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G.I.-30 SEPT. 1976

GEOCRES No. 42A-33

DIST. 16 REGION                     

W.P. No. 8-79-01/02

CONT. No. 81-217

W. O. No.                     

STR. SITE No.                     

HWY. No. 11

LOCATION Proposed Culvert  
Replacement

No of PAGES -                     

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

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	Culvert Replacement at Sta. 415+30 Hwy. 11, Twp. of Taylor, District of Cochrane, W.P. 8-79-02

NOTE: For purposes of the contract these reports supercede  
all other foundation reports done by or for the Ministry  
in connection with the above mentioned projects.

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

$S_u$ (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: 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 DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

### ABBREVIATIONS & SYMBOLS

#### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $\bar{C}U$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

#### FIELD SAMPLING

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

#### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_A$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_P$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE  
 $w$  SLOPE ANGLE-BACKFACE OF WALL  
 $\beta$  ANGLE OF SLOPE  
 $N_q, N_c$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

#### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_P$  PLASTIC LIMIT  
 $w_S$  SHRINKAGE LIMIT  
 $I_P$  PLASTICITY INDEX =  $w_L - w_P$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_P}{w_L - w_P}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_P}$   
 $A_c$  ACTIVITY =  $\frac{I_P}{w_L - w_P}$  Soil Fraction  
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

#### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $a, b$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS

#### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $\alpha_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\sigma'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

## FOUNDATION INVESTIGATION REPORT

For

Proposed Culvert Replacement  
1.07 Miles North of West Junction Hwy. #101  
Township of Taylor, District of Cochrane  
Lot 2, Con. I  
W.P. 8-79-01  
Hwy. #11, District #16 (Cochrane)

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INTRODUCTION

This report contains the results of a foundation investigation carried out at this location during the period of May 8-10, 1980. The field work was carried out with a continuous flight auger machine mounted on a muskeg vehicle, and equipped with 3½ inch I.D. hollow stem augers. Dynamic cone penetration tests were performed adjacent to two of the four boreholes.

SITE DESCRIPTION

The terrain in this vicinity, apart from the roadway embankment and creek valley is flat and tree covered.

SUBSURFACE CONDITIONSGeneral

Apart from the existing Hwy. #11 fill materials (gravelly sand or silty clay to clay) the subsoil at this location was found to be uniform and consists of a soft to firm stratified deposit (silty clay and clay) to a minimum El. 800+.

Since no recent survey data is available at this time (Sept. 1980), all the quoted elevations are referenced to an assumed datum:  $\phi$  of Hwy. #11; Sta. 512+40; El. 866+. This data is shown on the supplied plan and profile. The boundaries between the different strata, together with the obtained field and laboratory test results, are shown on the Record of Borehole Sheets contained in the Appendix. The stratigraphical profile on Drawing No. 87901-A is based upon this information. A description of encountered subsoil types is given below.

### Fill Material

Two types of fill material were encountered a) gravelly sand and b) silty clay to clay.

#### Gravelly Sand, Traces of Silt and Clay

At the location of B.H. #1 a granular type stratum was encountered which extends from the shoulder level to slightly below the indicated invert level of the existing 10 foot dia. pipe (El. 840.5+). The material in the zone consists of gravel (6-33%), sand (63-88%), silt and clay (4-6%). The moisture content is in the order of 4 to 7%. Standard Penetration Tests 'N' values (20 to 39 blows/ft.) indicate a compact to dense state.

This stratum appears to form in part the backfill and bedding material.

#### Silty Clay to Clay, With Sand & Trace of Gravel

This type of fill material was encountered in B.H. #2 from side slope level to El. 841+. B.H. #2 is located adjacent to the culvert. The material consists of silty clay to clay with sand and traces of gravel. The obtained grain size distribution test curves are plotted on Figure 1 of the Appendix. The moisture content ranges from 20 to 42%. The consistency varies from soft to hard.

#### Layers of Silty Clay and Clay

The native subsoil was found to consist of alternate layers of silt, silty clay and clay. The thickness of the individual layers are as follows:

Silty Clay: 0.2 to 0.7 in.  
Clay : 0.5 to 1.0 in.

Occasional organic intrusions were also observed within the deposit. Physical properties of the stratum as determined from field and laboratory tests are as follows:

	<u>Range:</u>
Natural Moisture Content (%)	22-56
Liquid Limit (%)	40-60
Plastic Limit (%)	16-34
Bulk Density (PCF)	104-107
Undrained Shear Strength (PSF)	

Unconfined Compression	403-547
Field Vane	440-1600
Sensitivity	2-4
Organic Content (%)	5.5-9.5

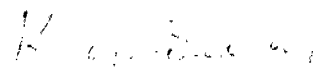
Grain-size distribution tests indicate the following percentage spread of the different particle sizes; sand and gravel: 0%, silt: 19-24%, and clay: 76-81%.

A plot of liquid limit versus plasticity index (Figure 2) shows most of the points to fall within the CI-CH zones. The consistency of the overall deposit ranges from soft to stiff.

#### Groundwater Conditions

The groundwater is assumed to be the same as the prevailing water level in the creek.

  
P. Payer, P. Eng.  
Foundations Engineer

  
K.G. Selby, P. Eng.  
Senior Foundations Engineer

## APPENDIX



RECORD OF BOREHOLE No 1

7

W P 8-79-01 LOCATION Sta. 512+30; o/s 14' Rt. of Hwy. 11 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Cont. Flight Auger - Hollow Stem & Cone Test COMPILED BY S.C.  
DATUM Assumed DATE May 8, 1980 CHECKED BY [Signature]

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					
866.0	Ground Level																
0.0																	
	Gravelly Sand		1	SS	39		860										6 88 (6)
	Traces of Silt & Clay		2	SS	39	*											
	(Fill Material)																
	Compact to Dense		3	SS	20		850										33 63 (4)
			4	SS	24												
840.5			5	SS	38		840										
25.5	Layers of Silt Clay & Clay		6	TW	PH												
	Occasional Organic Intrusions		7	TW	PM		830										104.5 0 0 19 81
	Soft to Stiff		8	TW	PH		820										
			9	TW	PM		810										104
807.5	End of Borehole																
806.0	End of Cone Test																
60.0	*Note: Water Level Not Established.																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20  
15  
10  
5  
5 (%) STRAIN AT FAILURE





RECORD OF BOREHOLE No 2

8

W P 8-79-01 LOCATION Sta. 512+08; o/s 36' Lt. @ Hwy. 11 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Cont. Flight Auger - Hollow Stem & Cone Test COMPILED BY S.C.  
DATUM Assumed DATE May 9, 1980 CHECKED BY *CP*

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				
859.0	Ground Level															
0.0	Silty Clay to Clay With Sand, Trace of Gravel (Fill Material) Soft to Hard		1	SS	4											0 2 29 69
			2	TW	PH											6 29 25 40
			3	SS	33											5 24 18 53
841.0			4	SS	18	*										
18.0	Layers of Silty Clay and Clay Occasional Organic Intrusions		5	SS	9											Om 8.3%
			6	SS	1											
	Soft to Firm		7	TW	PM										107	
			8	TW	PM											
			9	TW	PM											0 0 24 76
800.5																
58.5	End of Borehole															
	*Note: Water Level Not Established.															

