DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 31G-193

DIST. 9 REGION

W.P. No. 12-88-01

CONT. No. 89-09

W. O. No.

STR. SITE No. 27-61-245C

HWY. No. 17

LOCATION Mill Creek Culvert Reconstruction

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

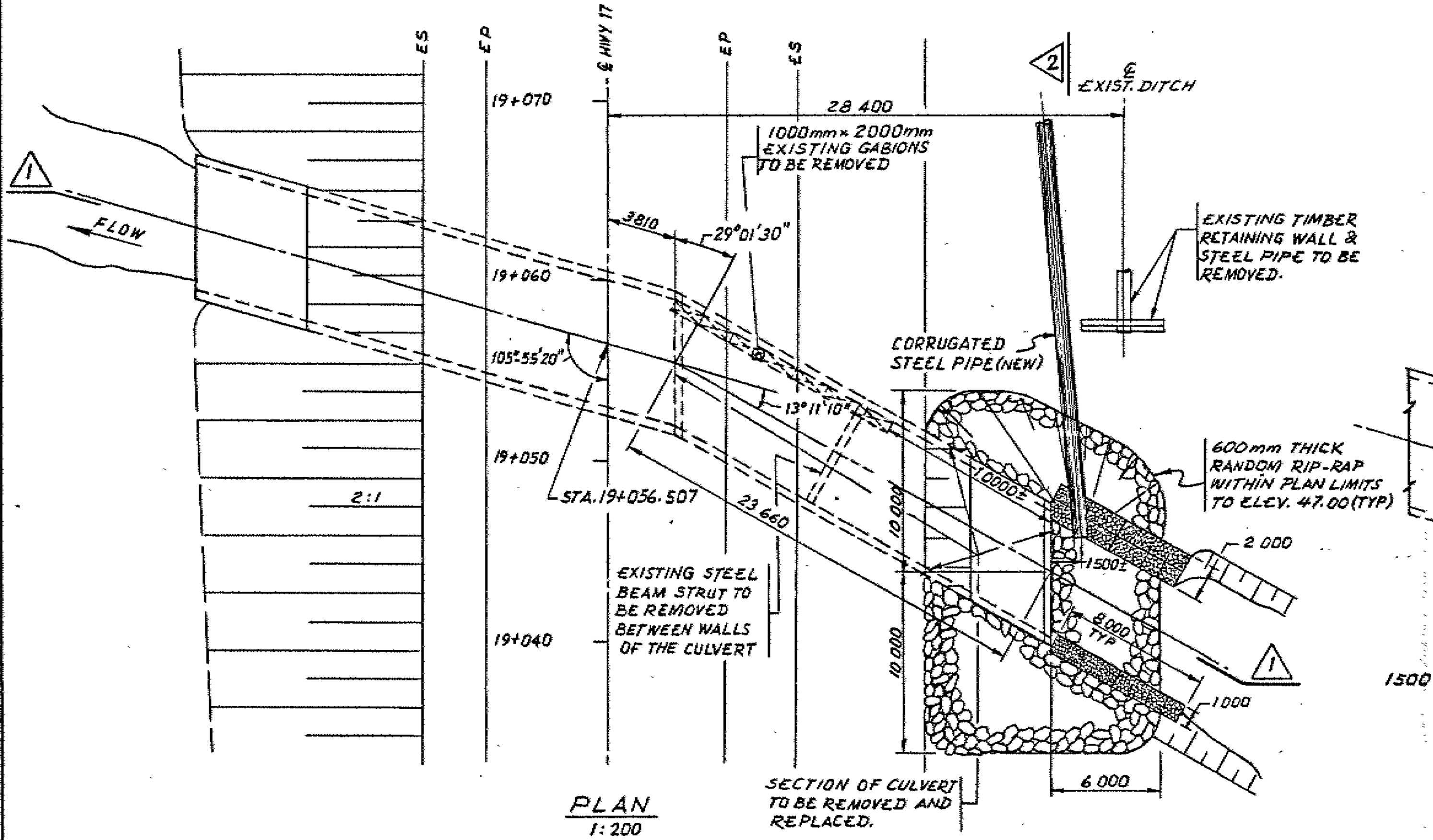
REMARKS:

G.I.-30 SEPT. 1976

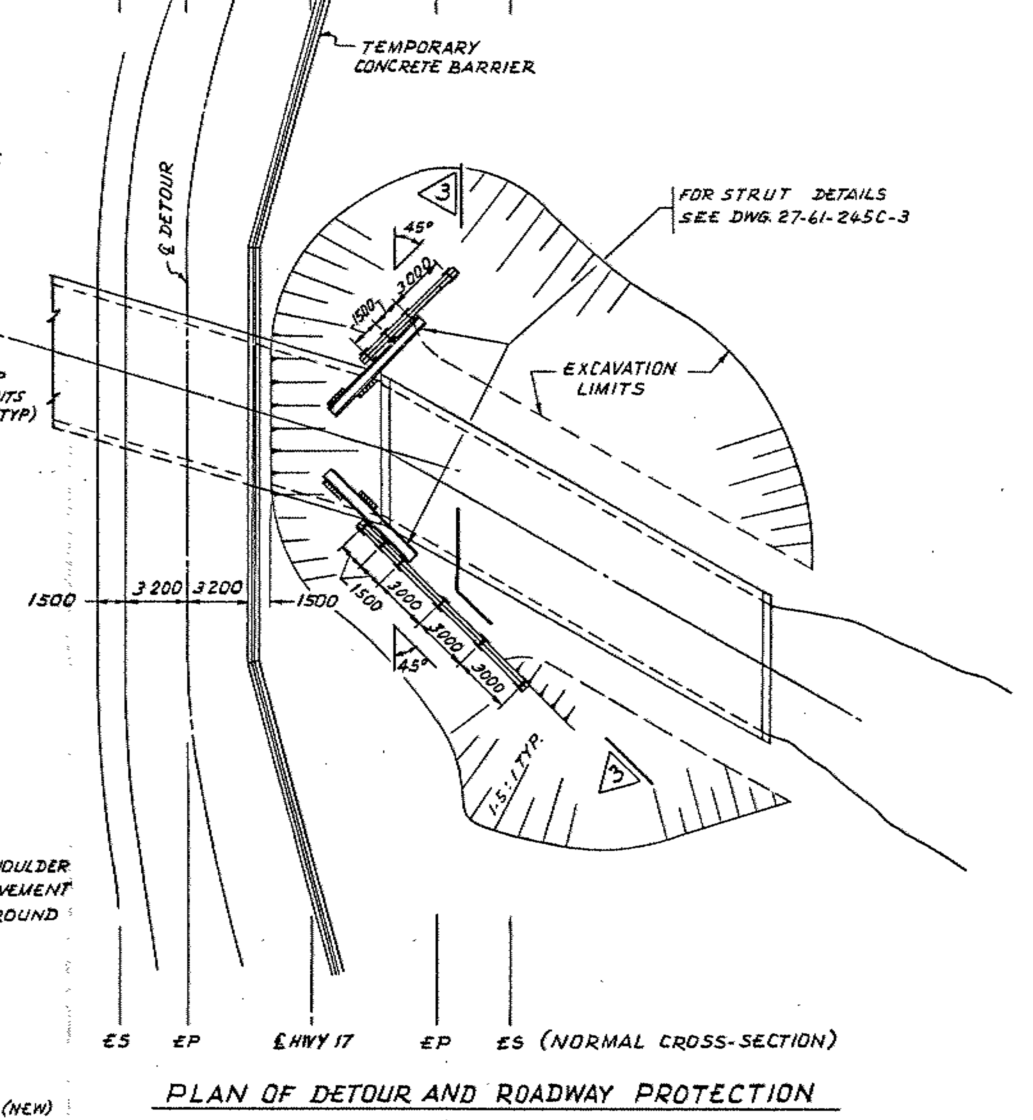
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DISTRICT - 9 OTTAWA	
CONT No	
WP No 12-88-01	
MILL CREEK CULVERT PARTIAL REPLACEMENT GENERAL ARRANGEMENT	SHEET 9

