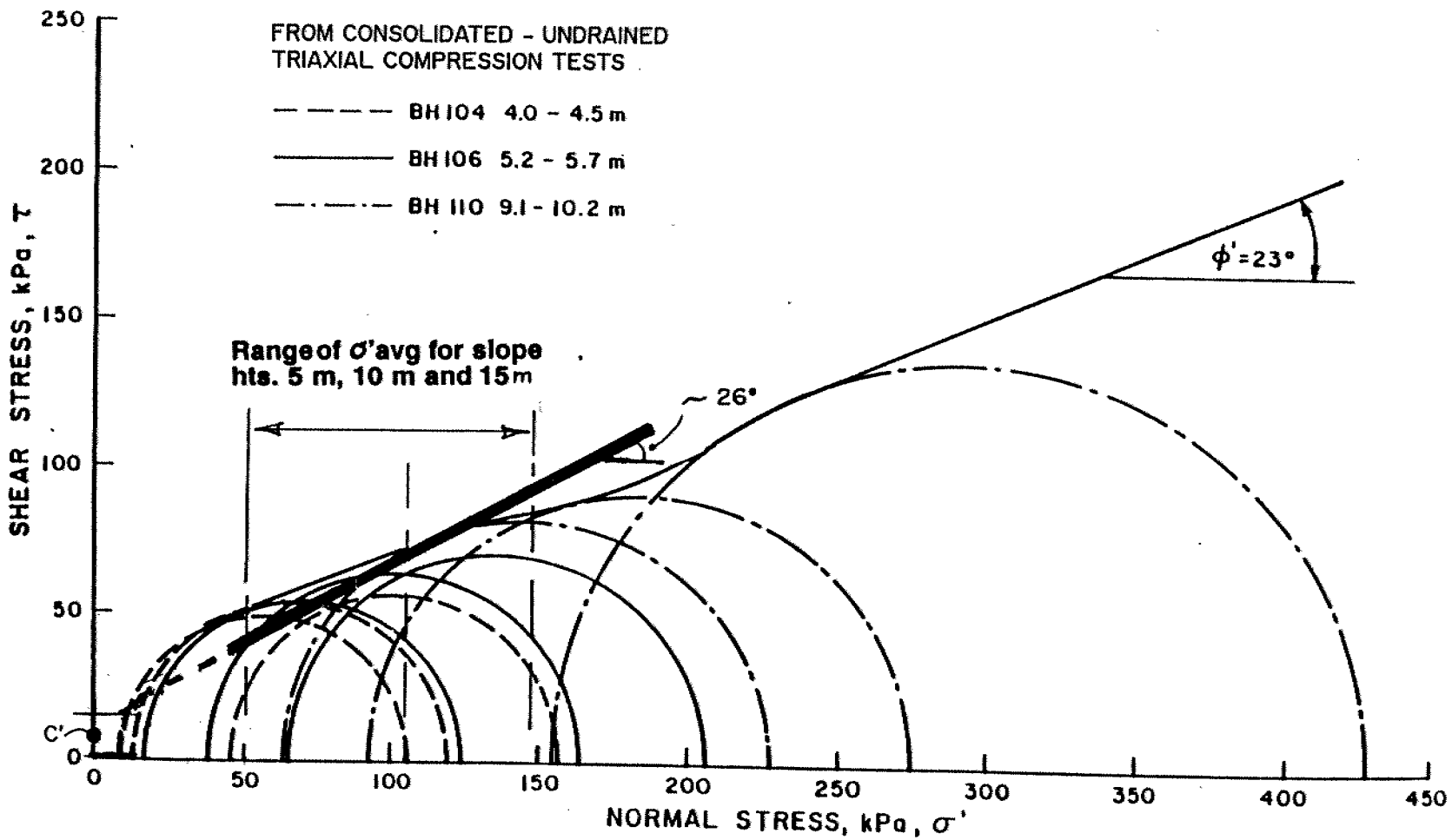
Date JUNE 12, 1990.  
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Chkd. *[Signature]*

# REVISED INTERPRETATION FOR EFFECTIVE STRESS PARAMETERS

FIGURE 9.