+3, x5: Numbers refer to  
Sensitivity

20  
15 - 5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 3

9

W P 8-79-01 LOCATION Sta. 512+21; o/s 50' Lt. of Hwy. 11 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Cont. Flight Auger - Solid Augers COMPILED BY S.C.  
DATUM Assumed DATE May 10, 1980 CHECKED BY CF

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					
855.0	Ground Level													
0.0	Layers of Silty Clay and Clay		1	AS	-									
	Trace of Sand		2	AS	-	*							0m9.5%	
838.5			3	AS	-									
16.5	End of Borehole													
	*Note: Water Level Not Established.													

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 4

10

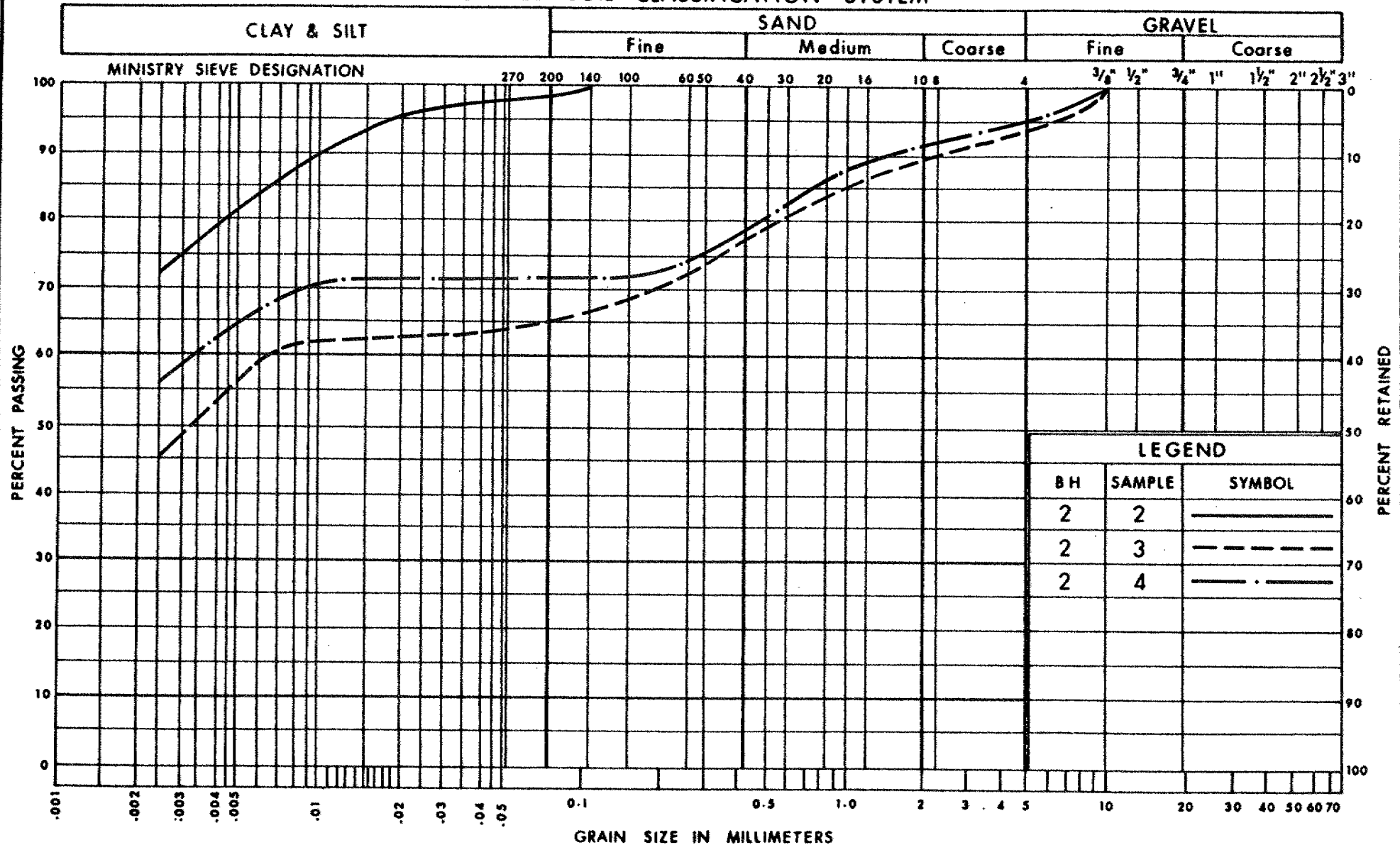
W P 8-79-01 LOCATION Sta. 511+85; o/s 72' Lt. of Hwy. 11 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Cont. Flight Auger - Solid Augers COMPILED BY S.C.  
DATUM Assumed DATE May 10, 1980 CHECKED BY JP

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 (%) 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>		
854.0	Ground Level																
0.0	Layers of Silty Clay and Clay		1	AS	-												
	Some Sand		2	AS	-	*											
	Traces of Gravel		3	AS	-												
			4	AS	-												
			5	AS	-												
832.5			6	AS	-												
21.5	End of Borehole																
	*Note: Water Level Not Established.																