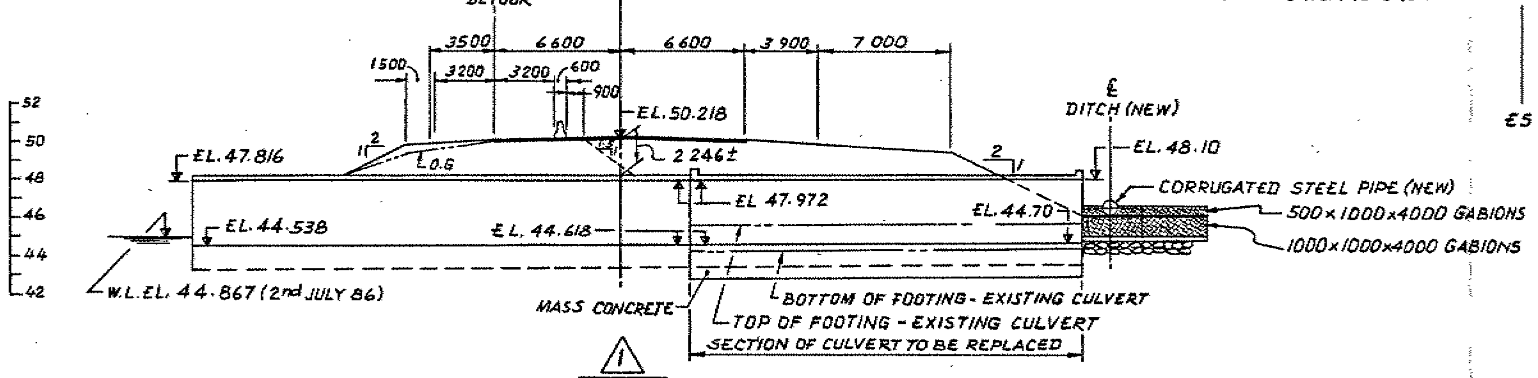


PLAN
1:200

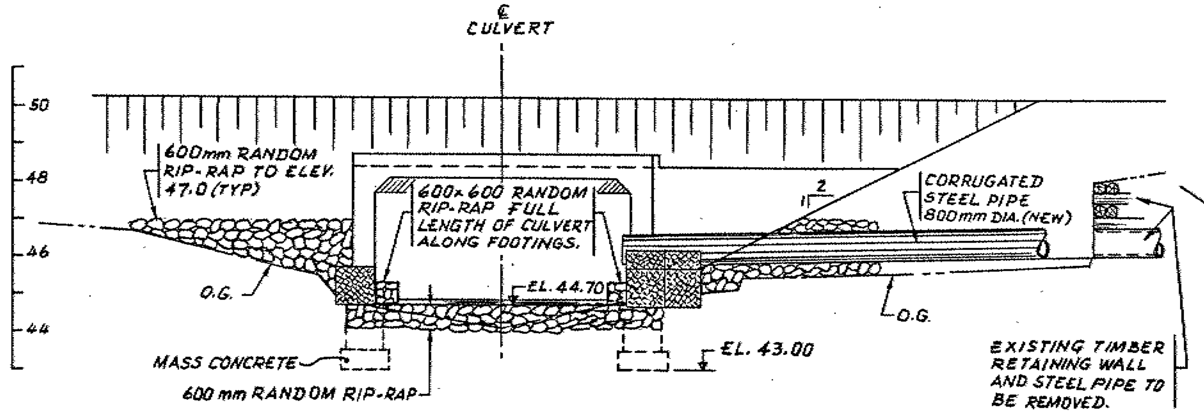


PLAN OF DETOUR AND ROADWAY PROTECTION
1:200

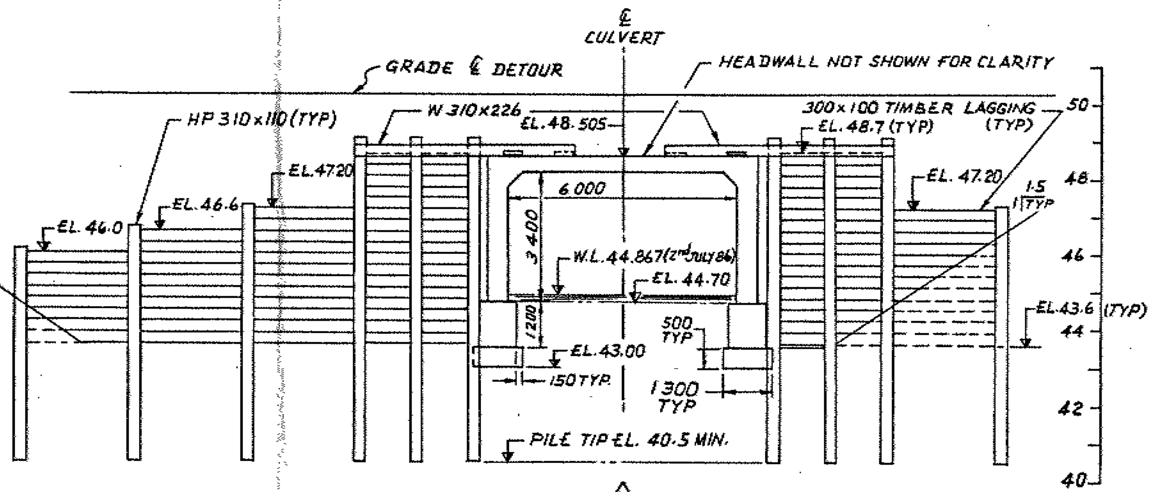
LEGEND
E.S. — EDGE OF SHOULDER
E.P. — EDGE OF PAVEMENT
O.G — ORIGINAL GROUND



1
1:200



2
1:100



3
1:100

NOTES:

- STEEL SHALL BE IN ACCORDANCE WITH C.S.A. STANDARD G.40.21M GRADE 350 W
- WELDING OF STRUCTURAL STEEL SHALL BE IN ACCORDANCE WITH C.S.A. W59
- TIMBER LAGGING SHALL BE NEW DOUGLAS FIR CONSTRUCTION GRADE. DIMENSION GIVEN IS ACTUAL SIZE REQUIRED.
- MACHINE EXCAVATION SHALL NOT BE CARRIED OUT CLOSER THAN 300mm FROM THE FACE OF SOLDIER PILES.

