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Ontario

Ministry of
Transportation and
Communications

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

WO 77-10548 DIST 16

HWY Twp. Rd. STR SITE 39E-36

Brower Creek Bridge

DISTRIBUTION

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DATE MAR 3 1 1978

FOUNDATION INVESTIGATION REPORT

For

Brower Creek Bridge
Township of Glackmeyer, District of Cochrane
Road Allowance Between Con. II & III
W.O. 77-10548, Site 39E-36
Township Road, District 16, Cochrane

INTRODUCTION

A foundation investigation was carried out during the period of December 11-14, 1977 for the above mentioned project. The fieldwork consisted of 2 sampled boreholes by using 3¼ inch I.D. hollow stem augers. This report contains the results of the field investigation.

SITE DESCRIPTION

The structure site is situated on a gently rolling terrain with pasture land and numerous woodlots in the vicinity. Mixed deciduous and coniferous trees make up the woodlots. Brower Creek meanders through the area in a channel approximately 12 feet below the existing bridge deck elevation. The height of approaches is in the order of 5 feet.

SUBSURFACE CONDITIONS

General

Apart from the surficial layers of fill material and organic material the subsoil was found to consist of an extensive deposit of very soft to firm clayey silt to silty clay deposit. The obtained field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The estimated stratigraphical profile is shown on Figure 3.

Fill Material

This zone was encountered in Borehole 2 only which was put down through the existing roadway for a depth of 5 feet. The consistency is estimated to be very stiff.

Organic Material

In Borehole 2 an approximate 3 feet thick dark brown organic material (decayed and undecayed) mixed with silt was encountered immediately below the ground surface.

Clayey Silt to Silty Clay

Immediately below the fill or organic materials an extensive deposit of clayey silt to silty clay with some sand and trace of gravel was intersected. The lower boundary was not determined since the borings were terminated within this deposit, but it is estimated that the thickness is over 55 feet. The upper portion of the stratum was found to contain silty sand layers and/or organic substances.

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

		Range
Natural Moisture Content	(%)	15- 58
Liquid Limit	(%)	21- 59
Plastic Limit	(%)	10- 22
Undrained Shear Strength	(PSF)	
Unconfined		295-322
Field Vane		150-800
Bulk Density	(PCF)	105-125
Sensitivity		1- 4

Grain size distribution curves are plotted on Figure 1.

Based on the shear strength tests' results the consistency is estimated to vary from very soft to firm.

Groundwater Conditions

No groundwater observation was carried out during the fieldwork. There are two flowing wells west of the structure which indicates artesion conditions. The source of the water is about 120 feet below ground level.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to erect a new 3 span structure incorporating a grade rise of about 3 to 4 feet at this location. The existing bridge is a five span timber trestle structure with an overall length of 75 feet and supported on timber pile bents. Many of the piles have been cut off around water level and the bridge superstructure replaced since original construction.

Structure Foundation

In view of the encountered subsoil conditions it is recommended that the new structure be supported on friction piles. The use of timber piles appears to be the most practical solution. No. 14 timber piles fitted with driving shoes are recommended. The embedded length of the piles should not be less than 40 feet. In determining the safe load carrying capacity (Q) the following equation may be used:

$$Q = 0.3L \text{ (tons)}$$

where L = embedded length in original ground (feet)

If any length of the piles remain over water level the entire pile should be treated to prevent decay.

Approach Embankments

The profile grade of the approaches will be some 16 feet higher than the creek bed. The approach embankments should be constructed with 2:1 side and forward slopes. In addition, it is recommended that forward slopes be provided with 8 foot wide berms at mid-height.

Care should be taken that no bouldery material is placed at locations where piles have to be driven. It is recommended that this portion of the fill should not contain larger sizes than 2 inches. Rip-rap should be placed on the slopes for a distance of 2 feet above the observed high water level. Up to 3 inches of settlements are anticipated.

P. Payer, P. Eng.
Senior Engineer

K.G. Selby, P. Eng.
Supervising Engineer

REGISTERED PROFESSIONAL ENGINEER
P. PAYER
PROVINCE OF ONTARIO

March, 1978

APPENDIX

Ministry of Transportation and Communications, Ontario

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

WO 77-10548 LOCATION Sta. 10+32; o/s 20' Lt. ℄ Twp. Rd. ORIGINATED BY JM

DIST 16 HWY Twp. Rd. BOREHOLE TYPE Continuous Flight Auger & Cone Test COMPILED BY JM

DATUM Assumed DATE December 11 & 12, 1977 CHECKED BY

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
91.0	Ground Level						90
0.0	Organic Material						
88.0	Dark Brown						
3.0	Clayey Silt to Silty Clay — Organics; Silty Sand Layer		1	SS	15		
			2	SS	5		
			3	SS	2		80
	Some Sand Trace of Gravel		4	TW	PM		
			5	SS	2		
	Very Soft to Firm		6	SS	3		70
			7	SS	3		
			8	TW	PM		60
			9	SS	–		
			10	SS	3		50
			11	SS	–		
							40
			12	SS	5		
33.5							
57.5	End of Borehole						30
	Probable Clayey Silt to Silty Clay						20
12.0							
79.0	End of Cone Test						
	Note: Groundwater level was not observed						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH PSF