$C' \sim 0^\circ$  TO 12 kPa

$\phi' \sim 25^\circ - 26^\circ$

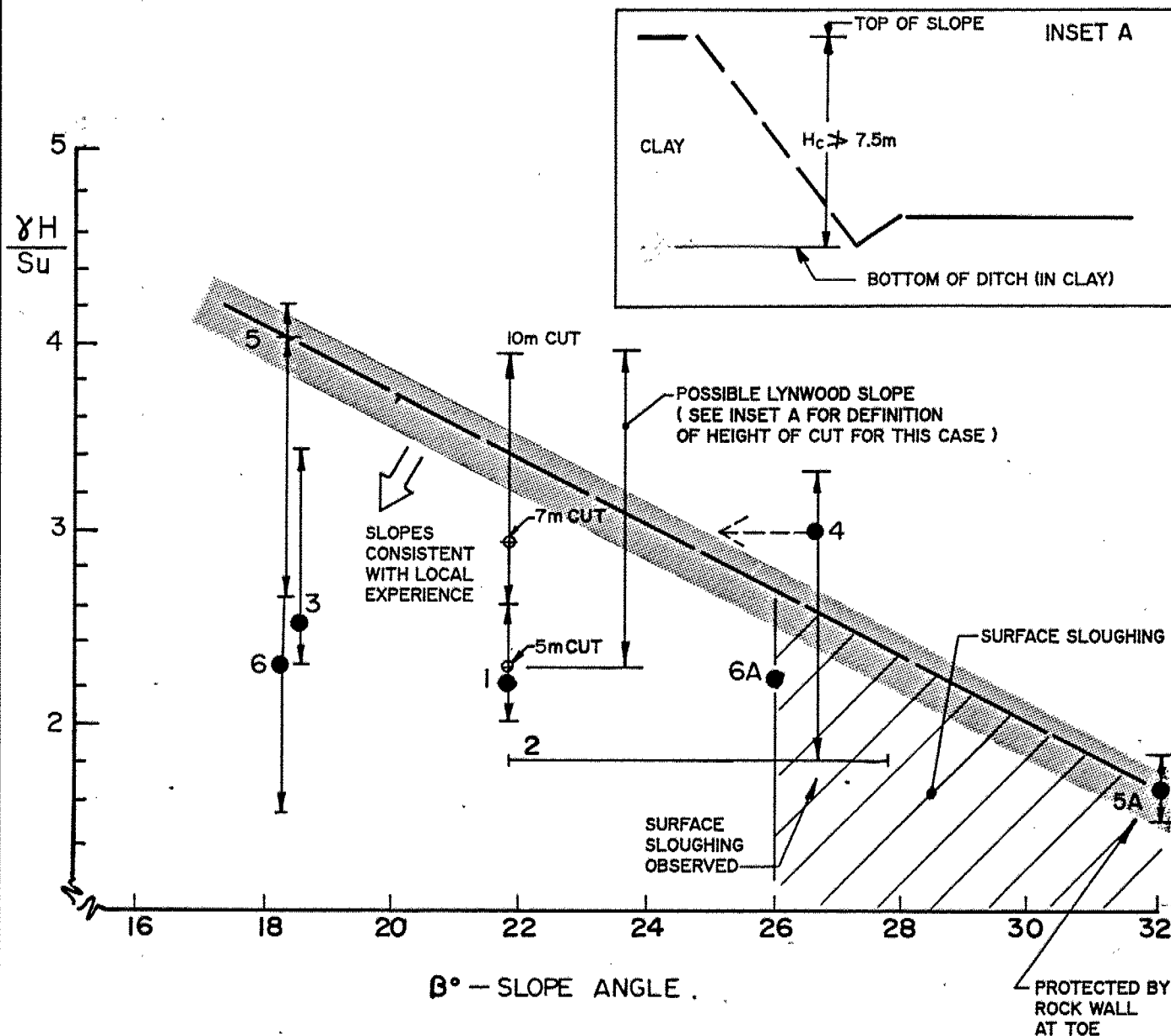
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"NORMALIZED" SLOPE DATA  $\gamma H/S_u$  VS  $\beta$   
(SLOPE ANGLE)

FIGURE 10.



LEGEND

●  $\gamma H/S_u$  AVERAGE

— INDICATES RANGE

1. HERON ROAD
2. BILLING BRIDGE TRANSITWAY STATION
3. HUNT CLUB ROAD UNDERPASS
4. ORLEANS BOULEVARD CUT
5. AND 5A PRESTON DR. ACCESS ROAD
6. AND 6A HIGHWAY 7 AND 15 UNDERPASS

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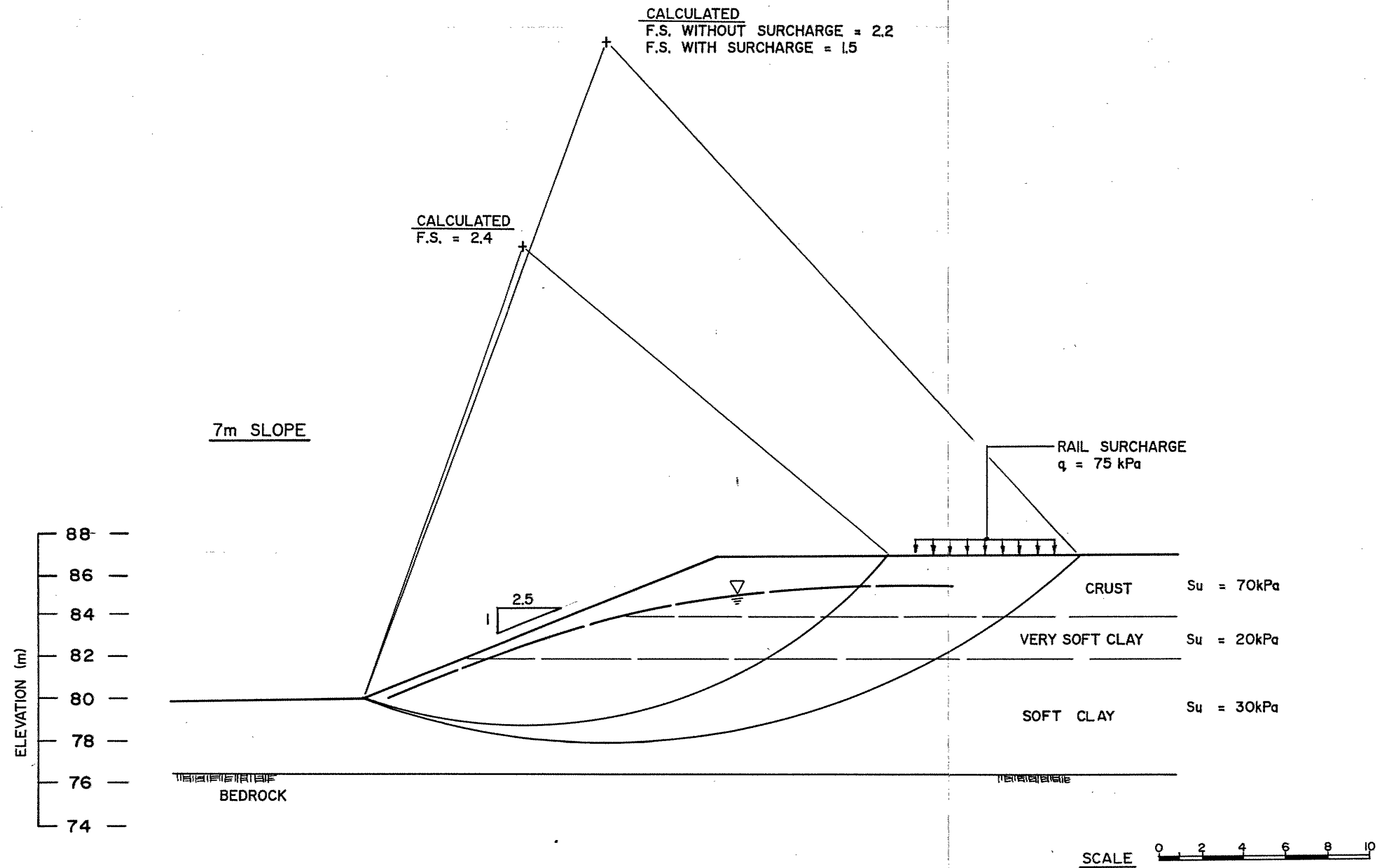
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Chkd. *RAL*