ROADWAY PROTECTION

1. DETOUR HWY 17 TRAFFIC AFTER INSTALLATION OF TEMPORARY PRECAST CONCRETE BARRIERS.
2. EXCAVATE FILL MATERIAL UP TO TOP OF EXISTING SOUTH CULVERT AND UP TO TOP OF TIMBER LAGGING AS SHOWN.
3. INSTALL TEMPORARY ROADWAY PROTECTION INCLUDING DRIVING OF SOLDIER PILES AND INSTALLATION OF STEEL BEAM STRUTS AS SHOWN.
4. EXCAVATE BACKFILL BEHIND THE ABUTMENTS OF EXISTING SOUTH CULVERT AND INSTALL TIMBER LAGGING AS EXCAVATION PROCEEDS.
5. REMOVE EXISTING SOUTH CULVERT INCLUDING GABIONS ALONG THE FOOTING OF THE EXISTING CULVERT AND A STEEL BEAM STRUT BETWEEN THE WALLS OF THE CULVERT.
6. CONSTRUCT NEW CULVERT AND BACKFILL AS PER REQUIREMENTS OF THE CONTRACT.
7. REMOVE STEEL BEAM STRUTS AND TIMBER LAGGING. THE SOLDIER PILES MAY BE REMOVED OR CUT-OFF TO A MINIMUM OF 1.2 METRE BELOW THE FINAL GRADE.
8. AN ALTERNATE ROADWAY PROTECTION METHOD MAY BE PROPOSED BY THE CONTRACTOR. DRAWINGS SHOWING HIS PROPOSED SCHEME SHALL BE SUBMITTED FOR APPROVAL THREE WEEKS PRIOR TO THE STARTING WORK.

LIST OF DRAWINGS:

27-61-245C/R1-1	GENERAL ARRANGEMENT
27-61-245C/R1-2	BORE HOLE LOCATION & SOIL STRATA
27-61-245C/R1-3	STRUT DETAILS
27-61-245C/R1-4	CULVERT DETAILS
27-61-245C/R1-5	QUANTITIES-STRUCTURE

APPLICABLE STANDARD DRAWINGS

STD. NO.	REVISION NO.	DESCRIPTION

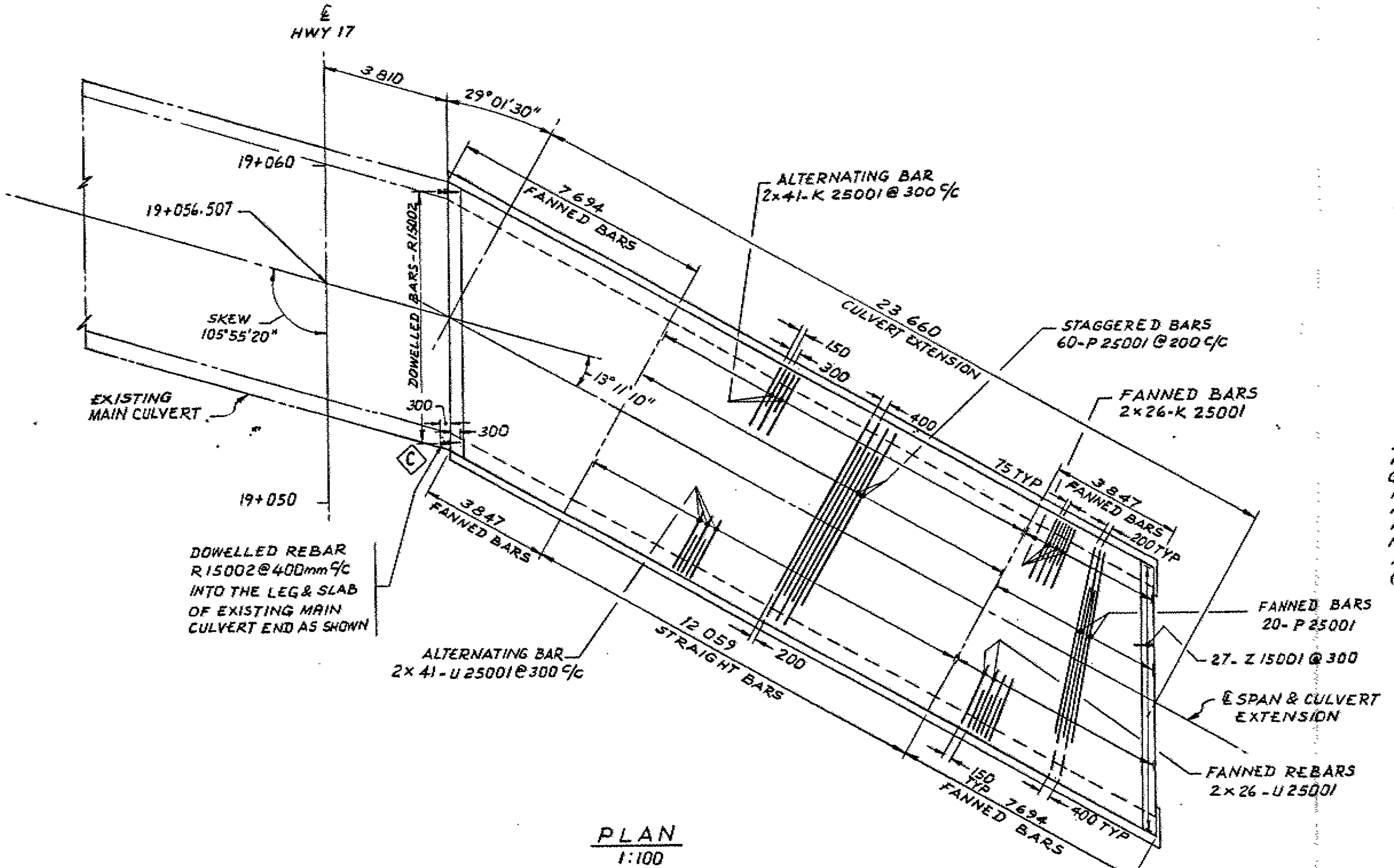
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION	
DESIGN AV/QI	CHECK Q.I.	LOADING OHBDC		DATE JAN/88
DRAWING TMN	CHECK AVD	SITE No 27-61-245C/R1		DWG 1

METRIC

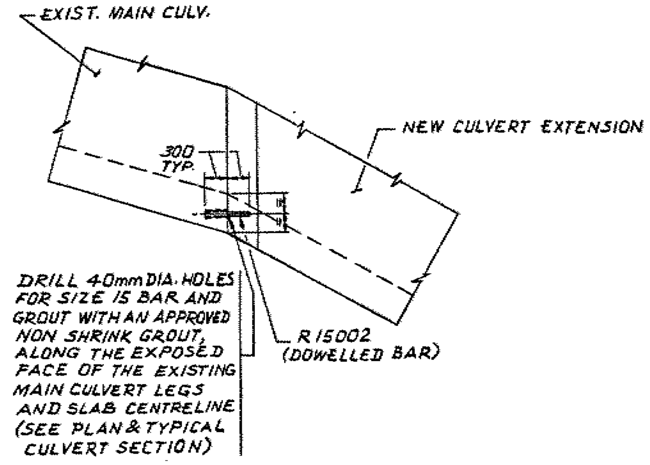
DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.

