

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 316-195

DIST. 9 REGION

W.P. No. 300-87-01

CONT. No.

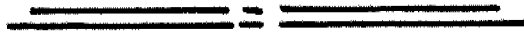
W. O. No.

STR. SITE No.

HWY. No. 34

LOCATION Culvert Failure at
Hwy 417

No of PAGES -



OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry
of
Transportation

*File
Copy*

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 300-87-01

DIST 9

HWY 34

STR SITE N/A

Culvert Replacement at Hwy. 34 Near Hwy. 417

DISTRIBUTION

E.C. Lane (2)
T.W. Murphy
J.W. Reid
M.J. Bernhardt (2)
K.G. Bassi
J.H. Peer
T. Yakutchuk
G. Szekreny
L. Saulnier (Cover Only)
M. MacClean (Cover Only)
File Copy

FOUNDATION INVESTIGATION REPORT

FOR

Culvert Replacement at Hwy. 34 Near Hwy. 417

W.P. 300-87-01, Site N/A

Hwy. 34, District 9, Ottawa

INTRODUCTION

This report summarizes the foundation investigation for the proposed culvert replacement at Hwy. 34 near Hwy. 417.

SITE DESCRIPTION

The site is located at the south approach to the Hwy. 417/34 structure, approximately 250 m south (along Hwy. 34) of the Hwy. 417 WB centreline.

This area is a clay plain with low local relief except for the Hwy. 417/34 interchange embankments which are up to 6 m high.

The distressed culvert at this location is a 37± m long, 3.2± m x 2.0± m corrugated steel pipe arch. The floor of the culvert has sheared along a bolt line and buckled upwards over a distance of approximately 20 m, and the roof has sagged in the distressed area. Clay, mixed with sand, has flowed into the zone vacated by the buckled floor.

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 87 08 05 and 87 08 28. A continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers and a B-size core barrel was used.

The investigation consisted of

- 3 sampled boreholes accompanied by dynamic cone penetration tests

and

- 1 sampled borehole.

Bedrock core samples were collected at each borehole location.

The boreholes have been identified as BH #1 to #4 inclusive.

Survey details were provided by the Eastern Region Surveys and Plans Section.

The sampling program included split spoon samples which provided Standard Penetration ('N') values for assessment of the in situ state of compaction of the non-cohesive materials, and for an indication of shear strengths of cohesive materials. These samples also provided material for identification purposes. Shelby tube samples were collected in the cohesive deposits to provide undistributed samples for unconfined undrained compression, consolidation and unit weight tests. In addition bedrock cores were collected to determine the quality of bedrock.

The laboratory testing program consisted of

- grain size analyses
- natural moisture content determinations
- Atterberg Limit determination
- unconfined undrained compression tests
- consolidation tests
- unit weight tests

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 3008701-A.

The subsurface conditions consist of a 6± m high fill overlying 11± m of native overburden, then shale bedrock.

The highway embankment consists of 6± m of compact to very dense silty sand with occasional boulder zones.

The native overburden consists of 9± m of generally soft to firm sensitive clay underlain by 2± m of compact silty sand glacial till.

Detailed descriptions of the various deposits encountered are as follows:

Silty Sand (Fill)

This non-cohesive material is fill for the existing Hwy. 34 embankment. It has been described as silty sand, some/with gravel, trace clay containing occasional silt zones and occasional boulder zones.

At BH #1 and BH #2, it extended from the surface for thickness ranging from 6.1 m to 6.7 m.

Based on the results of Standard Penetration Tests ('N' values ranging from 12 to 100+), the fill is in a compact to very dense state. However, the higher 'N' values may be attributable to bouldery zones and the fill is considered to be typically compact to dense.

A typical grain size distribution is illustrated below:

Gravel	18-43%
Sand	36-56%
Silt	13-40%
Clay	3-6%

Typical natural moisture contents of the fill are below 10%.

Clay

This cohesive deposit underlies the Hwy. 34 fill. It has been described as clay of high plasticity, some/with silt, trace sand, containing occasional silt seams and with traces of organics in the upper 1± m.

At the borehole locations, it extends for thickness ranging from 8.2 to 10.7 m.

Based on the results of field vane tests, laboratory unconfined undrained compression tests and Standard Penetration Tests, the shear strength of the clay varies from 20 to 50 kPa. The higher strengths were observed in a shallow zone immediately underlying the fill. A comparison of field vane sensitivity values, (4 to 15), strain at failure for the unconfined undrained tests and the natural moisture content values indicates that the clay has moderate to high sensitivity.