STABILITY ANALYSES (UNDRAINED)  
USING DESIGN PROFILE (7m SLOPE)

FIGURE 11.



Date..... JUNE 13, 1990.  
Project..... 901 - 1339

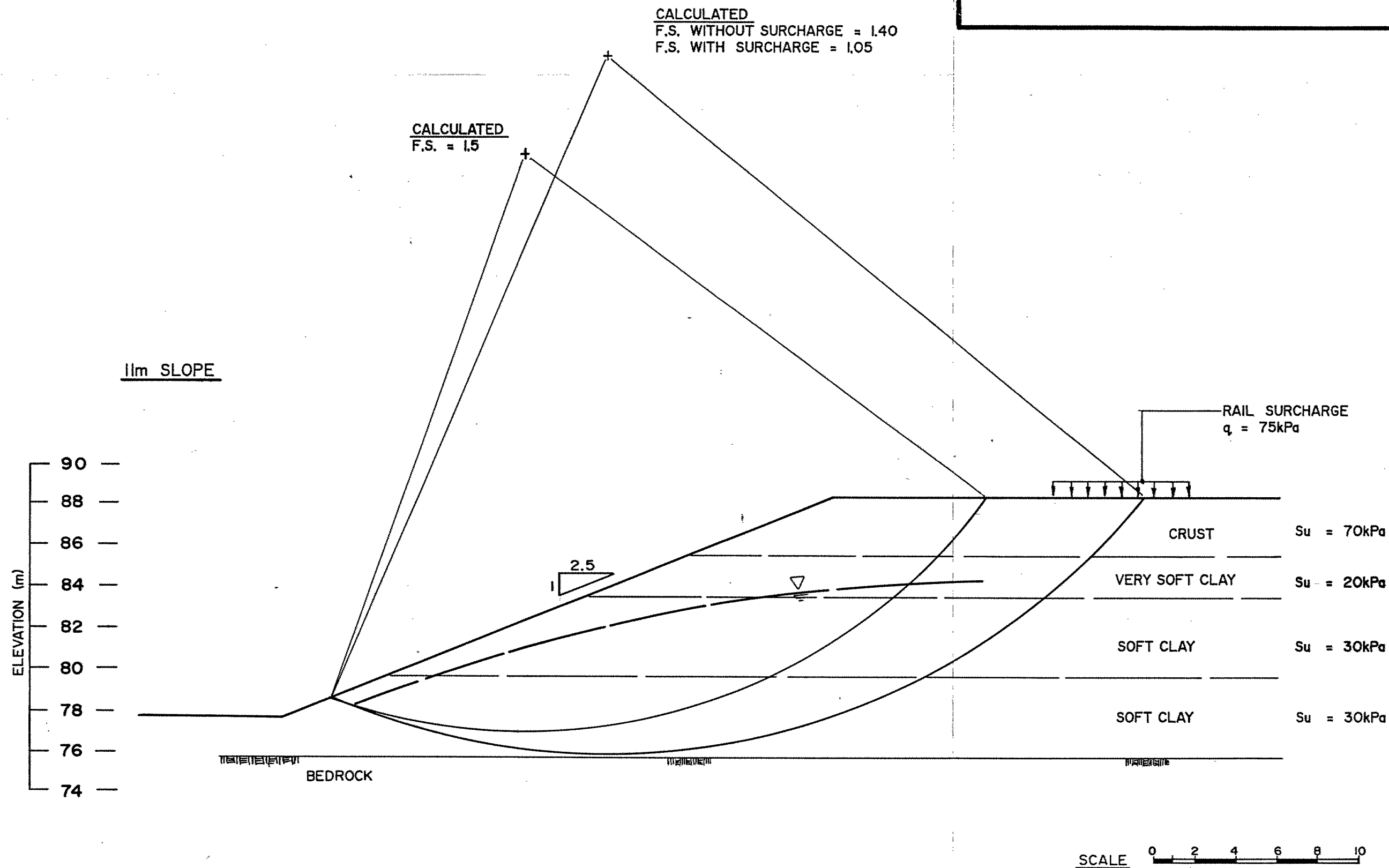
**Golder Associates**

Drawn..... R.B.C.  
Chkd..... *R.B.C.*



STABILITY ANALYSES (UNDRAINED)  
USING DESIGN PROFILE (11m SLOPE)

FIGURE 12.