\*<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

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

## UNIFIED SOIL CLASSIFICATION SYSTEM



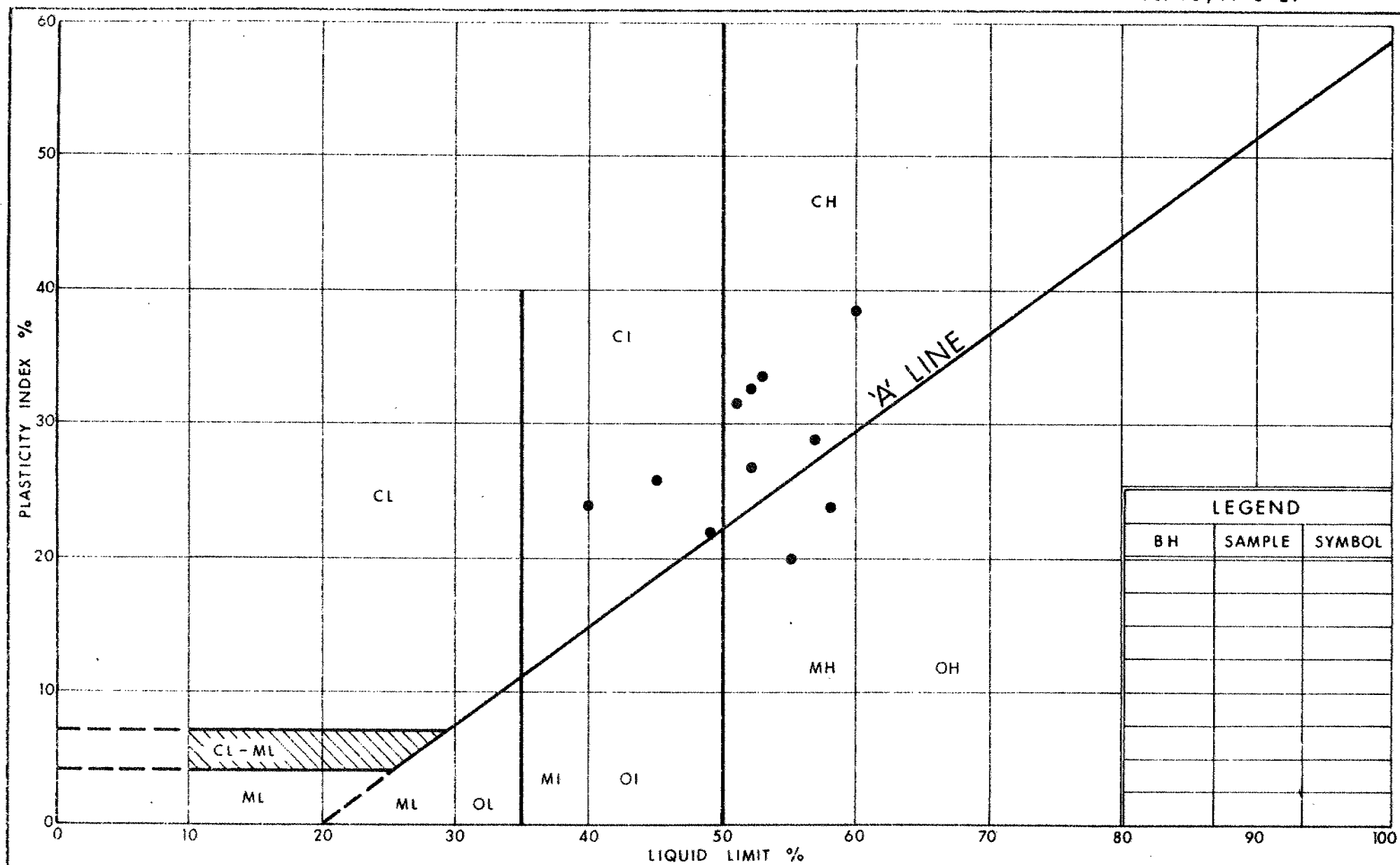
Ministry of  
Transportation and  
Communications

## GRAIN SIZE DISTRIBUTION

SILTY CLAY TO CLAY (FILL)  
WITH SAND, TRACE OF GRAVEL

FIG No 1

WP 8-79-01



Ministry of  
Transportation and  
Communications

# PLASTICITY CHART LAYERS OF SILTY CLAY & CLAY

FIG No 2

W P 8-79-01

Foundation Investigation Report  
For  
Proposed Culvert Replacement  
2.2 Miles North of West Junction Hwy. #101  
Township of Taylor, District of Cochrane  
Lot 4, Con. II  
W.P. 8-79-02, Site: Nil  
Hwy. #11, District #16 (Cochrane)

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## INTRODUCTION

This report contains the results of a foundation investigation carried out at this location during the period of May 6-8, 1980. The fieldwork was carried out with a continuous flight auger machine mounted on a muskeg vehicle, and equipped with 3¼ inch I.D. Hollow Stem Augers. Dynamic Cone Penetration Tests were performed adjacent to all but one borehole.

## SITE DESCRIPTION

The terrain in this vicinity, apart from the roadway embankment and creek is relatively flat and tree covered.

## SUBSURFACE CONDITIONS

### General

Apart from the fill material (sand and gravel), generally uniform subsoil conditions were found to prevail over the site area. The subsoil consists of a deposit of stratified silt, silty clay and clay with trace of sand to a minimum El. 827<sub>±</sub>.

In this report, all the horizontal and vertical measurements (chainages and elevations) are referenced to an arbitrary chosen point taken from the 'Plan and Profile' which was supplied to us by the Northern Region. This 'Plan and Profile' drawing was based and prepared on a May, 1971 survey information and updated in July, 1975. The description of the arbitrary selected reference point is as follows: Intersection of Hwy. #11 Ø and existing culvert Ø at Sta. 451+30; assumed elevation at this location: El. 882<sub>±</sub>. The extent of the fill

material and the underlying subsoil, together with the obtained field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The stratigraphical profile of Drawing No. 87902-A is based upon this information. A brief description of the fill material and original subsoil is as follows:

#### Fill Material

The material in the existing Hwy. #11 embankment was found to consist of sand and gravel with traces of silt and clay. The maximum thickness observed is about 25 ft. (El. 857+). The upper 7 to 8 ft. was found to be frozen at the time of the field investigation. The moisture content ranges from 4-24%. The obtained 'N' values indicate a loose to dense state.

#### Layers of Silt, Silty Clay and Clay

A stratified, basically cohesive type deposit was encountered immediately below the original ground level or the above described fill material at all boring locations. The lower boundary was not determined since the borings were terminated within this stratum at El. 827+. Dynamic cone penetration tests were advanced below El. 810 and are indicating somewhat similar subsoil conditions. The material in the deposit consists of irregular layers and zones of silt, silty clay and clay. In addition occasional gravel zones and organic intrusions were also observed throughout the stratum.

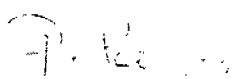
Physical properties of the material as determined from field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (%)	33-63
Liquid Limit (%)	30-59
Plastic Limit (%)	13-33
Bulk Density (PCF)	100-118
Undrained Shear Strength (PSF)	
Unconfined Compression	235-890
Field Vane	480-1440
Sensitivity	2-5

A plot of Liquid Limit Versus Plasticity Index (Figure 1) shows the points to fall within the CL-CI-CH zones. The consistency of the overall deposit ranges from very soft to firm.

#### GROUNDWATER CONDITIONS

The groundwater is assumed to be the same as the prevailing water level in the creek.