Results of Atterberg Limit and Natural Moisture Content tests are summarized below:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Moisture Content (w)	33.5-75.5%	60.2%	65.5%
Liquid Limit (w_L)	48.0-78.0%	62.2%	58.5%
Plastic Limit (w_p)	22.0-40.5%	27.5%	27.5%
Plasticity Index (I_p)	27.5-50.0%	34.7%	31.7%

A typical grain size distribution for this deposit is illustrated in Figure 1.

Unit weights vary from 14.9 to 16.1 kN/m³

Results of two consolidation tests are illustrated in Figure 2, and indicate that the material is in a slightly over-consolidated condition.

Silty Sand (Glacial Till)

This non-cohesive deposit underlies the clay. It has been described as silty sand with gravel.

At the borehole locations its thickness ranges from 0.9 to 1.9 m.

Based on the results of Standard Penetration Tests ('N' values varying from 18 to 44), the deposit is compact to dense.

A typical grain size distribution is illustrated below:

Gravel	34.5-36.5%
Sand	32.5-39.0%
Silt	25.5-29.0%
Clay	1.0-2.0%

Bedrock

The bedrock consists of shale of the Carlsbad Formation. The upper 1.5 to 2.6 m is slightly to moderately weathered. Refer to Table 1 (Appendix) for the Geologist's description of the core.

Groundwater

Due to the low permeability of the clay deposit, it was not possible to establish the exact groundwater elevation during the short period of the investigation. However, it can be assumed that the groundwater elevation was between elevation 69.5 m and 70.5 m at the time of the field investigation.

DISCUSSION

The culvert is underlain by 9± m of very soft to stiff clay, and the culvert distress is associated with the behaviour of this deposit. The stability of the embankment has been analyzed and is marginal but adequate. However, settlement analysis has indicated that the load originally imposed by the highway embankment could have caused up to 0.5 m of settlement. Based on these analyses, and on field inspections of the material that has flowed into the buckled floor of the culvert, it is our opinion that the culvert distress can be attributed to a number of causes, including inadequate bedding, differential settlements, reduction of shear strength due to disturbance of the clay and overstressing of the foundation soil due to marginal slope stability.

A comparison of the consolidation characteristics of the clay deposit beneath, and outside the embankment, indicate that at least 80% of the anticipated settlement has already occurred, and approximately 0.1 m to 0.15 m of additional settlement could still occur under the same loading conditions.

The stability of embankments was evaluated using Bishop's total stress analysis. The assumptions and results are illustrated in Figure 3. A safety factor of 1.2 was obtained for a typical 6 m high slope. Although this safety factor is lower than normally acceptable, in our opinion it is sufficient in this case due to the proven performance of the existing embankment.

RECOMMENDATIONS

The culvert is severely distressed and should be replaced in the 1988 construction season in order to prevent complete failure of the culvert and to ensure the integrity of the Hwy. 34 embankment.

The culvert may be replaced with either a circular section corrugated steel pipe or a concrete box culvert of appropriate size. Either type of culvert should be founded on a minimum 2 m thick pad of Granular 'A' with the culvert invert at the same elevation as the existing culvert. Since considerable consolidation of the upper clay zone has already resulted from the load imposed by the existing embankment, the settlements and marginal stability that may have contributed to

the distress of the existing culvert will not affect the performance of a replacement culvert.

The minimum dimensions for the granular pad are illustrated in Figure 4. Due to slope stability concerns, 2H:1V slopes are recommended for temporary excavations as well as final embankments.

For the purposes of the O.H.B.D.C. the following design values are recommended for a culvert founded on a 2 m thick pad of compacted Granular 'A'.

Factored Bearing Capacity at U.L.S. = 75 kPa
Bearing Capacity at S.L.S. Type II = 50 kPa

The granular material should be placed by end dumping and carefully compacted so as to not disturb the underlying sensitive clay. Class 1 non-woven geotextile (EOS 75-150 um) should be placed at the clay/granular pad interface in the zone below the elevation of the culvert invert.

The replacement culvert should be constructed with a mid-span camber of 0.15 m to compensate for anticipated future settlements. The upstream half of the pipe should be laid on almost a flat grade. The 150 mm elevation drop is between the mid-span and outlet.