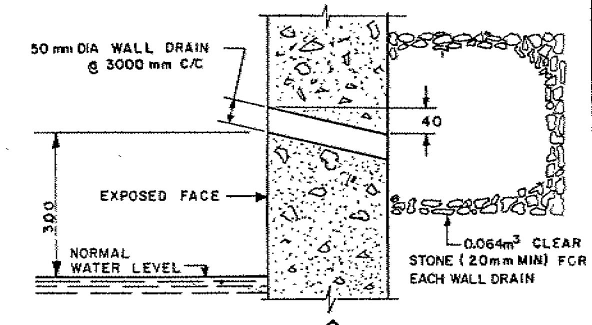
CONT No	
WP No **12-88-01**	
CULVERT-**PARTIAL REPLACEMENT** **MILL CREEK** **CULVERT DETAILS**	SHEET 12



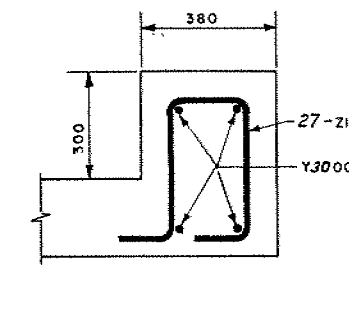
PLAN
1:100

NOTE: THE FANNED REBARS ARE TYPICAL AT EITHER END OF THE CULVERT EXTENSION.



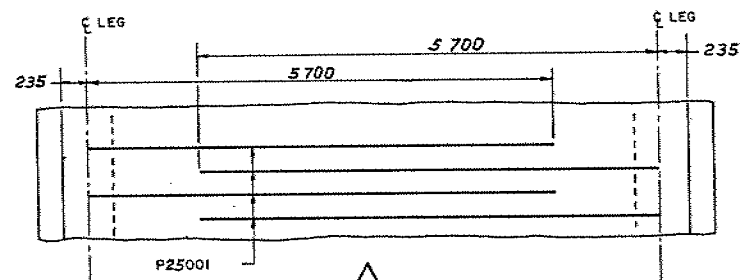


A

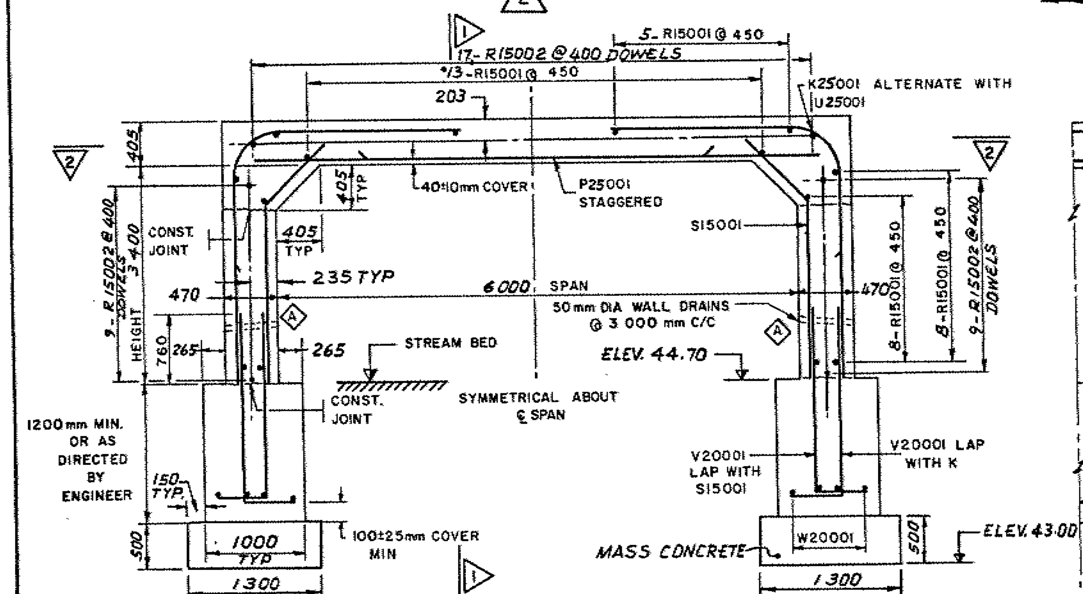


B

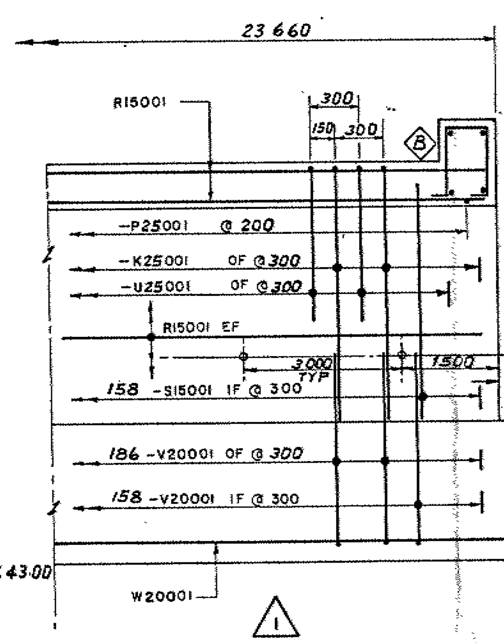
PREPARED BY : T.M. NADAVALLIL
CHECKED BY : A. ROUD
REVIEWED BY : Q.I. ISLAM



2



TYPICAL CULVERT SECTION
(HEADER WALL NOT SHOWN)



1

REINFORCING STEEL SCHEDULE

* VERTICAL DIMENSIONS

MARK	No REQ'D	C/C	LENGTH	DETAILS	REMARKS
P25001	100	200	5 700	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED & FANNED AT ENDS
K25001	186	300	5 203	1295; *3 289; R = 394	K BARS ALTERNATE WITH U BARS
U25001	186	300	3 743	1829; *1295; R = 394	
S15001	158	300	3 849	* 2 985; 45°; 864	INSIDE FACE OF LEGS
R15001	110	450	11 985	STRAIGHT 55 LINES 2 PER LINE	LONGITUDINAL STEEL (LAP 450) @ 450 TOP SLAB & LEGS
V20001	344	SEE REMARKS	2 267	* 1810; 457	FOOTING DOWELS SPACING - 300 IF SPACING - 300 OF
W20001	16	—	12 085	STRAIGHT	LONGITUDINAL IN FOOTING (LAP 450)
Y30001	8	—	7 760	STRAIGHT	HEADER WALL
Z15001	54	300	1 730	*600; 230; 150; 150	HEADER WALL
R15002	35	400	600	STRAIGHT	DOWELS BETWEEN NEW & OLD CULVERT

STD RIGID FRAME OPEN CULVERT
AT STATION ______

SPAN 6.0m HEIGHT 3.4m LENGTH 23.66m FILL HEIGHT 2.438m

GENERAL NOTES

- CLASS OF CONCRETE 30 MPa
- CLEAR COVER TO REINFORCING STEEL 70±20mm EXCEPT AS NOTED
- ALL EXPOSED CORNERS TO BE CHAMFERED 20 mm
- NO CONCRETE SHALL BE PLACED FOR ANY FOOTING, UNTIL THE DEPTH OF THE EXCAVATION AND CHARACTER OF THE FOUNDATION MATERIAL HAVE BEEN APPROVED BY THE ENGINEER
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY
- CULVERTS AND RETAINING WALLS (WHERE APPLICABLE) SHALL BE BUILT IN ACCORDANCE WITH MTC FORM 904
- REINFORCING STEEL SHALL BE HARD GRADE
- STEEL FOR EACH CULVERT (INCLUDING RETAINING WALLS WHERE APPLICABLE) SHALL BE BUNDLED SEPARATELY AND MARKED WITH STATION NUMBER
- WALL DRAIN OPENINGS TO BE FORMED USING NON-METALLIC MATERIAL. VERTICAL LOCATION OF WALL DRAINS SHALL BE DETERMINED IN THE FIELD BY THE ENGINEER
- I F DENOTES INSIDE FACE
- O F DENOTES OUTSIDE FACE
- E F DENOTES EACH FACE