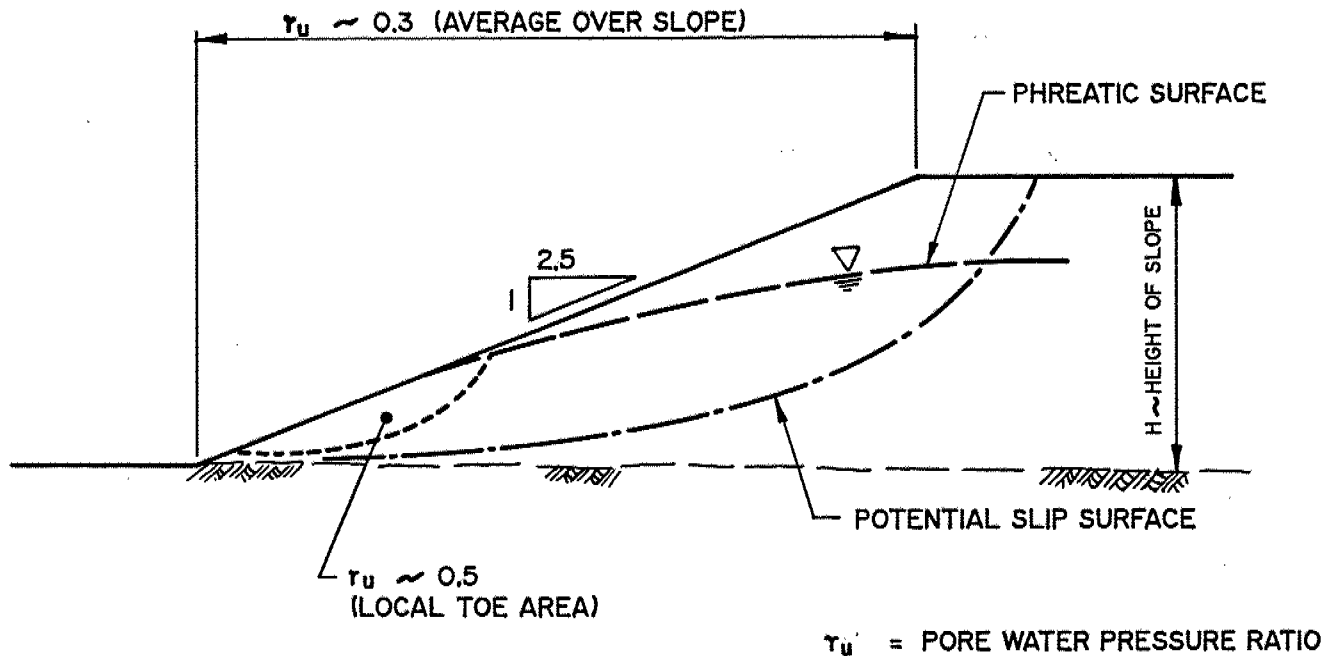
Date..... JUNE 13, 1990.  
Project..... 901 - 1339

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Drawn..... R.B.C.  
Chkd..... R.N.

# SUMMARY OF $C'$ , $\phi'$ AND $F$ FROM EFFECTIVE STRESS ANALYSES

FIGURE 13.



## SLOPE CONFIGURATION

SUMMARY OF $C'$ , $\phi'$ - ANALYSIS				
H (m)	$C'$ (kPa)	$\phi'$	$C'/\gamma H$	FACTOR OF SAFETY = F
5 TO 6	5	$26^\circ$	0.05	1.3 ( $r_u = 0.3$ , OVERALL SLOPE) 1.0 ( $r_u = 0.5$ , LOCAL TOE AREA)
10 TO 11	5	$26^\circ$	0.025	1.2 ( $r_u = 0.3$ )
15	5	$26^\circ$	0.02	1.1 ( $r_u = 0.3$ )

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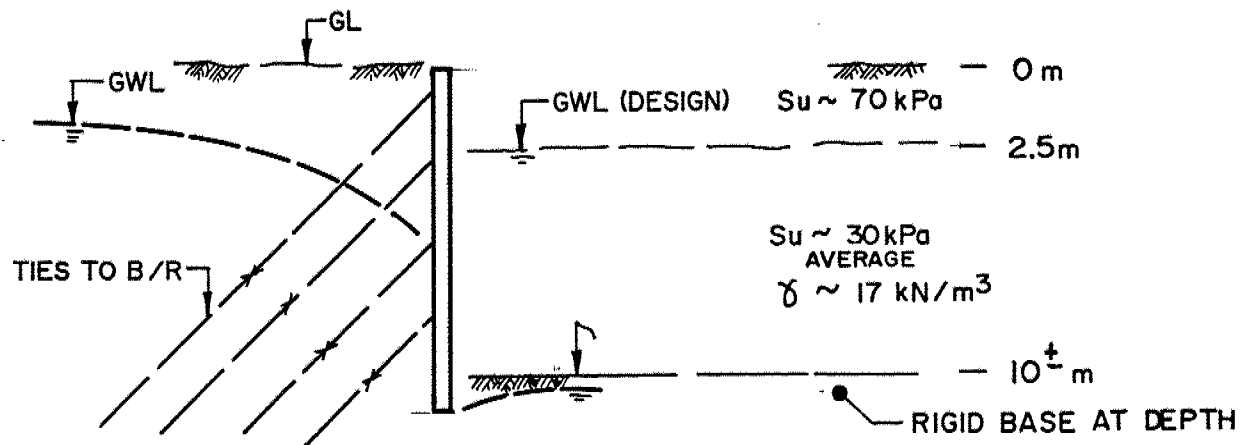
Drawn R.B.C.