P. Payer, P. Eng.  
Foundations Engineer



K.G. Selby, P. Eng.  
Senior Foundations Engineer



## APPENDIX

# RECORD OF BOREHOLE No 1

17

W P 8-79-02 LOCATION Sta. 451+72; o/s 61' Rt. - Hwy. #11 E ORIGINATED BY H.T.  
 DIST 16 HWY 11 BOREHOLE TYPE Hand Auger Hole COMPILED BY S.C.  
 DATUM Assumed DATE May 6, 1980 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			20	40	60	80	100					
862.5	Ground Level															
0.0	Layers of Clay and Silty Clay		1	SS	PM	860										7 37 56
	Trace of Sand		2	SS	PM											
	Organic Intrusions		3	SS	PM											
	Soft to Firm															
849.0						850										
13.5	End of Borehole															

+3, x5: Numbers refer to  
Sensitivity

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

# RECORD OF BOREHOLE No 2

18

W P 8-79-02 LOCATION Sta. 451+48; o/s 14' Rt. - Hwy. #11 E ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem COMPILED BY S.C.  
DATUM Assumed DATE May 6, 1980 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			SHEAR STRENGTH							WATER CONTENT (%)			
								20 40 60 80 100										
882.0	Roadway Level																	
0.0	Sand & Gravel Traces of Silt and Clay (Fill Material) Loose to Compact		1	SS	Frozen									6 88 6				
			2	SS	19									5 85 10				
			3	SS	8									0 5 48 47				
			4	SS	11													
861.0			5	SS	11													
21.0	Layers of Silt Silty Clay and Clay Occasional Organics Trace of Sand Occasional Gravel Zones Very Soft to Firm		6	TW	PH								115.5					
			7	TW	PM													
			8	TW	PM								100					
835.0			9	TW	PM													
47.0	End of Borehole																	
816.0																		
66.0	End of Conehole																	

OFFICE REPORT ON SOIL EXPLORATION

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

W P 8-79-02 LOCATION Sta. 450+86; o/s 46' Lt. - Hwy. #11 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem COMPILED BY S.C.  
DATUM Assumed DATE May 7, 1980 CHECKED BY \_\_\_\_\_

[illegible]

+<sup>3</sup>, x<sup>5</sup> : Numbers refer to Sensitivity

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



# RECORD OF BOREHOLE No 4

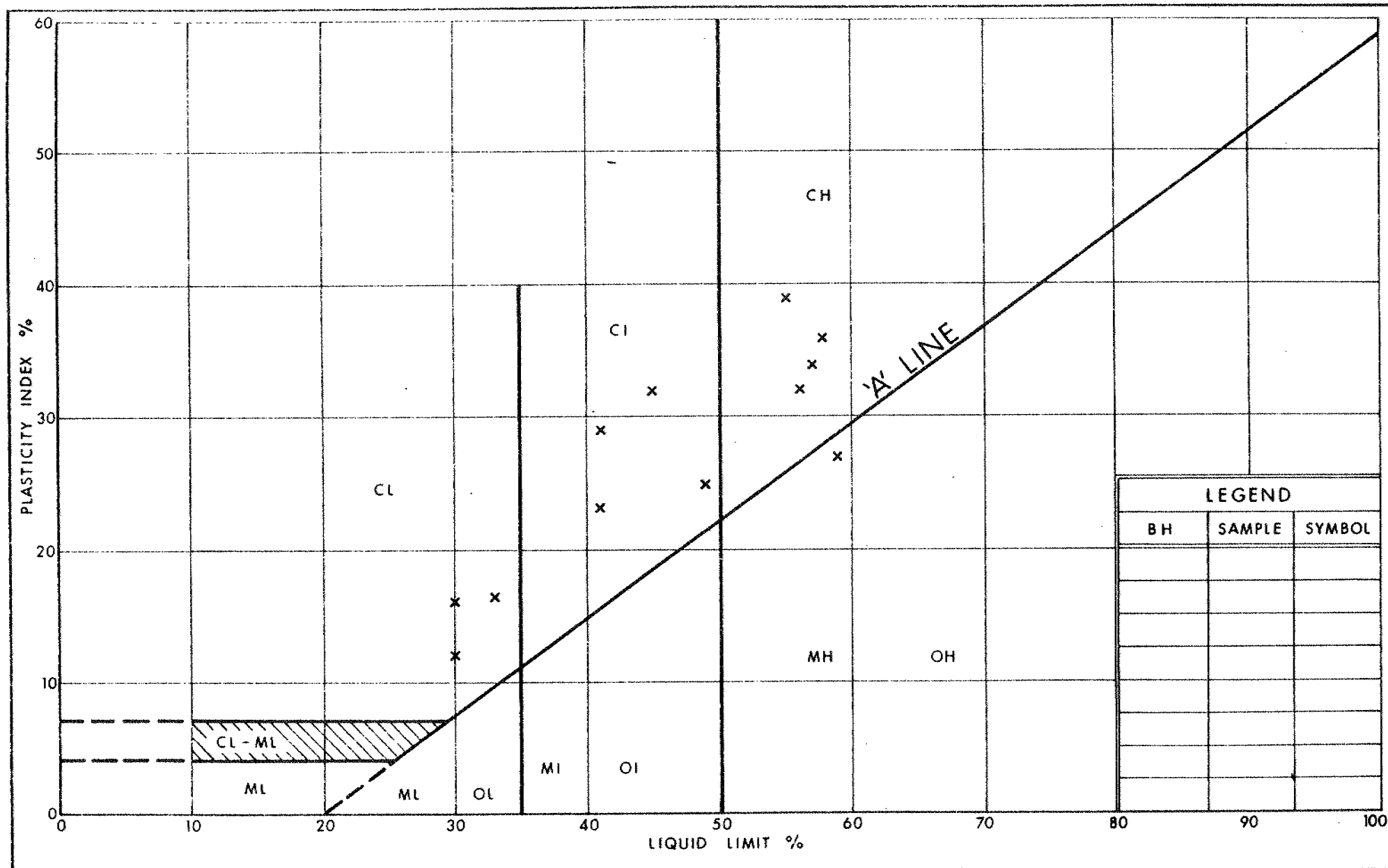
20

W P 8-79-02 LOCATION Sta. 451+14; o/s 13' Lt. - Hwy. #11 E  
DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem ORIGINATED BY H.T.  
DUM Assumed DATE May 8, 1980 COMPILED BY S.C.  
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	100					
882.0	Roadway Level													
0.0	Sand & Gravel Traces of Silt and Clay (Fill Material) Loose to Dense		1	SS	79		880							8 78 ( 14 )
			2	SS	38									
			3	SS	14									
856.9			4	SS	5		870							1 94 ( 5 ) 1 95 ( 4 )
25.1	Layers of Silt Silty Clay and Clay Trace of Sand Occasional Gravel Zones and Organic Intrusions Very Soft to Firm		5	SS	8		860						118	
			6	TW	PH									
			7	SS	1		850							
			8	TW	PM									
			9	SS	3		840						104 106	
827.0			10	TW	PM									
			11	SS	3		830							
55.0	End of Borehole													
809.0							820							
73.0	End of Conehole						810							

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



Ministry of  
Transportation and  
Communications

**PLASTICITY CHART**  
LAYERS OF SILT, SILTY CLAY AND CLAY, TRACE OF SAND, OCC.  
GRAVEL ZONES AND ORGANIC INTRUSIONS

FIG No 1

W P 8-79-02

No FILE



Ontario

Ministry of  
Transportation and  
Communications

51-217

# foundation investigation and design report

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 8-79-02

DIST #16

HWY #11

STR SITE

Proposed Culvert Replacement

*CONT. 81-217*

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Foundation Investigation Report  
For  
Proposed Culvert Replacement  
2.2 Miles North of West Junction Hwy. #101  
Township of Taylor, District of Cochrane  
Lot 4, Con. II  
W.P. 8-79-02, Site: Nil  
Hwy. #11, District #16 (Cochrane)

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## INTRODUCTION

This report contains the results of a foundation investigation carried out at this location during the period of May 6-8, 1980. The fieldwork was carried out with a continuous flight auger machine mounted on a muskeg vehicle, and equipped with 3¼ inch I.D. Hollow Stem Augers. Dynamic Cone Penetration Tests were performed adjacent to all but one borehole.