QUANTITIES				
ITEM	LEGS & SLAB	FOOTINGS	HEAD WALL	TOTAL
MASS OF REINF STL tonnes				14.6
VOL. OF CONCRETE cubic metres				205
VOL. MASS CONCRETE cubic metres	—			31

CO PRESCOTT	
TWP LONGUEUIL	
LOT 45	CON VILLAGE OF L'ORIGNAL
HWY 17	DIST 9 - OTTAWA

STANDARD DRAWING MARCH 1982	SS 114-1

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION
DESIGN STD	CHECK Q.I	LOADING OHBDC	DATE MAY/88
DRAWING TMN	CHECK	SITE No 27-61-265C/R1	DWG 4

ENGINEERING MATERIALS OFFICE

FOUNDATION DESIGN SECTION

~~WP 7118-86-07~~ CONT 89-09

~~WO 86-46013~~ WP 12-88-01 DIST 9

HWY 17 STR SITE -

Mill Creek Culvert Reconstruction

DISTRIBUTION

E.C. Lane
T.W. Murphy
J.W. Reid
M.J. Bernhardt
K.G. Bassi
J.H. Peer
T. Yakutchuk
L. Saulnier (Cover Only)
M. MacLean (Cover Only)
File Copy

GEOCRES 31G-193

DATE JAN 23 1987

FOUNDATION INVESTIGATION REPORT
For
Mill Creek Culvert Reconstruction
W.O. 86-46013 then WP 7418-86-01, then WP 12-88-01
Hwy. 17, District 9, Ottawa

INTRODUCTION

This report summarizes the subsurface information obtained from a foundation investigation carried out at the above-noted site on 86 08 18. The fieldwork consisted of 2 sampled boreholes advanced to depths of 7 and 7.8 m below the ground surface. One of the boreholes (BH 1) was also accompanied by a dynamic cone penetration test.

SITE DESCRIPTION AND GEOLOGY

The site is at the crossing of Mill Creek and Hwy. 17 near L'Original, in the Township of Longueuil, County of Prescott and Russell.

The crossing of Mill Creek is accomplished by means of an open culvert which is composed of two sections. The first section is approximately 24 m long and has an opening of approximately 6 m by 2.3 m. This section of culvert is approximately 45 years old. The second section was constructed 25 years ago and is 27.7± m long, with an opening of approximately 6.7 m by 3.4 m. Drawing 8646013-A in the Appendix illustrates the approximate culvert geometry and a longitudinal section along the culvert centreline.

Mill Creek flows in a northerly direction towards the Ottawa River which is situated some 3 km north. At this site, the creek channel is approximately 7 m wide and at the time of the investigation, the creek had a depth of about 0.8 m.

Physiographically, the site is situated in the Ottawa Valley Clay Plains. This region is generally characterized by deep deposits of sensitive clay interrupted by ridges of rock and sand (Ref: Chapman and Putnam, 1984). However, these typical deposits were not encountered at this particular site.

Land use in the vicinity of the site is rural with some minor residential and commercial dwellings scattered throughout.

SUBSURFACE CONDITIONS

General

The predominant deposit across this site consists of a glacial till described as a heterogeneous mixture of gravel, sand, silt and clay. Generally, this deposit is non-cohesive in nature but occasional cohesive zones are encountered. The till deposit is found under 4 to 5 m of other material consisting of silty clay, fine sands, and fill.

The boundaries of the various subsoil types, insitu and laboratory test results, as well as groundwater levels are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Drawing 8646013-A in the Appendix.

The various soils encountered at this site are described as follows:

Sand and Gravel (Fill)

Sand and gravel fill was encountered in BH 1 and BH 2 extending from the ground surface down to depths of approximately 0.6 and 1.1 m respectively. No samples of this dense cohesionless material were retrieved.

Sandy Silt to Silty Fine Sand (Fill)

Fill material consisting of sandy silt to silty fine sand was encountered in both the boreholes underlying the sand and gravel fill previously discussed. In BH 1 the thickness of this layer was found to be approximately 2.8 m while in BH 2 the thickness was approximately 0.5 m.

A grain size distribution test was carried out on one sample (BH 1, #2) of this material. The results indicated that the sample consisted of 67% silt, 30% fine sand, and 3% clay. However, because of the nature of the fill material it should not be assumed that these results indicate the overall character of the stratum.

Based on visual classification of samples from this non-cohesive layer, the fill material can be generally described as sandy silt to silty fine sand, trace clay. Isolated cohesive zones consisting of silty clay or slightly plastic silt were also encountered within this fill.

Based on the interpretation of Standard Penetration Test 'N' values ranging generally between 6 and 12 blows/0.3 m, it would appear that this fill was well compacted.

It should be noted that when this material is subjected to an unbalanced hydrostatic pressure, 'boiling' will be experienced.

Original Topsoil

The original topsoil surface was encountered between Elev. 46 and 47 in the two boreholes. In BH 1, the thickness of this organic deposit was found to be about 0.6 m, while in BH 2 the thickness was approximately 0.3 m. The thickness may vary depending on location.

Based on visual classification, this material can be described as very loose silty fine sand, trace clay, with organics. Generally, the deposit is non-cohesive in nature, however, cohesive zones are not unlikely.

'Boiling' will be experienced when this material is subjected to an unbalanced hydrostatic pressure.

Silty Fine Sand

A 0.4 m thick seam of silty fine sand, trace clay was encountered in BH 1 at Elev. 45.9. No laboratory tests were carried out on samples of this cohesionless material.

Based on the interpretation of Standard Penetration Test 'N' values, this deposit can be considered to be in a loose state.

It should be noted that 'boiling' will result when this cohesionless material is subjected to a unbalanced hydrostatic pressure.

Silty Clay (CI)/Clay (CH)

Underlying the silty fine sand with organics in BH 2 is a 1.8 m± thick stratum of silty clay of intermediate plasticity (CI), some sand.

An Atterberg Limits Test was carried out on one sample of this material with the following results: $W = 34\%$, $W_L = 36.5\%$, $W_p = 15.5\%$, $I_p = 21\%$. These results indicate that this cohesive material is of intermediate plasticity (CI group).

Based on the interpretation of Standard Penetration Test 'N' values, this deposit can be considered to have a firm to stiff consistency.

Underlying the loose silty fine sand in BH 1 is a 0.8 m± thick deposit of stiff clay of high plasticity (CH group), some sand. An Atterberg Limits Test was carried out on a sample of this material with the following results: W = 43%, W_L = 56%, W_p = 21%, I_p = 35%.

It should be noted, however, that these cohesive materials described do not form distinct layers with distinguishable boundaries. In all likelihood, the deposit consists of pockets of silty clay (CI) and clay (CH). These zones of variable plasticity may be randomly dispersed within the stratum.

Glacial Till

Underlying the cohesive material previously described is a glacial deposit consisting of a heterogeneous mixture of gravel, sand, silt and clay. In BH 1, this deposit was encountered at Elev. 44.7± while in BH 2, it was found at Elev. 45.3±.

Based on the interpretation of Standard Penetration Test 'N' values ranging between 17 and well over 100 blows/0.3 m, this deposit can be considered to be in a compact to very dense state.

Grain size distribution tests were carried out on 4 samples of this material. The results are shown in graphical form on Fig. 1 in the Appendix. Based on the distribution, this glacial deposit can be described as a heterogeneous mixture of gravel, sand, silt and clay.