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL × LAB VANE

200 400 600 800 1000

Frozen Zone Preaugered

S=3 S=4 S=3 S=2 S=2 S=1 S=2 S=3 S=3 S=2 S=2

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
Org. 6.9%	
	1 47 32 20
	0 1 29 70
105	
	2 23 35 40

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

W O 77-10548 LOCATION Sta. 9+48; Off-set 6' Rt. ℄ Twp. Rd. ORIGINATED BY JM

DIST 16 HWY Twp. Rd. BOREHOLE TYPE Continuous Flight Auger & Cone Test COMPILED BY JM

DATUM Assumed DATE December 13 & 14, 1977 CHECKED BY

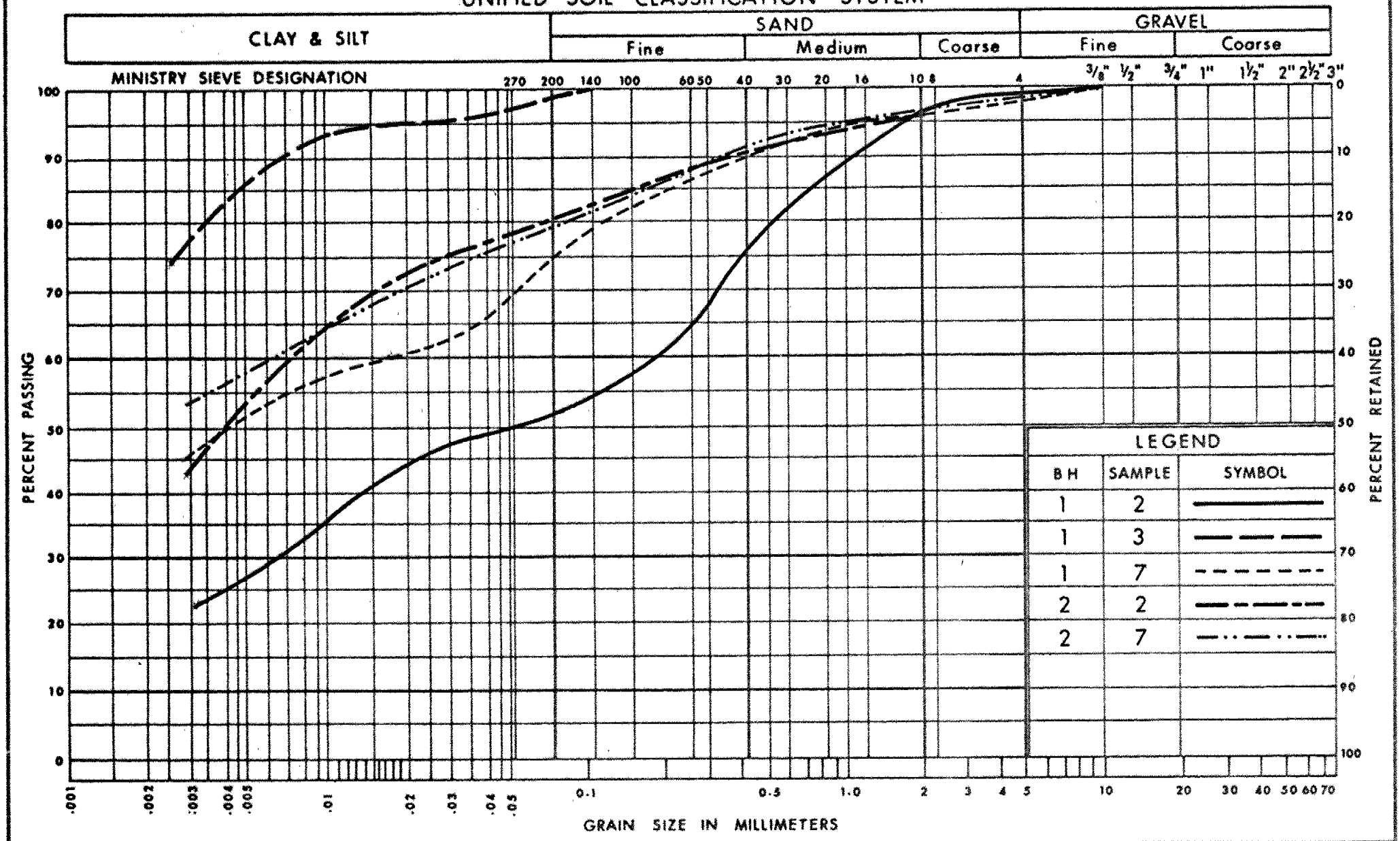
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH PSF (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 200 400 600 800 1000)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL; WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.7	Ground Level										
0.0	Silty Clay Very Stiff							Augered to 3'			
90.7	Fill Material		1	SS	19						
5.0	Clayey Silt to Silty Clay Organics (Wood)		2	SS	30	8"	90				2 18 45 35
			3	SS	100/						
			4	SS	6			S=2			
			5	SS	5			S=2			
	Very Soft to Firm		6	SS	2		80	S=2			
			7	TW	PM			S=3		120	2 19 29 50
			8	SS	4		70	S=2			
63.2			9	TW	PM			S=3		125	
32.5	End of Borehole						60				
	Probable Clayey Silt to Silty Clay						50				
40.7											
55.0	End of Cone Test										
	Note: Groundwater Level was not observed										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