The bedding and backfill to the culvert should be constructed in accordance with OPSD - 803.03 with frost penetration at 1.8 m.

Backfill should consist of Granular 'A' or Granular 'B' for which the following properties are recommended:

Granular 'A' $\gamma = 22.8 \text{ kN/m}^3$ $\phi = 35^\circ$
Granular 'B' $\gamma = 21.2 \text{ kN/m}^3$ $\phi = 30^\circ$

In the zone above that specified in the OPSD specification for backfill, the subexcavated granular fill from this site is suitable for fill.

The backfill should be constructed in 300 mm lifts on alternating sides of the culvert so that the maximum differential in backfill heights at no time exceed 300 mm.

Excavations for footings carried out below the water level prevailing at the time of construction may require dewatering. Dewatering operations may involve the construction of an upstream dam of impervious material to divert the creek. Due to the relatively impervious nature of the clay subsoil, normal sump pumping will adequately dewater the excavation.

If construction of the replacement culvert is to be staged, shoring will be required along the centreline of Hwy. 34. This shoring may consist of a steel H pile/timber lagging system. Alternatively, interlocking sheet piles may be used to construct the shoring. The piles should be driven to bedrock. The estimated bedrock elevation is 60 m. The following soil parameters are recommended for computation of earth pressures for shoring design.

<u>Material</u>	Elevation	<u>c_u</u>	<u>ϕ</u>	<u>γ</u>
	From - To (m)	(kPa)	(°)	(kN/m ³)
Silty Sand (Highway embankment fill)	Surface - 70.0	-	30°	20.4
Clay	70.0 - 68.0	50	-	17.3
	68.0 - 62.0	30	-	17.3
	62.0 - 61.0	50	-	17.3
Silty Sand (Glacial Till)	61.0 - 60.0	-	35	21.2

A 0.6 m thick clay seal should be constructed at the culvert inlet. It should extend from the high water level to 2 m beyond the toe of slope, and a sufficient distance along the embankment to cover the granular bedding and culvert backfill within this zone.

The embankments at both the inlet and outlet should be protected with a 0.6 m thick blanket of rock protection extending from the high water level to 2 m beyond the toe of slope, and a sufficient distance along the embankment to cover the granular bedding and culvert backfill within this zone.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of D. Protulipac, Engineering Student.

The equipment used was owned and operated by Johnston Drilling Co. Ltd.

The report was written by D. Dundas, Senior Foundations Engineer, and reviewed by M. Devata, Chief Foundations Engineer (East).



D. H. Dundas

D.H. Dundas, P.Eng.