Chkd. *R.B.C.*

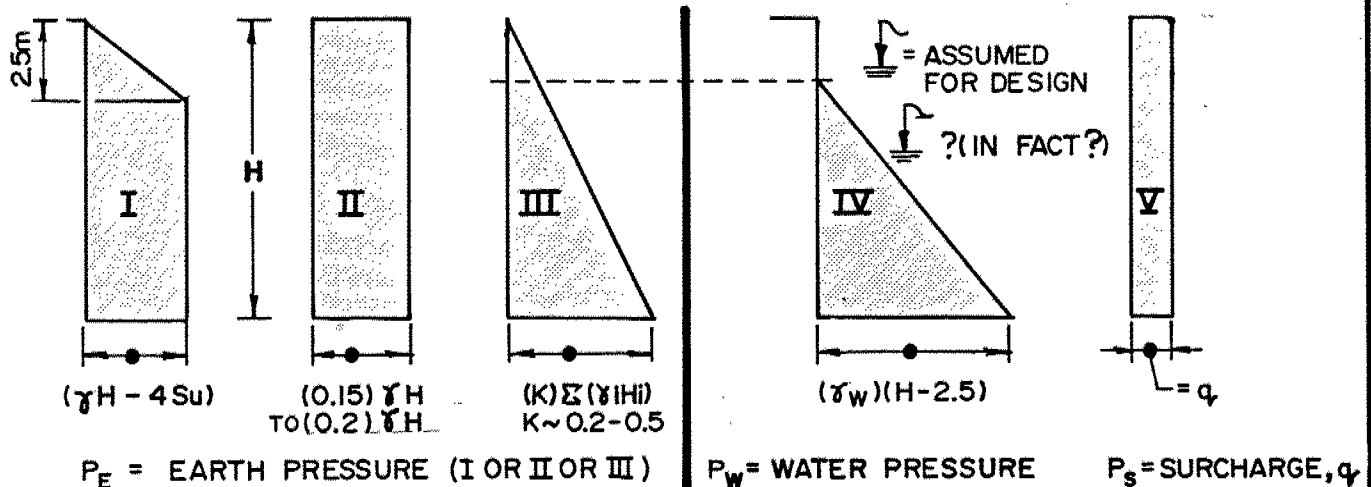
# APPROXIMATE DESIGN LATERAL PRESSURE DISTRIBUTIONS

FIGURE 14 .

## CONDITIONS ASSUMED FOR PRELIMINARY WALL DESIGN



## ASSUMED RANGE (S) OF DESIGN PRESSURES ON THE WALL



## EXAMPLE DESIGN PRESSURE(S) WHERE $H = 10\text{m}$

FOR CASE I  $\Sigma P_E \sim 440 \text{ kN/m}$

FOR CASE II  $\Sigma P_E \sim 350 \text{ kN/m}$

FOR CASE III  $\Sigma P_E \sim 280 \text{ kN/m}$

(WHERE  $K = 0.5$ )

$\gamma' = 7 \text{ kN/m}^3$

FOR CASE IV  $\Sigma P_W \sim 275 \text{ kN/m}$  ( $H = 10\text{m}$ )

FOR CASE V  $\Sigma P_S \sim 50 \text{ kN/m}$  ( $K = 0.5$ )

CASE III PROBABLY MORE APPROPRIATE FOR LONG TERM CASE ,

$\Sigma P_E = 280 \text{ kN/m}$

THUS ,  $\Sigma P$  (FOR DESIGN) =  $\Sigma P_E + \Sigma P_W + \Sigma P_S = 280 + 275 + 50 = 605 \text{ kN/m}$