UNIFIED SOIL CLASSIFICATION SYSTEM

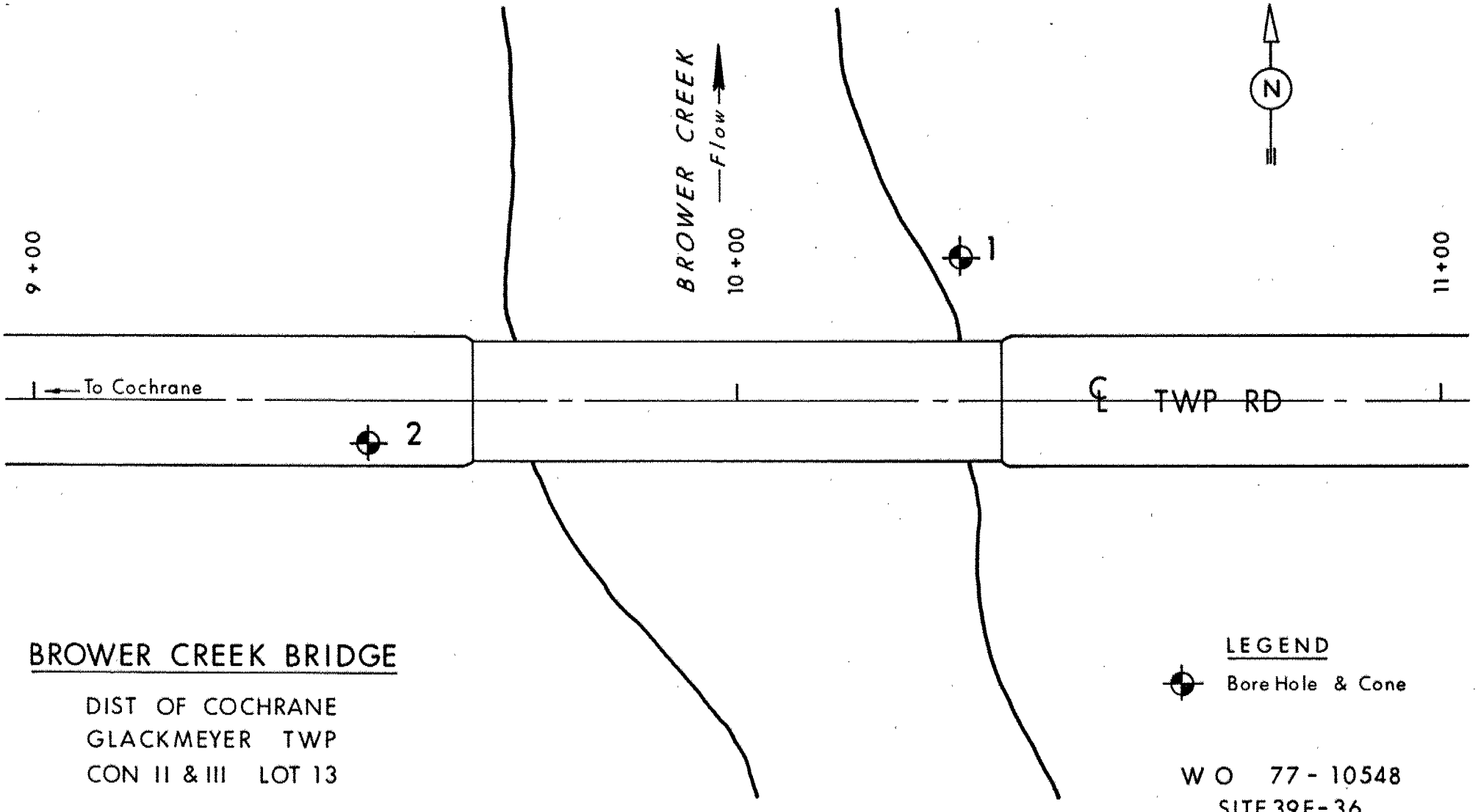


Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO SILTY CLAY
SOME SAND, TRACE OF GRAVEL