Sr. Foundations Engineer

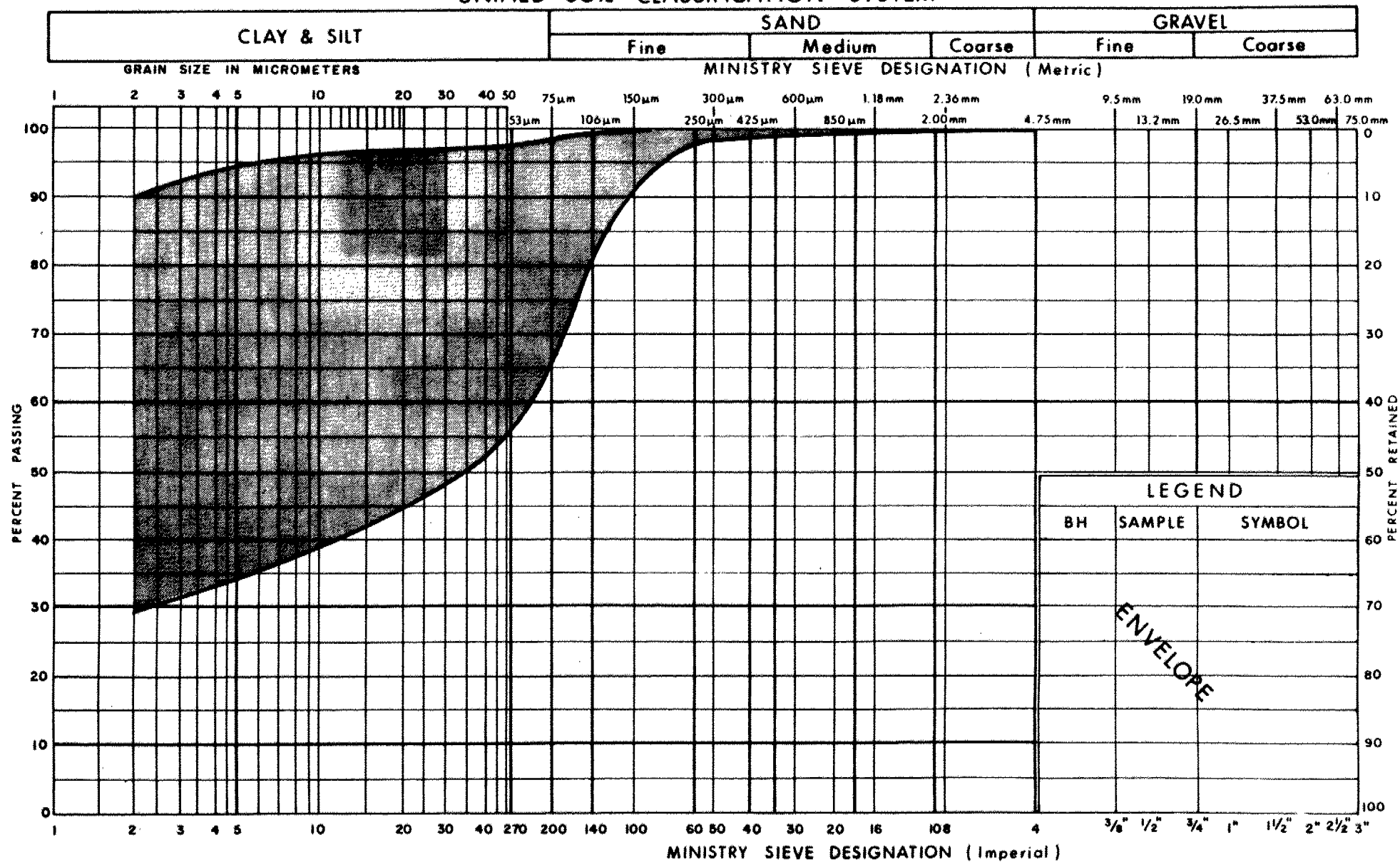
M. Devata

M. Devata, P.Eng.

Chief Foundations Engineer
(East)

A P P E N D I X

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAY SOME / WITH SILT TRACE SAND