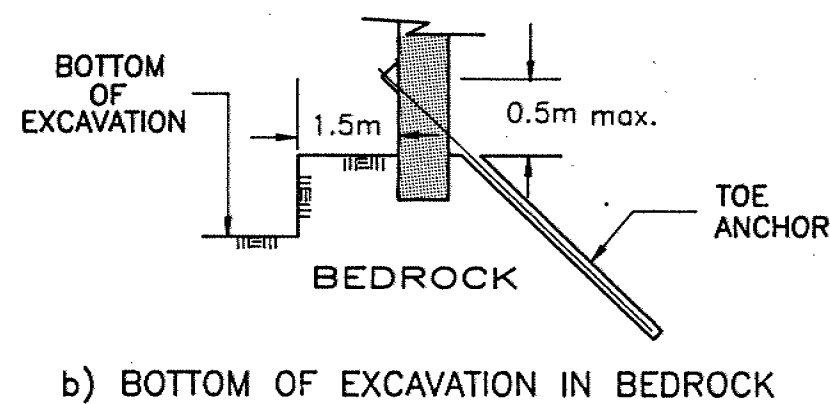
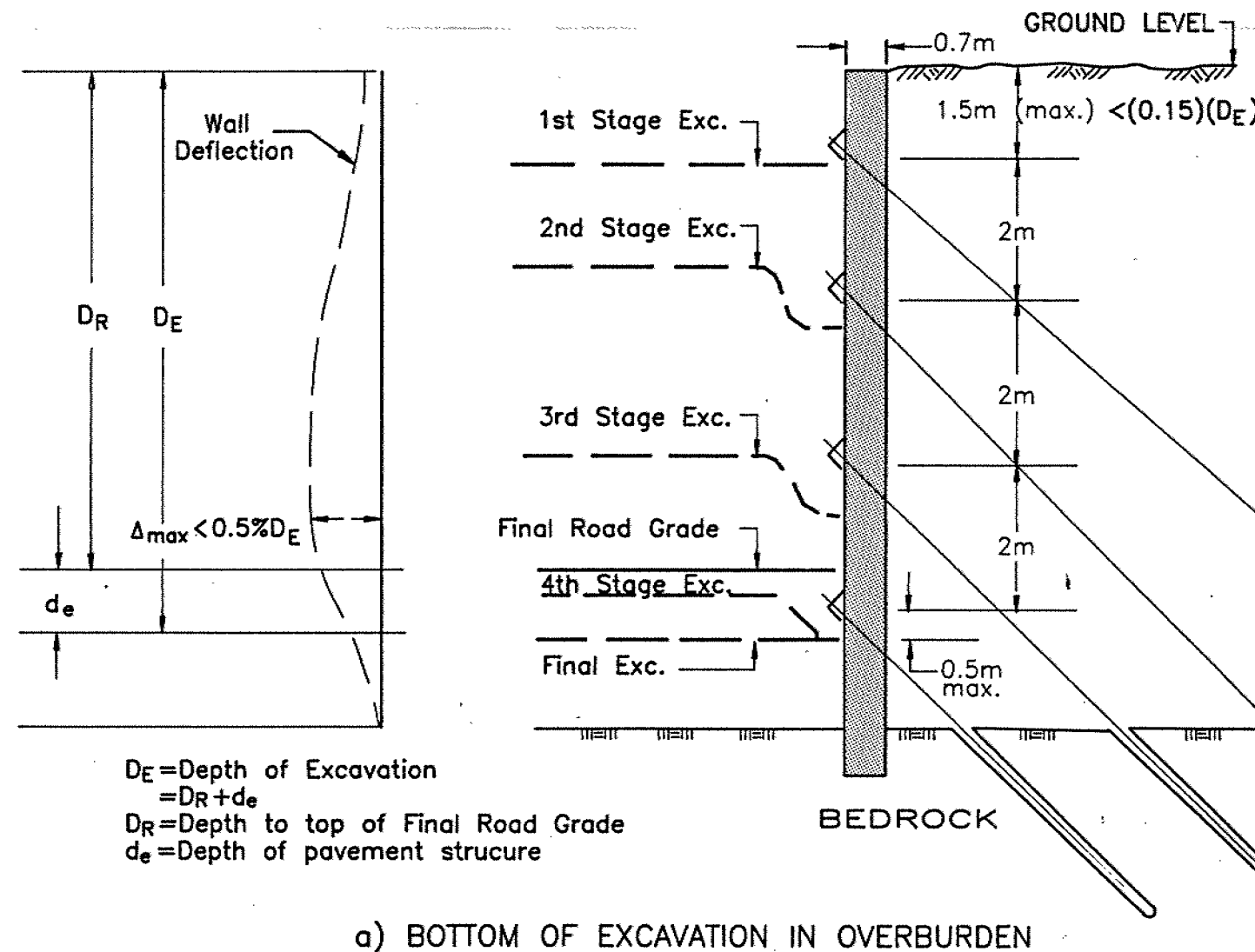
Date JUNE 13, 1990.