FIG No 1
W O 77 - 10548



BROWER CREEK BRIDGE

DIST OF COCHRANE
GLACKMEYER TWP
CON II & III LOT 13

LEGEND

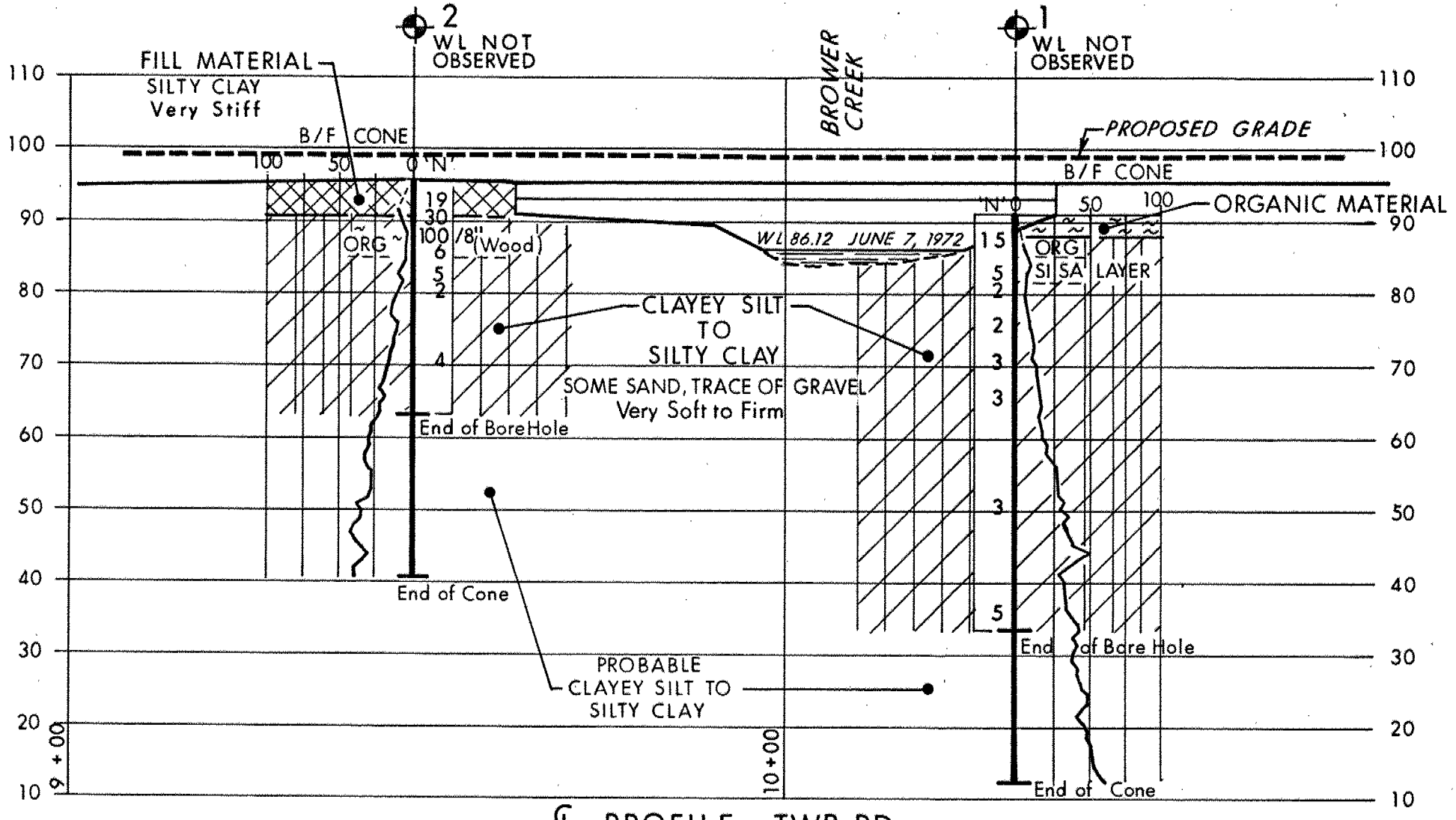
Bore Hole & Cone

W O 77 - 10548
SITE 39E-36
DIST 16

PLAN

SCALE 1" = 20'

Figure No 2



℄ PROFILE - TWP RD

SCALE 1" = 20'

DIST OF COCHRANE
GLACKMEYER TWP
CON II & III LOT 13

Figure No 3

BROWER CREEK BRIDGE
WO 77-10548 DIST 16
SITE 39E-36

EXPLANATION OF TERMS USED IN REPORT

'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 $\bar{N}$.

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. $\overline{CIU}$ = 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

μ	COEFFICIENT OF FRICTION
δ	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
ω	SLOPE ANGLE-BACKFACE OF WALL
β	ANGLE OF SLOPE
N_γ, N_q, N_c	BEARING CAPACITY FACTORS
D_f	DEPTH OF FOOTING
B,L	FOOTING DIMENSIONS

INDEX PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	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 = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
A_c	ACTIVITY = $\frac{I_p \text{ of soil}}{\%\text{ of } 2\mu m \text{ Soil Fraction}}$
Om	ORGANIC MATTER CONTENT
S_r	DEGREE OF SATURATION
S	SENSITIVITY = $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

STRENGTH PARAMETERS

ϕ	ANGLE OF SHEARING RESISTANCE
τ_f	PEAK SHEAR STRENGTH
τ_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
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	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

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

HYDRAULIC TERMS

h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
j	SEEPAGE FORCE PER UNIT VOLUME
η	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
OCR	OVERCONSOLIDATION RATIO

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 42H-11

DIST. 16 REGION

W.P. No.

CONT. No.

W. O. No. 80-10525(R)

STR. SITE No. 39E-35

HWY. No. LOC

LOCATION BROWER CREEK @
BLACKMEYER TWP RD.
(2.0 KM NORTH OF HWY 574)

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

for

W.O. 80-10525R, Site 39E-35

Township of Glackmeyer, District of Cochrane

Lots 12 & 13, Con. II

Township Road, District 16, Cochrane

FOUNDATION INVESTIGATION REPORT
for
W.O. 80-10525R, Site 39E-35
Township of Glackmeyer, District of Cochrane
Lots 12 & 13, Con. II
Township Road, District 16, Cochrane

INTRODUCTION

Warnock Hersey Professional Services Limited have been retained by the Ontario Ministry of Transportation and Communications, under Agreement No. 4242-9081-18, to investigate and report on the geotechnical aspects of the above structure site. The fieldwork consisted of 3 sampled boreholes put down by means of 89 mm I.D. hollow stem augers. This report contains the results of the field investigation, subsequent laboratory tests and geotechnical analyses.