## SITE DESCRIPTION

The terrain in this vicinity, apart from the roadway embankment and creek is relatively flat and tree covered.

## SUBSURFACE CONDITIONS

### General

Apart from the fill material (sand and gravel), generally uniform subsoil conditions were found to prevail over the site area. The subsoil consists of a deposit of stratified silt, silty clay and clay with trace of sand to a minimum El. 827<sub>±</sub>.

In this report, all the horizontal and vertical measurements (chainages and elevations) are referenced to an arbitrary chosen point taken from the 'Plan and Profile' which was supplied to us by the Northern Region. This 'Plan and Profile' drawing was based and prepared on a May, 1971 survey information and updated in July, 1975. The description of the arbitrary selected reference point is as follows: Intersection of Hwy. #11 Ø and existing culvert Ø at Sta. 451+30; assumed elevation at this location: El. 882<sub>±</sub>. The extent of the fill

material and the underlying subsoil, together with the obtained field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The stratigraphical profile of Drawing No. 87902-A is based upon this information. A brief description of the fill material and original subsoil is as follows:

#### Fill Material

The material in the existing Hwy. #11 embankment was found to consist of sand and gravel with traces of silt and clay. The maximum thickness observed is about 25 ft. (El. 857+). The upper 7 to 8 ft. was found to be frozen at the time of the field investigation. The moisture content ranges from 4-24%. The obtained 'N' values indicate a loose to dense state.

#### Layers of Silt, Silty Clay and Clay

A stratified, basically cohesive type deposit was encountered immediately below the original ground level or the above described fill material at all boring locations. The lower boundary was not determined since the borings were terminated within this stratum at El. 827+. Dynamic cone penetration tests were advanced below El. 810 and are indicating somewhat similar subsoil conditions. The material in the deposit consists of irregular layers and zones of silt, silty clay and clay. In addition occasional gravel zones and organic intrusions were also observed throughout the stratum.

Physical properties of the material as determined from field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (%)	33-63
Liquid Limit (%)	30-59
Plastic Limit (%)	13-33
Bulk Density (PCF)	100-118
Undrained Shear Strength (PSF)	
Unconfined Compression	235-890
Field Vane	480-1440
Sensitivity	2-5

A plot of Liquid Limit Versus Plasticity Index (Figure 1) shows the points to fall within the CL-CI-CH zones. The consistency of the overall deposit ranges from very soft to firm.

#### GROUNDWATER CONDITIONS

The groundwater is assumed to be the same as the prevailing water level in the creek.

## DISCUSSION AND RECOMMENDATIONS

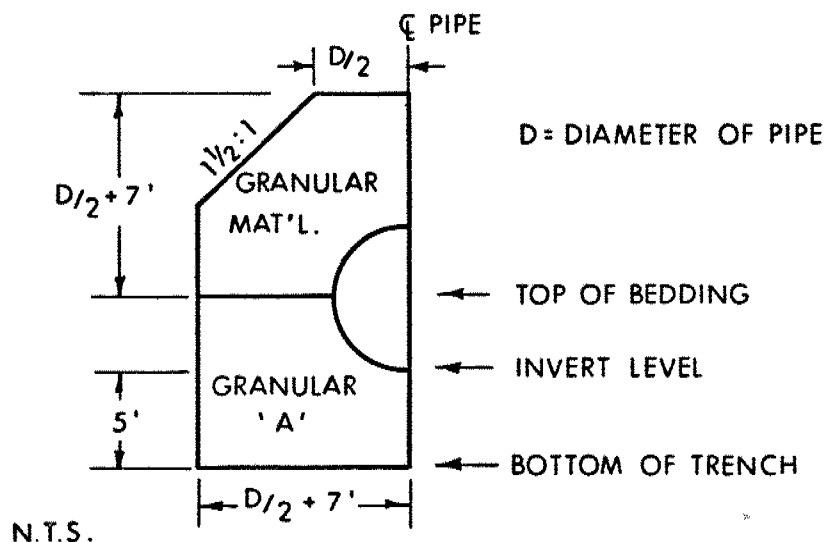
### General

It is proposed to replace the existing circular (structural plate) culvert at this location. The existing pipe is about 126 feet long and 10 feet in diameter. It is understood, that several culvert replacements were taken place since the year of 1956. The methods of installations are not available. The pipe is badly distorted and sagged about 4 ft. In our opinion the past failures were caused by the combination of the following factors:

- a) Lack and/or poor condition of the bedding material.
- b) Frost susceptible subsoil.
- c) Differential settlement of the original subsoil.

### CSP Culvert Installation

In order to ensure the integrity and the future performance of the proposed new culvert it is recommended that the pertinent M.T.C. specifications and standards be followed. The bedding for this type of pipe is outlined on M.T.C. Standard DD-808A. The minimum backfill requirements are as illustrated below:

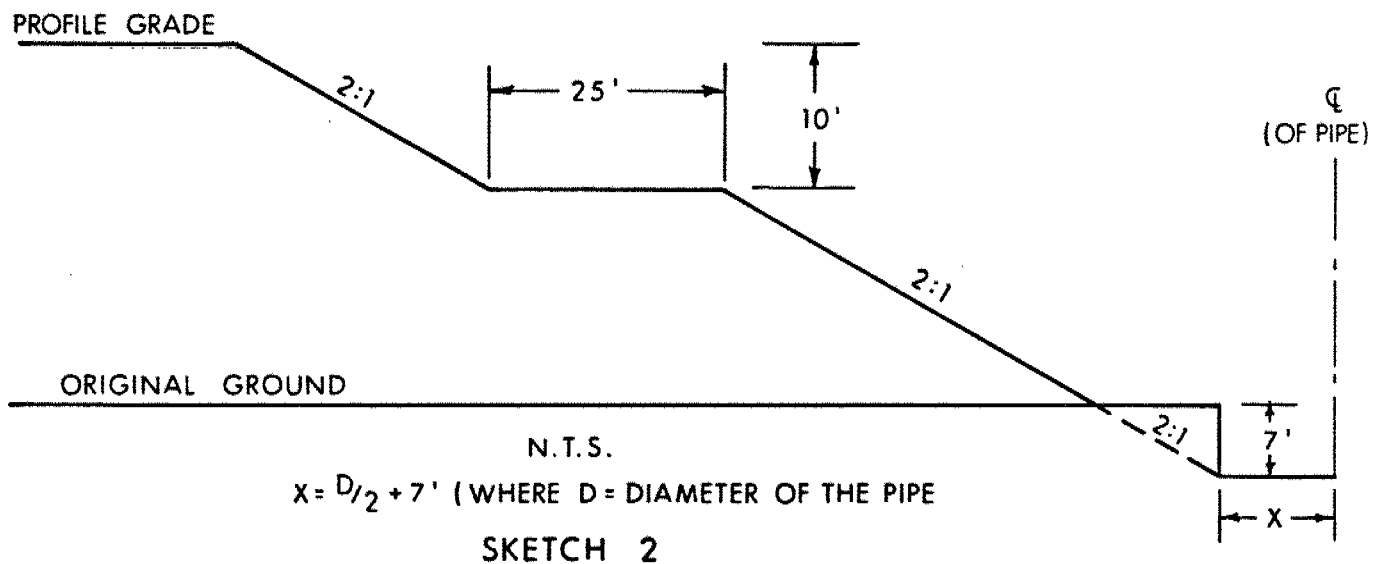


SKETCH 1

In order to place the culvert according to the current M.T.C. standards, excavation of the existing fill and the original subsoil will be required. To ensure the stability of the embankment, stability analyses were carried using the following assumptions:

Depth of excavation (below proposed new pipe invert level): 6 feet  
Height of existing embankment (over original ground) : 26 feet  
Undrained shear strength of the parent subsoil ( $c_u$ ) : 800 PSF

The obtained results have suggested the following geometry for duration of the construction:



The following construction sequence is recommended:

- 1) Excavate existing fill and the trench as illustrated above.
- 2) Place 5 ft. thick Granular 'A' at the bottom of trench.
- 3) Place bedding in dry and pipe in accordance with M.T.C. Standard DD-808A.
- 4) Backfill as shown on Sketch #1.

It is estimated that about 50% of the total predicted settlement have already been taken within the cohesive subsoil. To accommodate a further 18" of settlement the future culvert should be placed with a suitable camber.


In addition it is also recommended that the intake part of the culvert be provided with a headwall and the roadway embankment

be protected against erosion with wingwalls or rip-rap in the same vicinity.

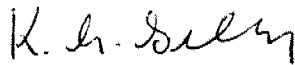
The final embankment should not be rebuilt with steeper slopes than 2:1.

#### MISCELLANEOUS

The fieldwork for this project was carried out by Mr. H. Tipler, Soils Engineer of the Regional Geotechnical Section. This report was written by Mr. P. Payer, and reviewed by Mr. K.G. Selby. The equipment used was owned and operated by Atcost Soil Drilling Inc.

  
P. Payer, P. Eng.  
Foundations Engineer



  
K.G. Selby, P. Eng.  
Senior Foundations Engineer

PP:ea

September 30, 1980.



W P 8-79-02 LOCATION Sta. 451+72; o/s 61' Rt. - Hwy. #11 E ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Hand Auger Hole COMPILED BY S.C.  
DATUM Assumed DATE May 6, 1980 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			SHEAR STRENGTH							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
862.5	Ground Level							20 40 60 80 100							
0.0	Layers of Clay and Silty Clay		1	SS	PM		860	5						7 37 56	
	Trace of Sand		2	SS	PM				4						
	Organic Intrusions		3	SS	PM				3.5						
	Soft to Firm							4							
849.0							850	3.5							
13.5	End of Borehole							3							

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 2

W P 8-79-02 LOCATION Sta. 451+48; o/s 14' Rt. - Hwy. #11 E ORIGINATED BY H.T.  
 DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem COMPILED BY S.C.  
 DATUM Assumed DATE May 6, 1980 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
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 (%)		
882.0 0.0	Roadway Level													GR SA SI CL
	Sand & Gravel Traces of Silt and Clay (Fill Material) Loose to Compact		1	SS	Frozen		880							6 88 6
			2	SS	19									5 85 10
			3	SS	8									0 5 48 47
			4	SS	11									
861.0 21.0			5	SS	11		860						115.5	
	Layers of Silt Silty Clay and Clay Occasional Organics Trace of Sand Occasional Gravel Zones Very Soft to Firm		6	TW	PH									
			7	TW	PM									
			8	TW	PM								100	
835.0 47.0	End of Borehole		9	TW	PM									
							830							
							820							
816.0 66.0	End of Conehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 3

W P 8-79-02 LOCATION Sta. 450+86; o/s 46' Lt. - Hwy. #11 ORIGINATED BY H.T.  
 DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem COMPILED BY S.C.  
 DATUM Assumed DATE May 7, 1980 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			20 40 60 80 100						
862.5	Ground Level												
0.0	Layers of Clay and Silty Clay. Trace of Sand. Organic Intrusions. Fine to Stiff		1	SS	2	860							9 53 38
854.0			2	TW	PH								
			3	SS	5								7 48 45
8.5	End of Borehole												
						850							
						840							
						830							
						820							
						810							
802.5													
60.0	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4