Project 901 - 1339

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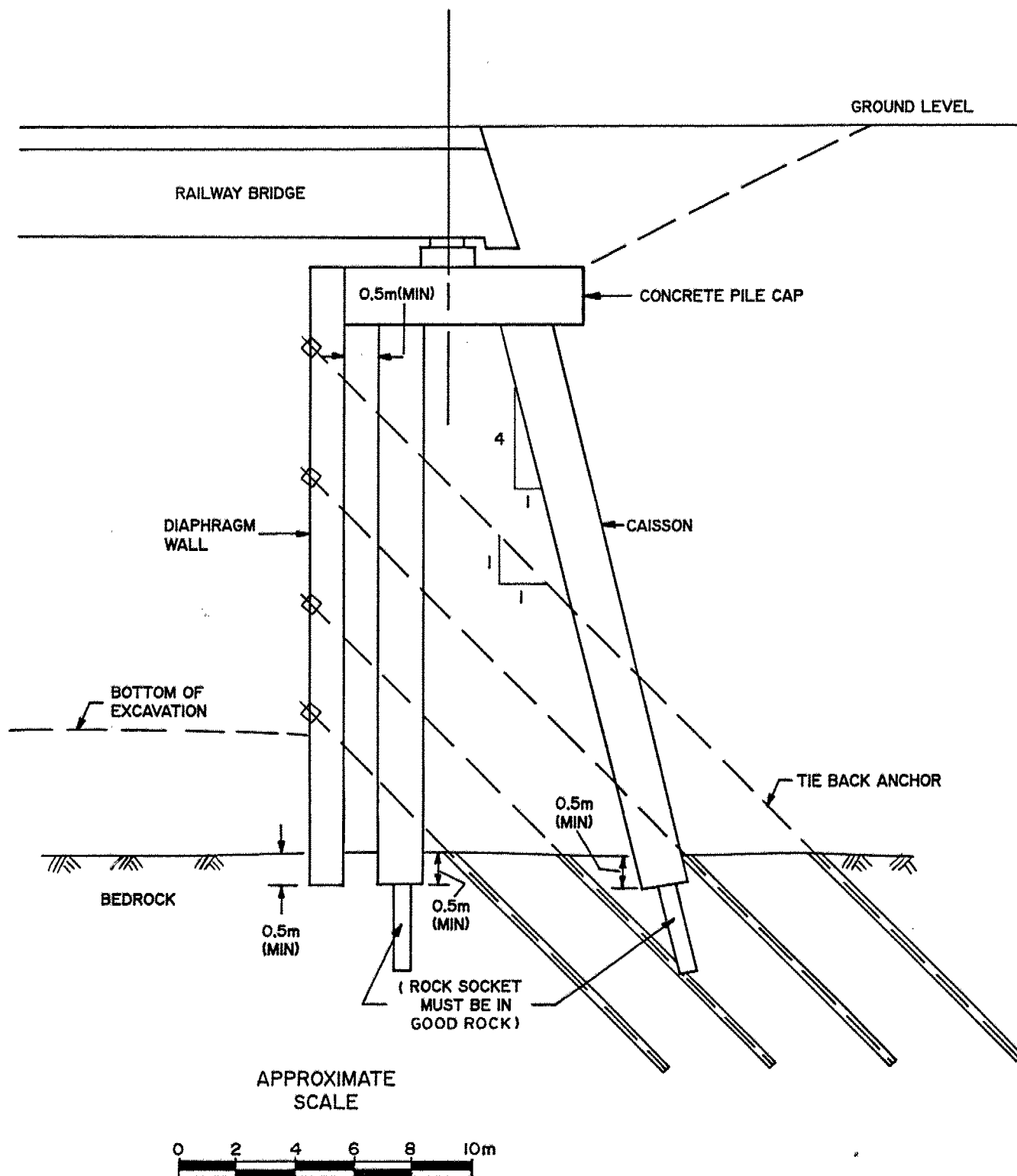
Drawn R.B.C.

Chkd. *[Signature]*



# NOTE

1. 1st level anchor at  $0.15D_E$  or 1.5m.
2. Subsequent anchor levels at 2m spacing.
3. Bottom support at 0.5m above base of excavation
4. Target maximum wall deflection  $\leq 0.5\% D_E$
5. Wall thickness  $\sim 70\text{cm}$ .
6. Wall should penetrate B/R  $\sim 0.5\text{m}$  (minimum)