SITE CONDITIONS

The structure site is characterized by gently rolling terrain. Brower Creek meanders through the area in a channel approximately 3 m below the existing bridge deck elevation. The height of approaches is in the order of 1.5 m. No channel side slope instability is evident. The existing timber bridge is in poor repair, and the road only in passable condition.

SUBSURFACE CONDITIONS

General

Beneath surficial layers of fill and organic materials, the subsoil consists of an extensive deposit of soft to firm silty clay with some sand and traces of gravel followed at about the 16 m depth by a firm to stiff clay deposit. Field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The estimated stratigraphical profile is shown on Drawing No. 8010525R-A.

Fill Material (Cont'd)

Fill was encountered in Boreholes 1 and 2 which were put down at the edges of the existing roadway. The fill material consists of sand and gravel and is contaminated with organics. It is estimated to be in a compact state of relative density.

Organic Material

In all three boreholes, dark brown organic silt and peat, up to 3 m thick was encountered immediately below the ground surface or the road fill material. N values ranged from 2 to 4 indicating a soft to firm consistency. One moisture content was observed at 86 percent.

Silty Clay with some sand and traces of gravel

Immediately below the fill or organic materials is an extensive deposit of silty clay with some sand and traces of gravel. The lower boundary of this deposit occurs at a depth of about 16 m. It is estimated that the thickness of this stratum is about 14 metres.

The engineering properties of the material, as determined from field and laboratory tests, are as follows:

		Range
Natural Moisture Content	(%)	20-30
Liquid Limit	(%)	30-35
Plastic Limit	(%)	16-20
Undrained Shear Strength	(kPa)	
Quick Triaxial		10-30
Field Vane		25-80
Unit Weight	(kN/m^3)	20
Sensitivity		2-5

The undrained shear strength, as measured by the field vane, increases linearly with depth from an initial value of about 30 kPa at the surface at a p/c_u ratio of about 0.3. Based on these shear strengths, the consistency of the deposit is estimated to range from soft to firm.

Silty Clay (Cont'd)

One consolidation test was carried out on a sample from the 10 m depth. This test shows the deposit to be slightly over-consolidated, with a compression index of just over 0.2 and an initial voids ratio of about 0.8.

Clay

At a depth of about 16 m, the silty clay deposit contacts a clay deposit which has a varved appearance, but is not a varved clay. It is not gritty, as the upper lying deposit is, and exhibits a firm to stiff consistency based on marginally higher undrained shear strengths of 50 to 70 kPa.

Groundwater Conditions

Groundwater observations carried out during the fieldwork indicate water levels comparable to the creek level. Near an adjacent structure site (39E-36) two flowing wells were reported in a prior investigation. These are believed to be the result of artesian flow from depths in excess of 35 m. The existence of similar artesian conditions at this site was not investigated.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to relocate the present road on a tangent alignment and to rechannelize Brower Creek in order to eliminate one meander bow. This proposal results in a new bridge location immediately to the north of the existing location, as shown on the plan in Drawing 8010525R-A.

Structure Foundation

Spread footings are not considered feasible due to the soft and compressible nature of the subsoil at this site. The use of timber piles is recommended. Timber piles should be pressure creosote treated. In determining the safe load carrying capacity, (Q), the following equation may be used for piles with minimum butt diameters of 330 mm:

$$Q = 10L \text{ (kN)}$$

Where L = length of pile in metres embedded in the silty clay stratum.

Prior to driving of piles, especially through new approach fills, the underlying compressible organic deposits should be subexcavated from within the plan limits of the new fill as per MTC Standard DD-406. Piles driven through compacted fills may be designed using the total length of the pile as L. Care should be taken to ensure that the approach fill is free from gravel sizes larger than 75 mm in areas where piles are to be driven.

Structure Foundation (Cont'd)

It is recommended that all timber piles be driven to a tip elevation of 16.0. At this elevation, the pile tips will rest on or be close to a thin silty sand layer and as such may derive some additional base capacity.

Approach Embankments

Approach fills will be of nominal height. However, at the new channel location, a berm of minimum 2 metres width is recommended between top of channel cut and toe of approach fill to prevent any erosion and undermining of the fill forward slopes. These slopes should also be rip-rapped, along with the channel cut slopes below them.

New fills should be placed on inorganic soil by stripping off the surficial topsoil and other organic deposits. Such fills will be stable at 2:1 side slopes for heights not in excess of 3 metres. Higher fills will require flatter slopes as shown in the table below.

Fill Height	Recommended Side and Forward Slopes
Less than 3 m	2:1
3-4 m	2-1/2:1
4-5 m	3:1
more than 5 m but less than 8 m	Provide 3 m wide berm at mid-height of fill

Settlements will occur over the long term as a result of any new fill construction. However, these should be of a tolerable magnitude since the silty clay deposit appears to be preconsolidated. Based on an estimated preconsolidation pressure value of 150 kPa, approach fills up to 6 m in height could be built in theory without inducing excessive settlements; however, such fills are likely to overstress the softer upper zones of the silty clay deposit, thus resulting in a creep type of settlement.