It should be noted that generally between 2 and 4% of clay-sized particles are evident within this predominantly non-cohesive deposit. However, in the sample tested from BH 2 (sample #4), 27% clay was evident making the fines quite cohesive. Therefore, even though the general character of the deposit is cohesionless, it can be anticipated that zones of slightly plastic material could be encountered.

In the two boreholes advanced for this investigation, no cobbles or boulders were encountered. However, it is a common characteristic of glacial tills to include occasional cobbles and boulders.

It should also be noted that if an excavation extends into this deposit, considerable seepage of water can be anticipated.

GROUNDWATER CONDITIONS

The groundwater level in the immediate vicinity of the culvert is directly governed by the water level in the creek. At the time of the investigation (August 1986), the water level in the creek was at Elev. 45.8±.

DISCUSSION AND RECOMMENDATIONS

Hwy. 17 crosses Mill Creek by means of an open culvert which is composed of two sections. The southerly section was constructed about 45 years ago and is 24 m± long with a 6 m x 2.3 m opening. This original culvert was extended northerly about 25 years ago by an additional 27.7 m±. The more recent culvert has an opening of 6.7 m x 3.4 m.

The southerly section is founded by means of shallow spread footings at Elev. 44.6 ±. This elevation is at or just below the level of the stream bed. The northerly section is also founded on spread footings, however, at an elevation of 43.3±.

It is proposed to demolish and reconstruct the southerly section of the culvert as it appears that structural failure has occurred.

Within the southerly section of the culvert, undermining of the footings is evident at various locations. As a result of the undermining, the culvert has experienced severe structural distress. A section of the east wall has failed laterally as no passive or frictional resistance was afforded by the eroded stream bed. Consequently, this portion of wall has experienced inward rotational movement as well as severe cracking. Continual settlement of the culvert is also evident as indicated by cracking and multiple layered patching of the Hwy. 17 pavement immediately above the distressed culvert.

An attempt was made over the years to protect the shallow footings of the southerly culvert. The stream bed along the inside walls of the culvert was lined with random rip-rap and the occasional gabion basket in order to minimize further scour of the stream bed. Recently, an attempt was also made to prevent the inward movement of the culvert walls by providing a steel beam to act as a prop from wall to wall.

In addition to the structural failure which has occurred, the concrete is severely deteriorating. Numerous areas of spalling are evident, and in some instances, the reinforcing steel is exposed.

In view of the poor condition of the culvert, it is proposed to demolish and reconstruct the original culvert. The following are our recommendations for the foundation design of the proposed rigid-frame open concrete culvert.

Bearing Capacity

The bearing capacity of a non-cohesive material is in part related to the width of the footing. For this reason, two alternatives are given for the design of the culvert footings (as follows):

	ALT. I	ALT. II
Footing Width	1.0 m	0.6 m
Founding Elev.	43.0 or lower	43.0 or lower
ULS Loading	550 kPa	475 kPa

It is anticipated that these factored capacities will produce settlements of less than 25 mm within the non-cohesive glacial till deposit. If higher loadings are required, this section should be contacted. However, it should be realized that larger settlements will result.

If it is desireable to found the footings at a higher elevation, mass concrete can be used to bring the founding level up from Elev. 43 to the required elevation.

Backfill and Lateral Earth Pressures

Backfill to the culvert should consist of Granular 'A' or 'B' and should be carried out in accordance with MTC Standard Special Provision #121 (dated Oct. 1983). Backfill requirements should also adhere to OPSD-803.02.

Computation of earth pressures should be carried out in accordance with Sect. 6.6.1.2 of the 1983 O.H.B.D.C. For design purposes, the following physical parameters can be used for the backfill material:

Material	ϕ	γ
Granular 'A'	35°	22.0 kN/m^3
Granular 'B'	30°	21.2 kN/m^3

Sliding Resistance

To check against sliding of the footings, a friction coefficient of tan 30° can be assumed to be mobilized between the footing concrete and the non-cohesive glacial till (Elev. 43). It should be assumed that the material in front of the culvert footings will not provide any passive resistance.

Frost Penetration

For this area of Ontario, it can be assumed that frost penetrates to a depth of 1.8 m below the ground surface.

Connection to Existing Culvert

It is not desireable to rigidly connect the proposed culvert to existing culvert as future differential settlements may result in cracking of the culvert walls.

Excavations and Fills

Temporary excavations extending below the groundwater level may be stable at a slope of 1.5H:1V. However, some sloughing and erosion of the non-cohesive slope-face material may be anticipated. Permanent fills should be constructed at slopes of 2H:1V.

Dewatering

In view of the non-cohesive nature of the subsoils, a dewatering scheme will be required during construction after the creek flow has been channelized through a pipe. The anticipated seepage into the excavation may be controlled by pumping from sumps.

It is essential that the founding level is not disturbed as a result of unbalanced hydrostatic pressures. Any disturbance of the founding material may reduce the bearing capacity.

Erosion Protection

To prevent future scouring, it would be desireable to have the culvert inlet protected by means of 0.6 m thick random rip-rap. The protection should be placed across the entire channel cross-section, up to the high water level, and extending to 6 m south of the culvert inlet.

In addition, 0.6 m thick rip-rap should be placed along the inside walls of the culvert so as to minimize the potential for future undermining of the footings. Alternatively, the stream bed within the culvert can be provided with a 100-150 mm thick mass concrete 'slab' to guard the stream bed and footings against potential scour.

Temporary Roadway Protection

If a roadway protection scheme is required for the construction of the culvert, this Section will review a design as it becomes available. If design parameters are required, this Section should be contacted.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of L. Politano (Project Foundations Engineer) and D. Madill (Student Engineer), utilizing equipment owned and operated by Marathon Drilling Company Ltd. of Ottawa.

This report was prepared by L. Politano and reviewed by M. Devata, Chief Foundations Engineer (East).

L. Politano, P. Eng.
Project Foundations Engineer

M. Devata, P. Eng.
Chief Foundations Engineer
(East)

JAN. 1987

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (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 $= \frac{c_u}{\tau_r}$