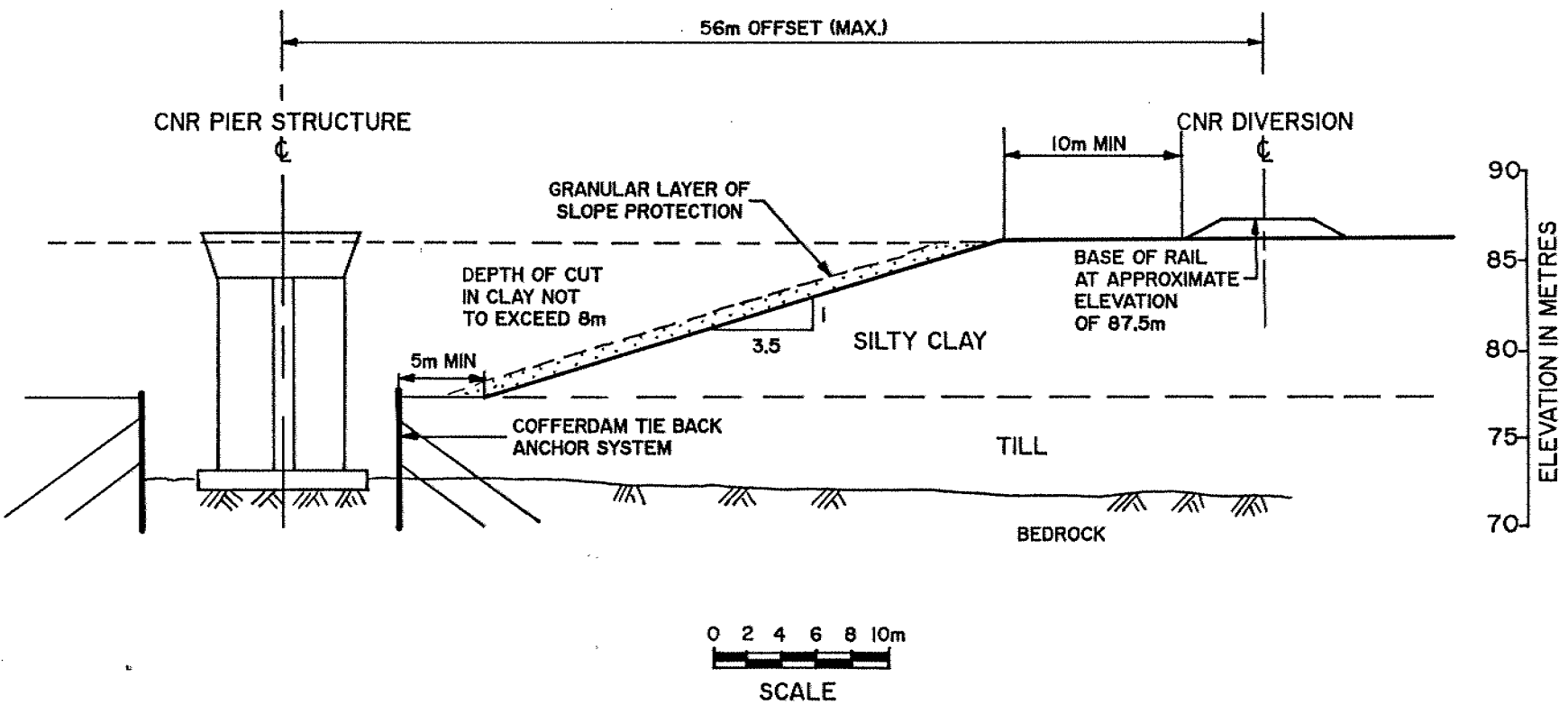
Date AUG. 14, 1990  
 Project 90I-1339

**Golder Associates**

Drawn D.J.R  
 Chkd. RW

# TEMPORARY EXCAVATION FOR BRIDGE PIER CONSTRUCTION

FIGURE 17



Date AUG. 14, 1990  
Project 90H1339

Golder Associates

Drawn D.J.R.  
Chkd. K.N.

**APPENDIX A**

**SUMMARY OF SITE GEOTECHNICAL DATA**

**August, 1990**

**901-1339**

SUMMARY OF SITE GEOTECHNICAL DATA(1)

PROPERTIES	REMARKS
<b>SOIL/ROCK PROPERTIES</b>	
o CLAY Undrained shear strength, Su	Top Layer 70 kPa Thin soft layer 20 kPa Lower Layer 30 kPa See Figures 3A, 3B and Figure 7
Unit Weight, $\gamma'$ $\gamma_c$	17 kN/m <sup>3</sup> 25 <sup>o</sup> - 26 <sup>o</sup> 0 - 12 kPa See Figure 9 5 kPa used for analysis
o TILL Unit Weight, $\gamma'$ $\gamma_c$	20.4 kN/m <sup>3</sup> 28 <sup>o</sup> 0 Acres Data
o ROCK Unconfined Compressive Strength	216 MPa to 245 MPa 231 MPa (average) Acres Data
o GROUNDWATER CONDITIONS	Underdrainage conditions. (Top of bedrock probably more permeable than overlying clay & till) See Figures 3A and 3B

RECOMMENDED DESIGN PARAMETERSDIAPHRAGM WALL

o Height o Thickness o Stiffness (EI) o Founding level o Target horiz. Deflection o Pressure Distribution o Earth Pressure Coefficient, K o Water pressure	>7.5 m 0.7 m ~ 1000 MNm <sup>2</sup> /m 0.5 m into Bedrock <0.5% of depth of excavation Triangular 0.5 Assume 2.5 m below ground level 500 kN - 1000 kN	with reinforcement minimum See Figure 15 See Figure 14
o Design Lateral Load/m of wall	500 kN - 1000 kN	See Figure 14
o Set-back of wall from rock face	1.5 m	Set-back required only if excavation for roadway extends to bedrock

ROCK ANCHOR

o Grout to Rock Bond o Grout Strength	Ultimate resistance 1000 kPa in good rock 30 MPa	See Figure 15
--	--	---------------

BEARING CAPACITY(2)

o Footings on good rock	3500 kPa at ULS <sup>(3)</sup> SLS	Do Not Govern Design Since Foundation is Assumed Unyielding
o Coefficient of Friction between good rock and concrete	ULS = 0.56	
o Caissons founded in good rock	3500 kPa at ULS <sup>(3)</sup>	To be Designed as End Bearing Column

INSULATION	1.8 m soil cover or equivalent or 150 mm (minimum) styrofoam SM or equivalent
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


NOTE: (1) The final geotechnical design parameters used for a specific design should be reviewed and approved by a geotechnical engineer

(2) Bearing Capacities are subject to reduction for inclined loads



(3) ULS = Ultimate Limit State  
SLS = Service Limit State



## LEGEND

-  CORED BOREHOLE  
 86.6 — GROUND SURFACE ELEVATION  
 75.3 — BEDROCK SURFACE ELEVATION  
 AUGER BOREHOLE TO REFUSAL  
 86.4 — GROUND SURFACE ELEVATION  
 73.3 — ELEVATION OF AUGER REFUSAL (INFERRED TOP OF BEDROCK)  
 BOREHOLE TERMINATED IN OVERBURDEN  
 87.3 — GROUND SURFACE ELEVATION

BOREHOLE SERIES No.	INVESTIGATION BY AGENCY	YEAR OF STUDY
90-W1	GOLDER ASSOCIATES	1990
89-1	GOLDER ASSOCIATES	1989
88-1	GOLDER ASSOCIATES	1988
103	ACRES	1990
MT08	MT0	1984

-  APPROXIMATE LOCATION WHERE DIAPHRAGM WALL IS PROPOSED.  
 APPROXIMATE LOCATION WHERE DEPTH OF CUT IN CLAY IS AT OR MARGINALLY EXCEEDS 7.5m. REFER TO SECTION 10.0 IN THE TEXT FOR POSSIBLE OPTIONS INSTEAD OF DIAPHRAGM WALL.

NOTE: BEDROCK AND GROUND SURFACE ELEVATIONS ARE APPROXIMATE ONLY.

NOTE: THIS FIGURE TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

0 5 10 20 30 50m  
SCALE, METRES

JUNE 1990  
GOLDER ASSOCIATES

Golder Associates