Rechannelization

Cut slopes of 2 to 3 metres depth will be stable at 2:1 or flatter side slopes within the silty clay stratum. It is recommended that in the vicinity of the new structure, and for a minimum distance of 10 metres on either side, the channel slopes be protected by rip-rap. Random rip-rap consisting of 300 mm or less sized stone should be at least 300 mm thick. For proper seepage control a minimum 150 mm thickness of granular A, B or C material should be provided below the rip rap.

The new channel excavation material may be used to fill in the by-passed sections of the existing channels. However, beneath the new road alignment, only inorganic, compacted, fill materials should be used to infill the by-passed channels. At such locations, any underlying stream bed organics should be removed prior to infilling. The side slopes of fills should be as per the recommendations given for approach embankments.

O.H.B.D.C. Provisions

If the OHBDC provisions are used for designing this structure, the following information may be useful.

Friction Piles with Tips at Elevation 16.0

Safe Capacity	100 kN
Factored Capacity at U.L.S.	150 kN
Capacity at S.L.S. Type II	100 kN

Stability Calculations

factored undrained shear strength of silty clay:

elevation: 26-20 20 kPa
elevation: 20-14 26 kPa

factored effective angle of internal friction of silty clay

$\phi_f = 13.7^o$

unit weight of silty clay = $19kN/m^3$

Respectfully submitted,

C. Mirza, P. Eng.
Manager,
Geotechnical Services

Report by B. Donofrio

Encl.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

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

Warnock Hersey Professional Services Ltd.
Since 1888 3210 American Drive Mississauga Ontario L4V1B3 (416)678-7820 Telex 06-968801

RECORD OF BOREHOLE No 1 METRIC

W O 80-10525 R LOCATION STA 0+333.5 %s 2.0 m Lt of ℄ ORIGINATED BY BD
DIST 16 HWY Municipal Rd BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY JT
DATUM Assumed DATE 1981 05 12 CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
29.4	Ground Level										
0.0 / 28.6	FILL, Sand and Gravel Occ. Organics Compact										
0.8	Frozen		1	SS	24		28				
	ORGANIC SILT AND PEAT, Occasional Stones Soft to Firm		2	SS	4						
			3	SS	4						
25.6			4	SS	5		26	+3			
3.8			5	SS	3			+4			
			6	SS	2		24				
			7	SS	2			+3			
	SILTY CLAY With Some Sand and Traces of Gravel Grey Soft to Firm		8	TW	PM		22	x9 x4 ●9 +3	o	20.1	
			9	SS	3		20	+2			
			10	SS	5		18	+2			
	Silty Sand		11	SS	7						0 70 (30)
			12	TW	PM		16	+3			
13.7			13	SS	4		14	+2			
15.7	End of Borehole						12				
	PROBABLY CLAY						10				
6.6							8				
22.8	End of Cone Test										

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

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Warnock Hersey Professional Services Ltd.
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RECORD OF BOREHOLE No 2

METRIC

W O 80-10525 R | LOCATION STA. 0+321.5 %s 2.5m Rt of ℄ | ORIGINATED BY BD
DIST 16 HWY Municipal Rd | BOREHOLE TYPE Hollow Stem Auger and Cone Test | COMPILED BY JT
DATUM Assumed | DATE 1981 05 13 | CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
28.8	Ground Level							
28.5	FILL MATERIAL							
0.3	ORGANIC SILT AND PEAT, With intermixed Silty Clay Seams, Soft		1	SS	3	▼		
			2	SS	2			
26.3			3	SS	6			
2.5			4	SS	2			
			5	SS	2			
			6	TW	PM		20.0	
	SILTY CLAY With Some Sand and Traces of Gravel Grey Soft to Firm		7	SS	2			
			8	SS	2			
			9	SS	2			
			10	TW	PM		19.0	P_o = 100 kPa P_c = 150 kPa C_c = 0.235 C_r = 0.035
	Silty Sand		11	SS	3			
			12	SS	7			
12.5			13	SS	7			
16.3			14	TW	PM			
	CLAY, Grey Firm to Stiff (Varved Appearance)		15	SS	2			
			16	SS	3			
			17	SS	3			
5.5			18	SS	2			
23.3	End of Borehole							

ELEVATION SCALE: 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT W_p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L
WATER CONTENT (%) 15 30 45

86%

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

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

OFFICE REPORT ON SOIL EXPLORATION

Warnock Hersey Professional Services Ltd.
Since 1888 3210 American Drive Mississauga Ontario L4V 1B3 (416)678-7820 Telex 06-968801

RECORD OF BOREHOLE No 3

METRIC

W O 80-10525 R LOCATION STA. 0+300.0 %s 2.5 m Rt of ℄ ORIGINATED BY B D
DIST 16 HWY Municipal Rd BOREHOLE TYPE Hollow Stem Auger COMPILED BY J T
DATUM Assumed DATE 1981 05 13 CHECKED BY C M