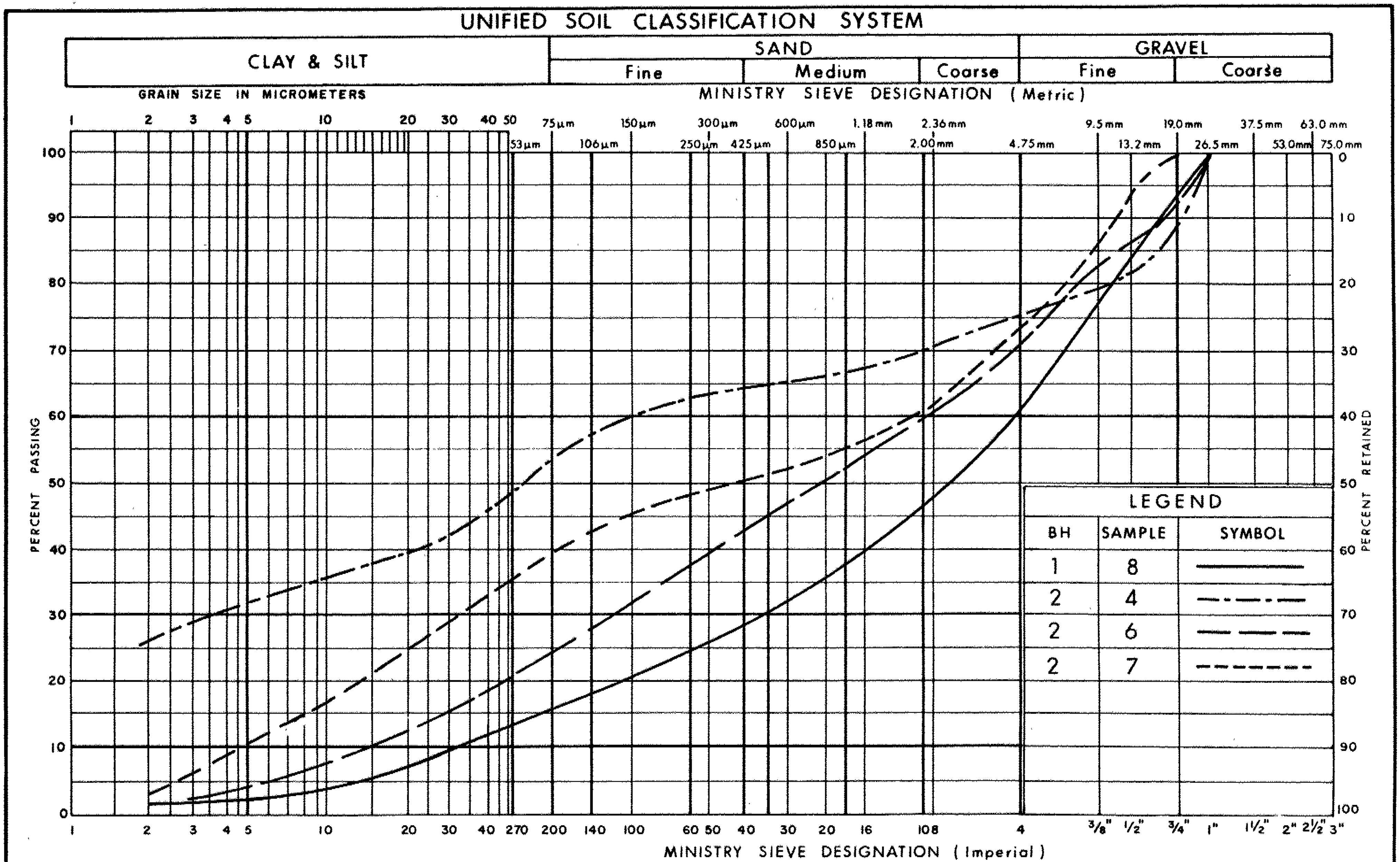
PHYSICAL PROPERTIES OF SOIL

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

78 12 M



Ministry of Transportation and Communications

Ontario

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF GRAVEL, SAND, SILT & CLAY

(GLACIAL TILL)

FIG No 1

WO 86 - 46013

Ministry of Transportation and Communications Ontario

RECORD OF BOREHOLE No 1

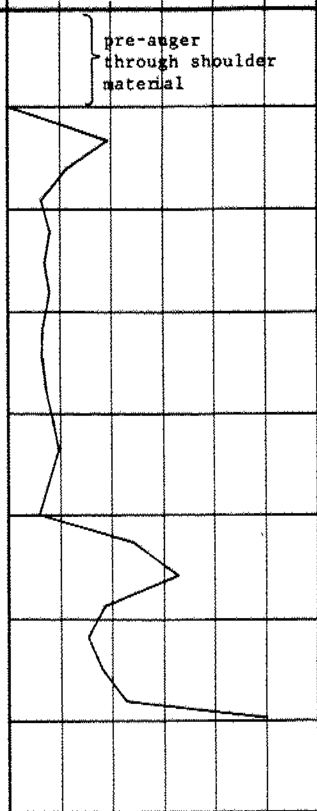
METRIC

WO 86-46013	LOCATION Sta. 19 + 055.6, O/S 10.6 Rt.		ORIGINATED BY DBM
DIST 9 HWY 17	BOREHOLE TYPE Hollow Stem Augers, Cone Test		COMPILED BY LP
DATUM Geodetic	DATE 86 08 18		CHECKED BY

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
49.9	Shoulder Surface						
0.0 / 49.3	Sand and Gravel (Fill)						
0.6	Sandy Silt to Silty Fine Sand trace clay (Fill)	1	SS	29		49	
		2	SS	12		48	0 30 67 3
		3	SS	6		47	
46.5		4	SS	7			
3.4 / 45.9	Silty Fine Sand, trace clay, with organics					46	
4.0 / 45.5	Silty Fine Sand (Loose)	5	SS	6			
4.4 / 44.7	Clay of high plasticity some sand (CH) Stiff	6	SS	13	▼	45	W_L = 56%
5.2	Heterogeneous Mixture of gravel sand, silt and clay (Glacial Till) Dense to Very Dense	7	SS	27		44	
		8	SS	35			39 44 15 2
		9	SS	49/8 cm*		43	
42.1		10	SS	50/5 cm*			
7.8	End of Borehole * Spoon bouncing						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE



PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications Ontario

RECORD OF BOREHOLE No 2

METRIC

WO 86-46013 LOCATION Sta. 19 + 043.1, O/S 16.4 m Rt. ORIGINATED BY DBM

DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY LP

DATUM Geodetic DATE 86 08 18 CHECKED BY

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
49.0	Ground Surface							
0.0 / 48.4	Sand and Gravel (Fill)							
1.1 / 47.4	Sandy Silt to Silty Fine Sand, trace clay (Fill); Silty Clay	1	SS	5		48		
1.6 / 47.1	Silty Fine Sand with organics	2	SS	3		47		
1.9 / 45.3	Silty Clay of Intermediate Plasticity some sand (CI) Firm to Stiff	3	SS	6		46		
3.7	with clay	4	SS	18	▼	45	W=48%	26 20 27 27
	Heterogeneous Mixture of gravel, sand, silt and clay (Glacial Till)	5	SS	17		44		
	Compact to Very Dense	6	SS	27		43		28 46 23 3
		7	SS	57				26 33 37 4
42.0 / 7.0	End of Borehole	8	SS	53/10 cm*				

* Spoon Bouncing

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength: O Unconfined, + Field Vane, ● Quick Triaxial, × Lab Vane

Plastic Limit W_p, Natural Moisture Content W, Liquid Limit W_L — Water Content (%): 10 20 30