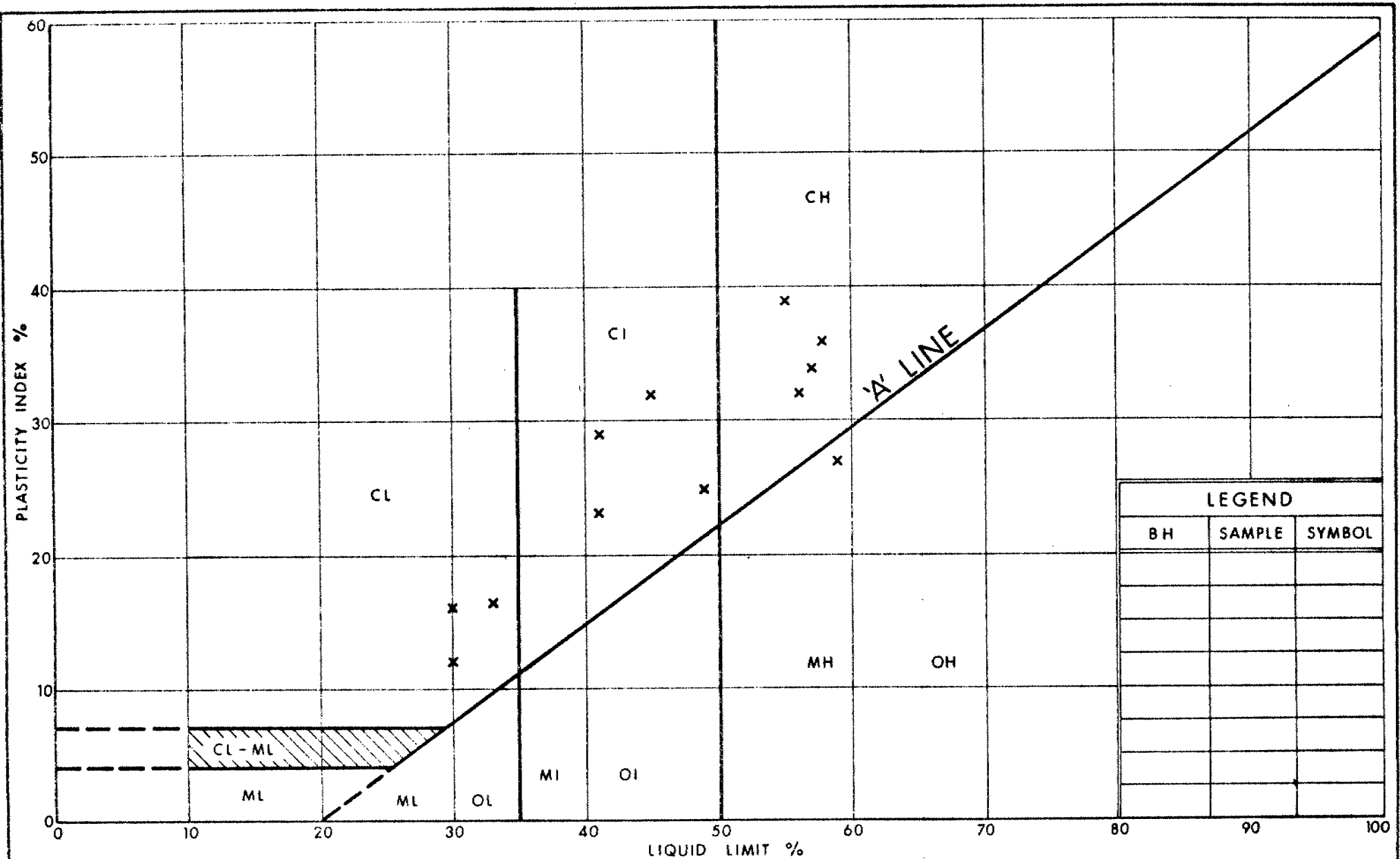
W P 8-79-02 LOCATION Sta. 451+14; o/s 13' Lt. - Hwy. #11 6 ORIGINATED BY H.T.  
DIST 16 HWY 11 BOREHOLE TYPE Continuous Flight Auger - Hollow Stem COMPILED BY S.C.  
DATUM Assumed DATE May 8, 1980 CHECKED BY

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					
882.0	Roadway Level												
0.0	Sand & Gravel Traces of Silt and Clay (Fill Material) Loose to Dense		1	SS	79								8 78 ( 14 )
			2	SS	38								
			3	SS	14								
			4	SS	5								1 94 ( 5 )
856.9			5	SS	8								1 95 ( 4 )
25.1	Layers of Silt Silty Clay and Clay Trace of Sand Occasional Gravel Zones and Organic Intrusions Very Soft to Firm		6	TW	PH							118	
			7	SS	1								
			8	TW	PM							104	
			9	SS	3							106	
			10	TW	PM								
827.0			11	SS	3								
55.0	End of Borehole												
809.0													
73.0	End of Conehole												

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of  
Transportation and  
Communications

**PLASTICITY CHART**  
LAYERS OF SILT, SILTY CLAY AND CLAY, TRACE OF SAND, OCC.  
GRAVEL ZONES AND ORGANIC INTRUSIONS

FIG No 1

W P 8-79-02

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

$S_u$ (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: 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 DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

#### ABBREVIATIONS & SYMBOLS

##### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $\bar{C}U$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

##### FIELD SAMPLING

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

##### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_A$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_P$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE  
 $w$  SLOPE ANGLE-BACKFACE OF WALL  
 $\beta$  ANGLE OF SLOPE  
 $N_c, N_q, N_\gamma$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

##### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_L - w_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } \mu m \text{ Soil Fraction}}$   
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

##### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS

##### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $m_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

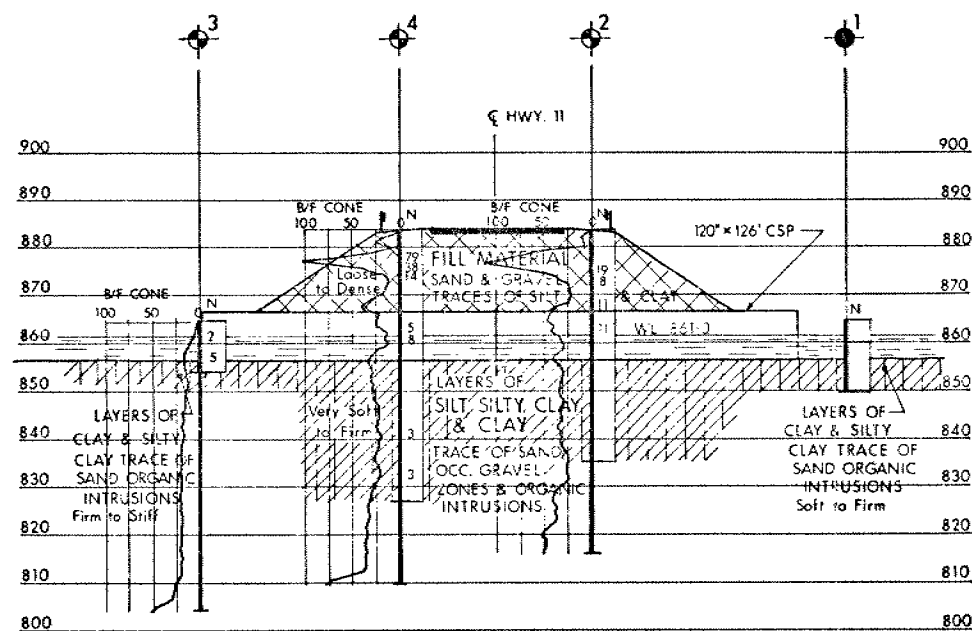
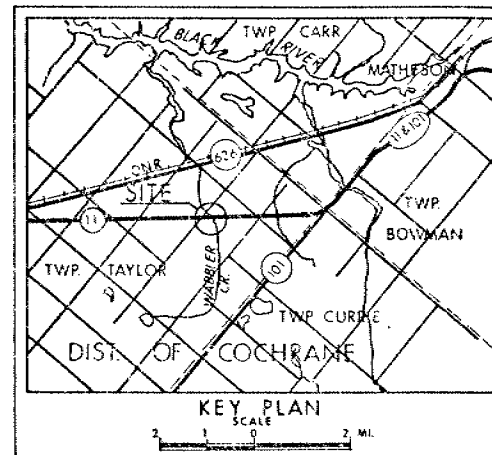
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PROJECT NO. 42A-33 (Formerly 08-47-308 75-10)