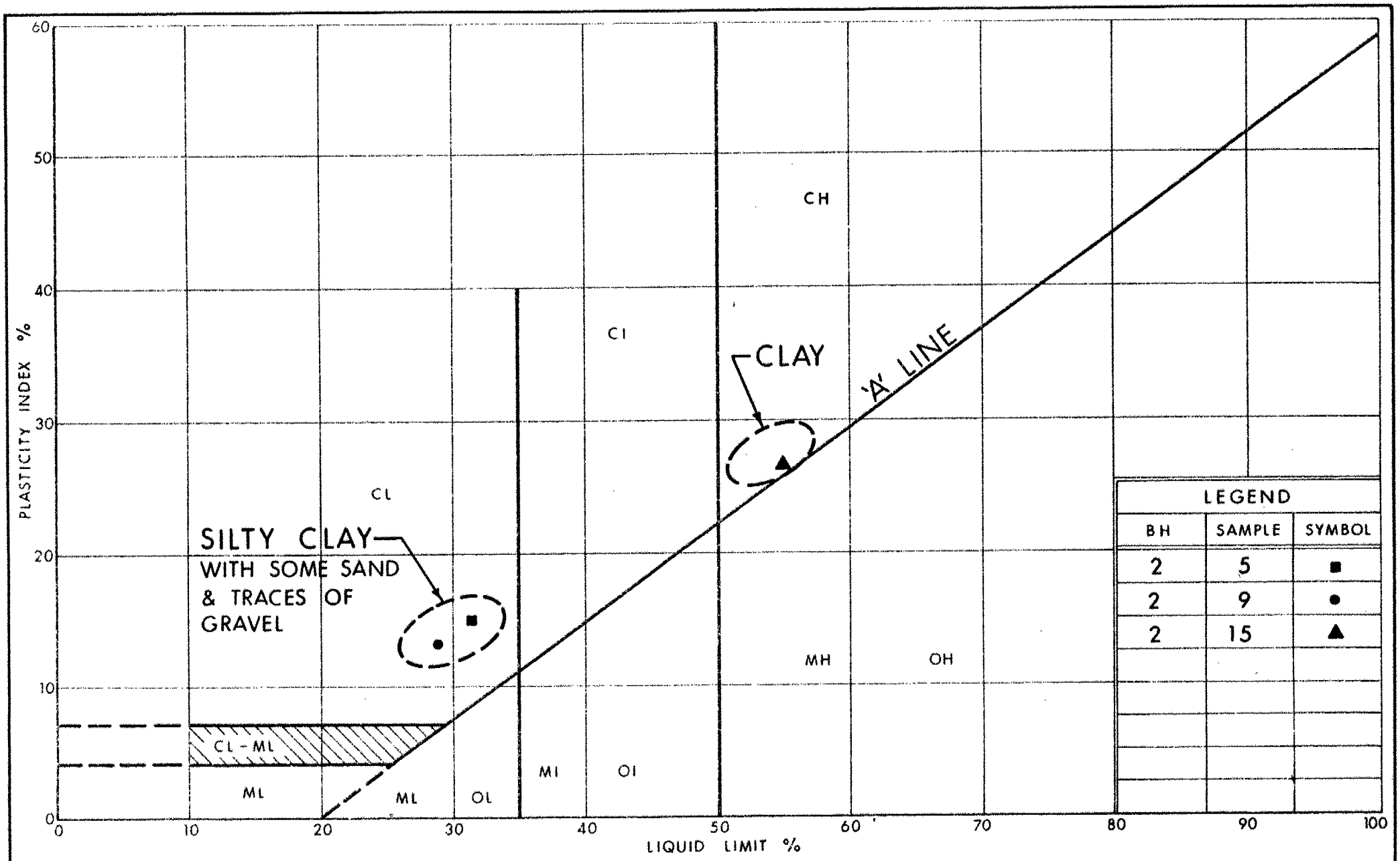
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
27.7	Ground Level										
0.0	ORGANIC SILT AND PEAT, Soft		1	SS	2						
26.2							26				
1.5	SILTY CLAY With Some Sand and Traces of Gravel Soft to Firm		2	SS	5						
			3	SS	2			+3			
23.9			4	SS	2		24	+3			
3.8	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Oct 75, FF-S-21



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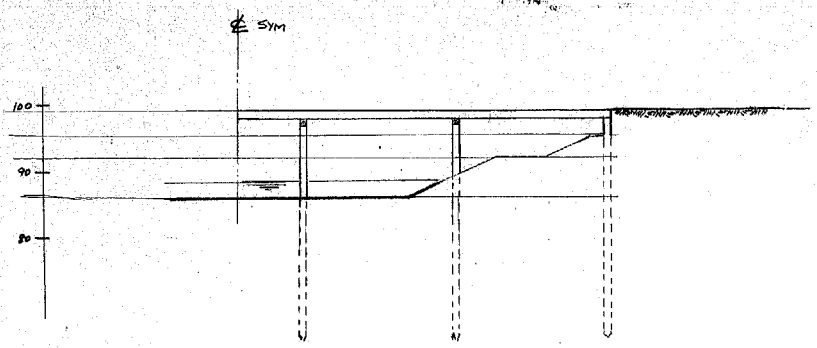
PLASTICITY CHART