+3, ×5 : Numbers refer to Sensitivity

15 ◇ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-207 82 04

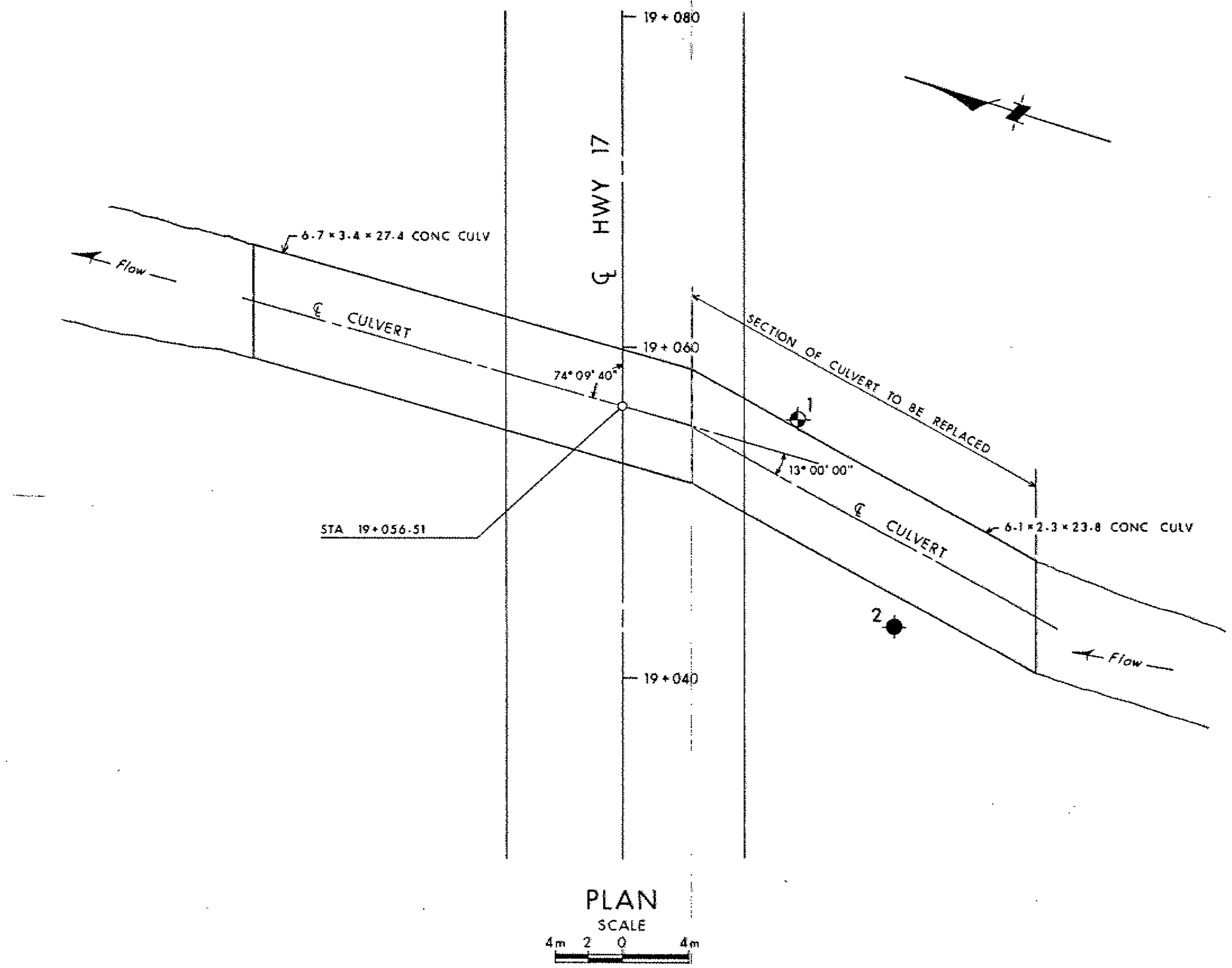
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WO No 86-46013

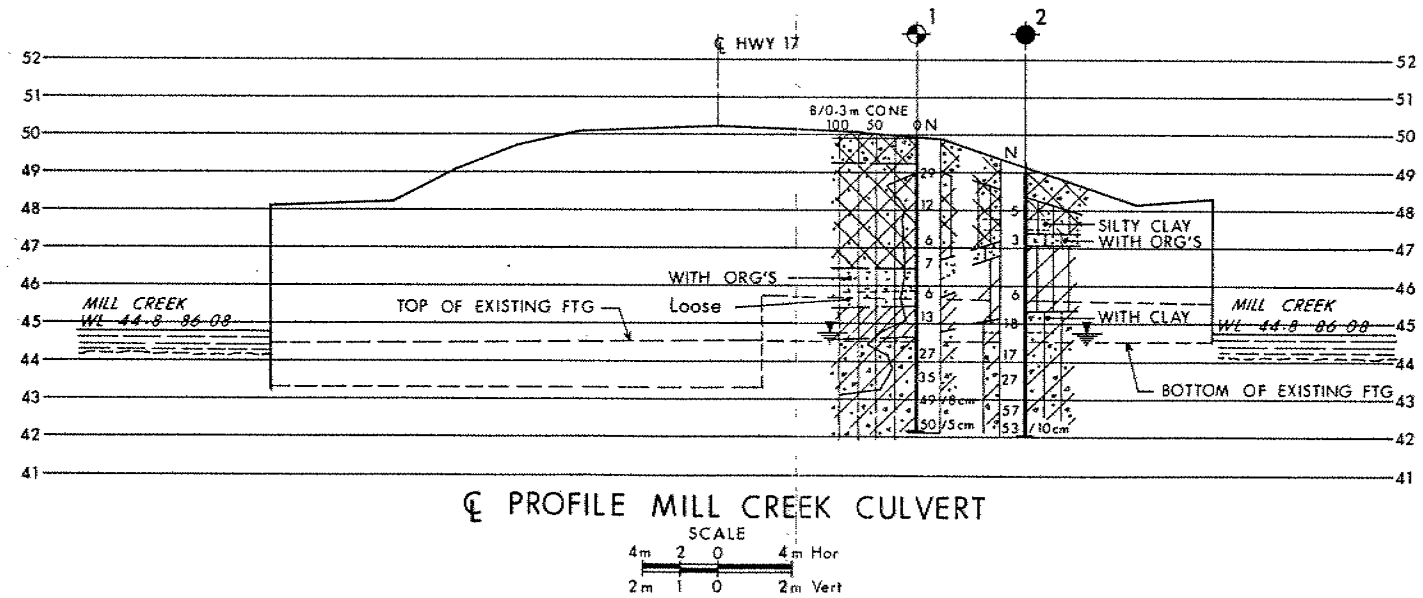
MILL CREEK CULVERT

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



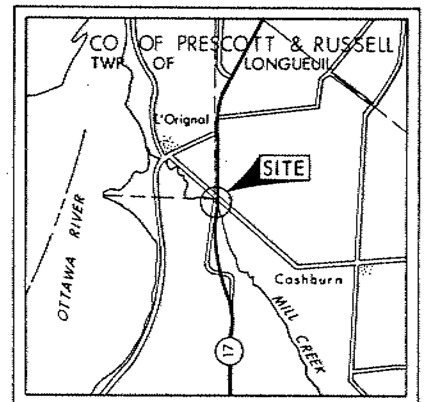
PLAN
SCALE
4m 2 0 4m



℄ PROFILE MILL CREEK CULVERT
SCALE
4m 2 0 4m Hor
2m 1 0 2m Vert

SOIL STRATIGRAPHY LEGEND

- SAND & GRAVEL (FILL)
- SANDY SILT TO SILTY FINE SAND (FILL) TRACE OF CLAY
- SILTY FINE SAND
- SILTY CLAY OF INTERMEDIATE PLASTICITY SOME SAND Firm to Stiff
- CLAY OF HIGH PLASTICITY SOME SAND Stiff
- HETEROGENEOUS MIXTURE OF GRAVEL, SAND, SILT & CLAY Compact to Very Dense (GLACIAL TILL)



KEY PLAN
SCALE
1km 0 1 2km

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation 86 08

No	ELEVATION	STATION	OFFSET
1	49·9	19+055·6	10·6m Rt
2	49·0	19+043·1	16·4m Rt

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

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

REV.	DATE	BY	DESCRIPTION

Geocres No 31G-193

HWY No 17			DIST 9
SUBM'D LP	CHECKED	DATE 87 01 08	SITE
DRAWN DT	CHECKED	APPROVED	DWG 8646013-A