CONT No  
WP No 8-79-02

CULVERT REPLACEMENT  
AT STA. 415+30

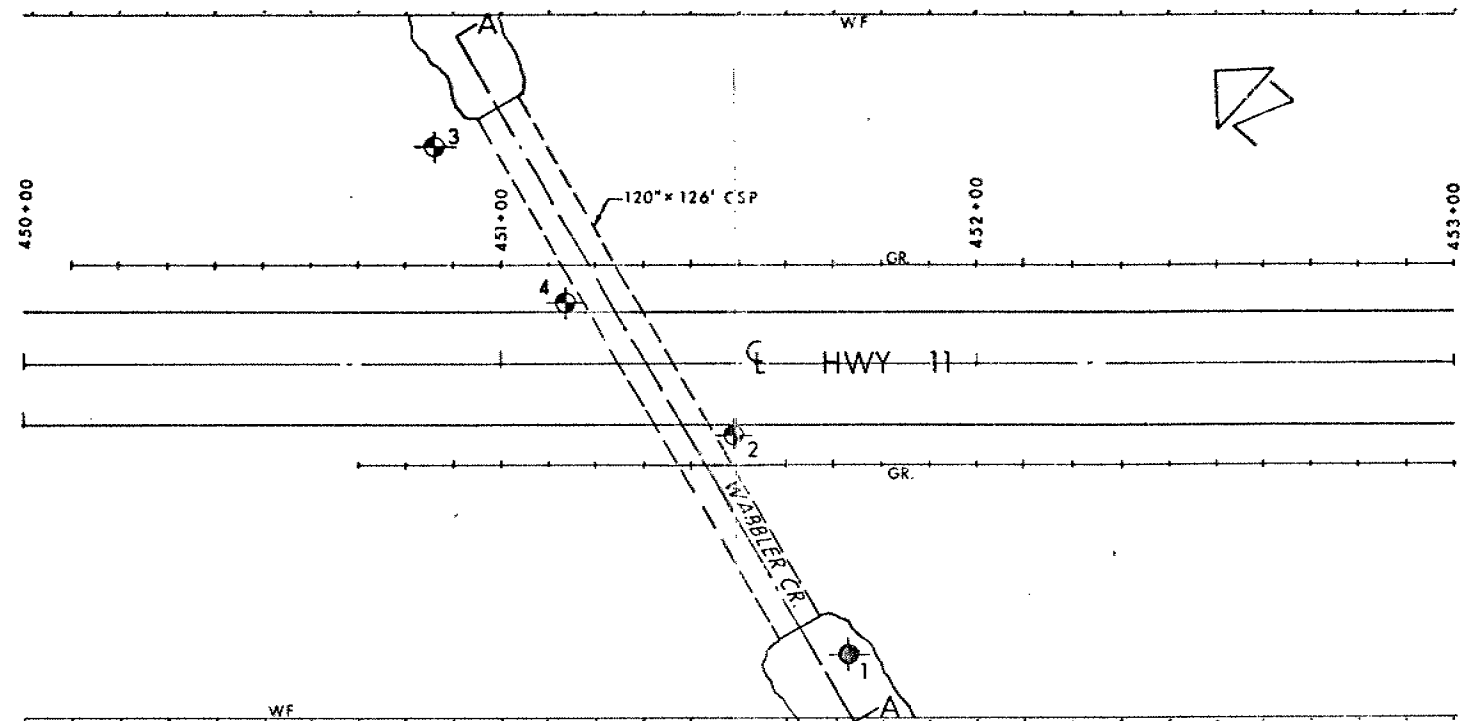
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



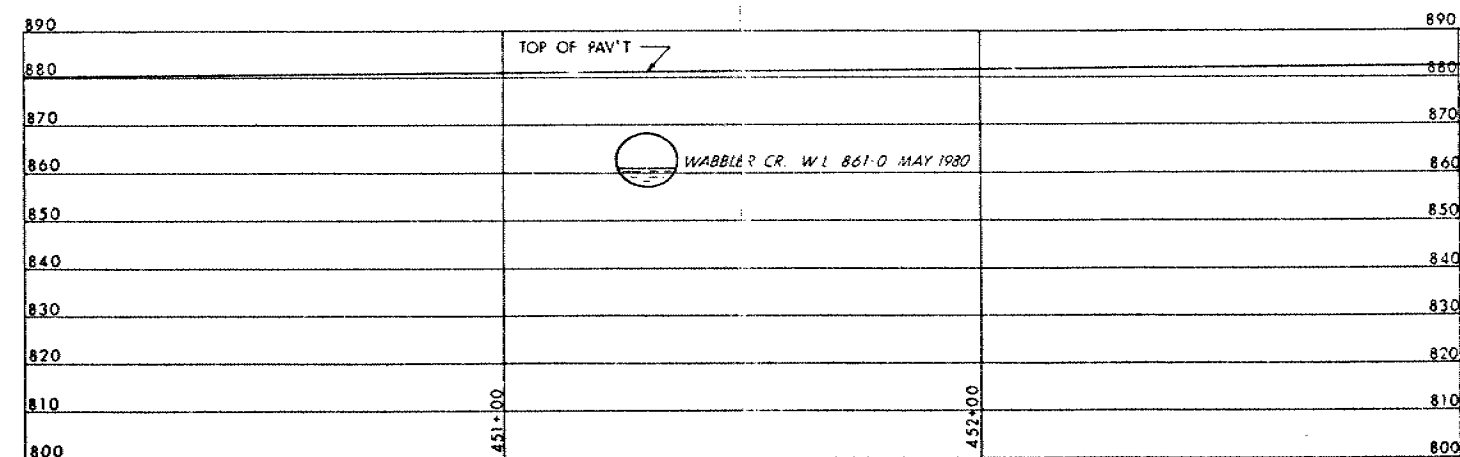
SECTION A-A

SCALE  
20 10 0 20 FT.



PLAN

SCALE  
20 10 0 20 FT.



PROFILE HWY 11

SCALE  
20 10 0 20 FT.

- LEGEND
- Bore Hole
  - Dynamic Cone Penetration Test (Cone)
  - Bore Hole & Cone
  - 'N' Blows/ft (Std Pen Test 350 ft lbs energy)
  - CONE Blows/ft (60° Cone, 350 ft lbs energy)
  - WL at time of investigation MAY 1980

No	ELEVATION	STATION	OFFSET
1	862.5	451+72	61' RT.
2	882.0	451+48	14' RT.
3	862.5	450+86	46' LT.
4	882.0	451+14	13' LT.

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

GEOCRES NO. 42A-33

HWY No. 11

SUBMIT. P. CHECKED / DATE 80 09 24 / SITE

DRAWN / CHECKED / APPROVED / DWG 87902-A