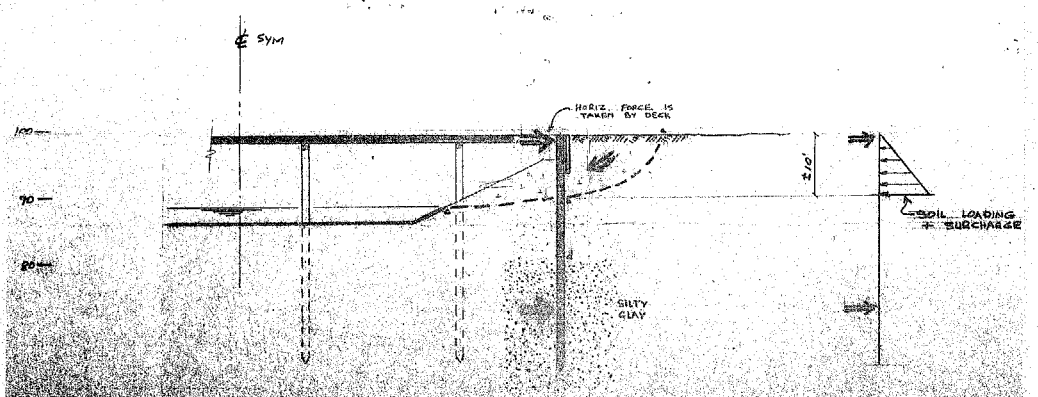
FIG No 1

WO 80-10525R



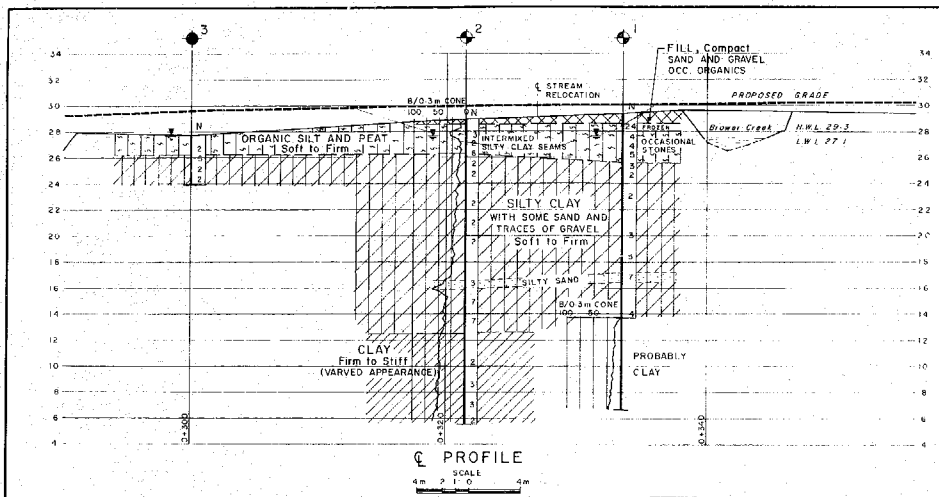
ELEVATION USING BERM TO RELIEVE ABUTMENT

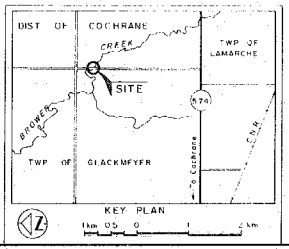
1" = 10'



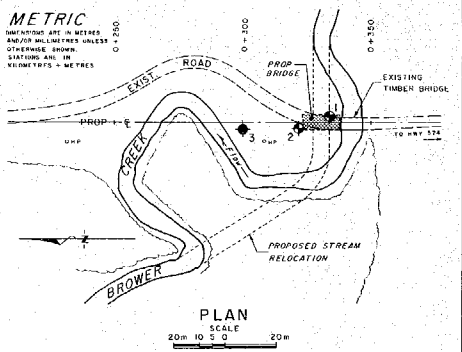
ELEVATION

1" = 10'





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



PLAN
SCALE
20m 10 5 0 20m

BM 2	ELEV. 29.220 (Assumed)
NAIL IN 6" Ø POPLAR STUMP STA 0+232.7, 9.2m Rt	
BM 3	ELEV. 31.037 (Assumed)
SPIKE IN W.FACE HP 7.5m Rt STA 0+391.5	

LEGEND

- Bore Hole
- Bore Hole and Cone
- N Blows/0.3m (Std Pen Test, 475 J/Blow)
- CONE Blows/0.3m (60° Cone, 475 J/Blow)
- W.L. at time of investigation 1981 06 18

No	ELEVATION	STATION	OFFSET
1	29.4	0+333.5	2.0m Lt
2	28.8	0+321.5	2.5m Rt
3	27.7	0+300.0	2.5m Rt

REF NORTHLAND ENGINEERING LTD PROJECT No SU-479 DWG. 1, 80 10 08

Warnock Hersey Professional Services Limited

BROWER CREEK CROSSING
(2 km North of Hwy 574)

DIST OF COCHRANE — TWP OF GLACKMEYER
CON 2 LOT 12 & 13 SITE 39E-5S DIST 16

DATE 1981 06 18 | W.O. 80-10525R | DWG No 8010525R-A