FIG No 1

W P 300-87-01

VOID RATIO - PRESSURE CURVES

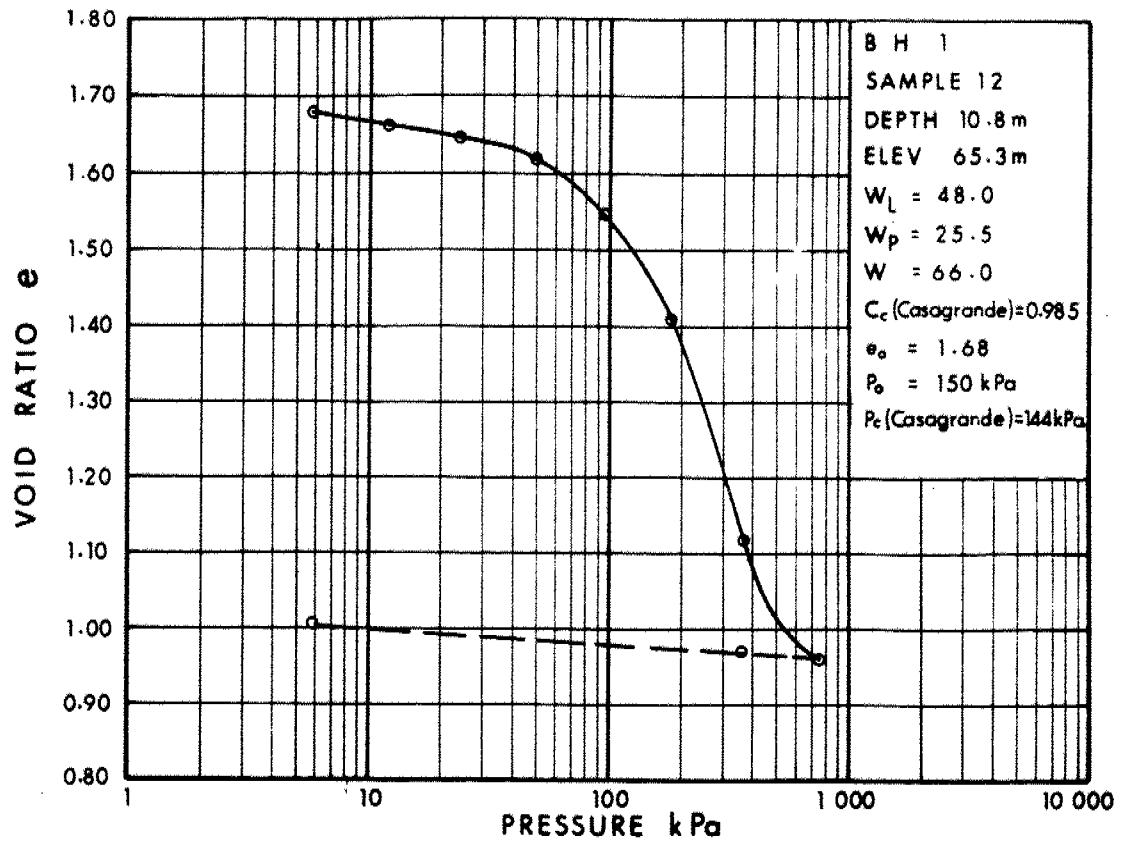
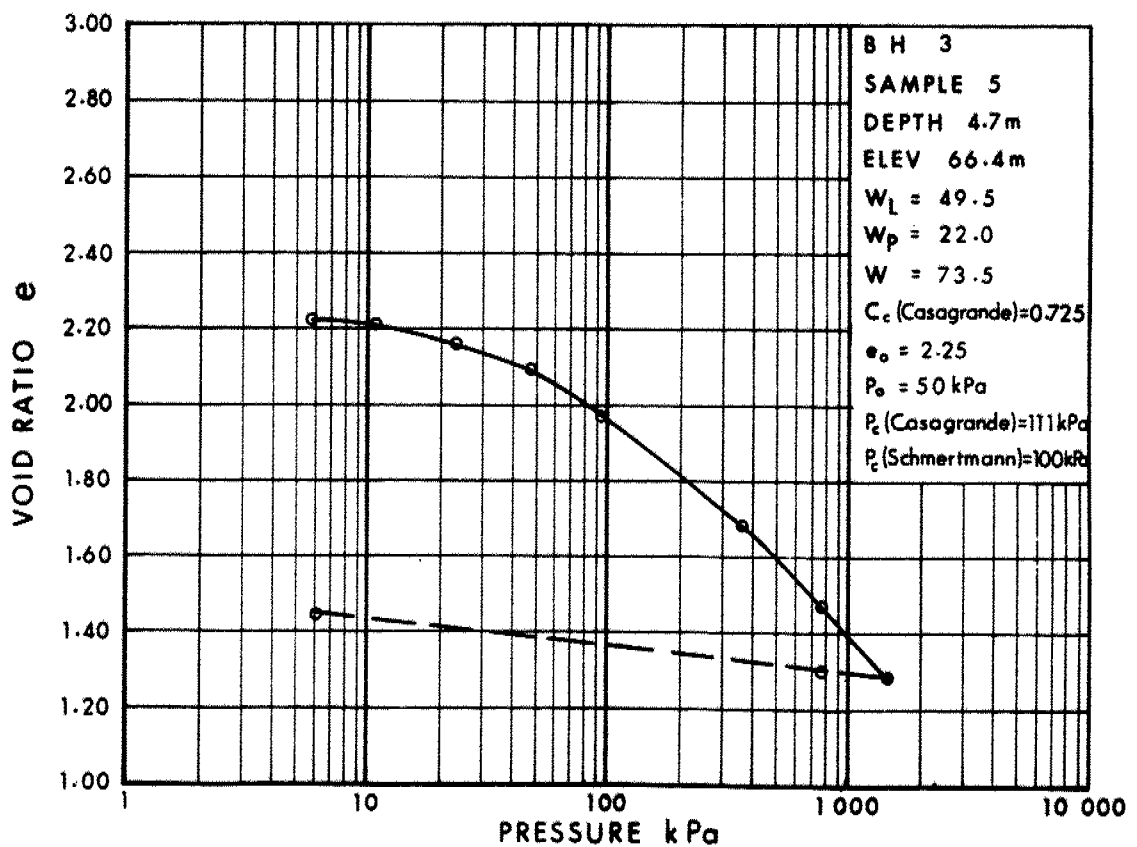


FIG No 2A (Under Embankment)



W P 300-87-01

FIG No 2B (Outside Embankment)

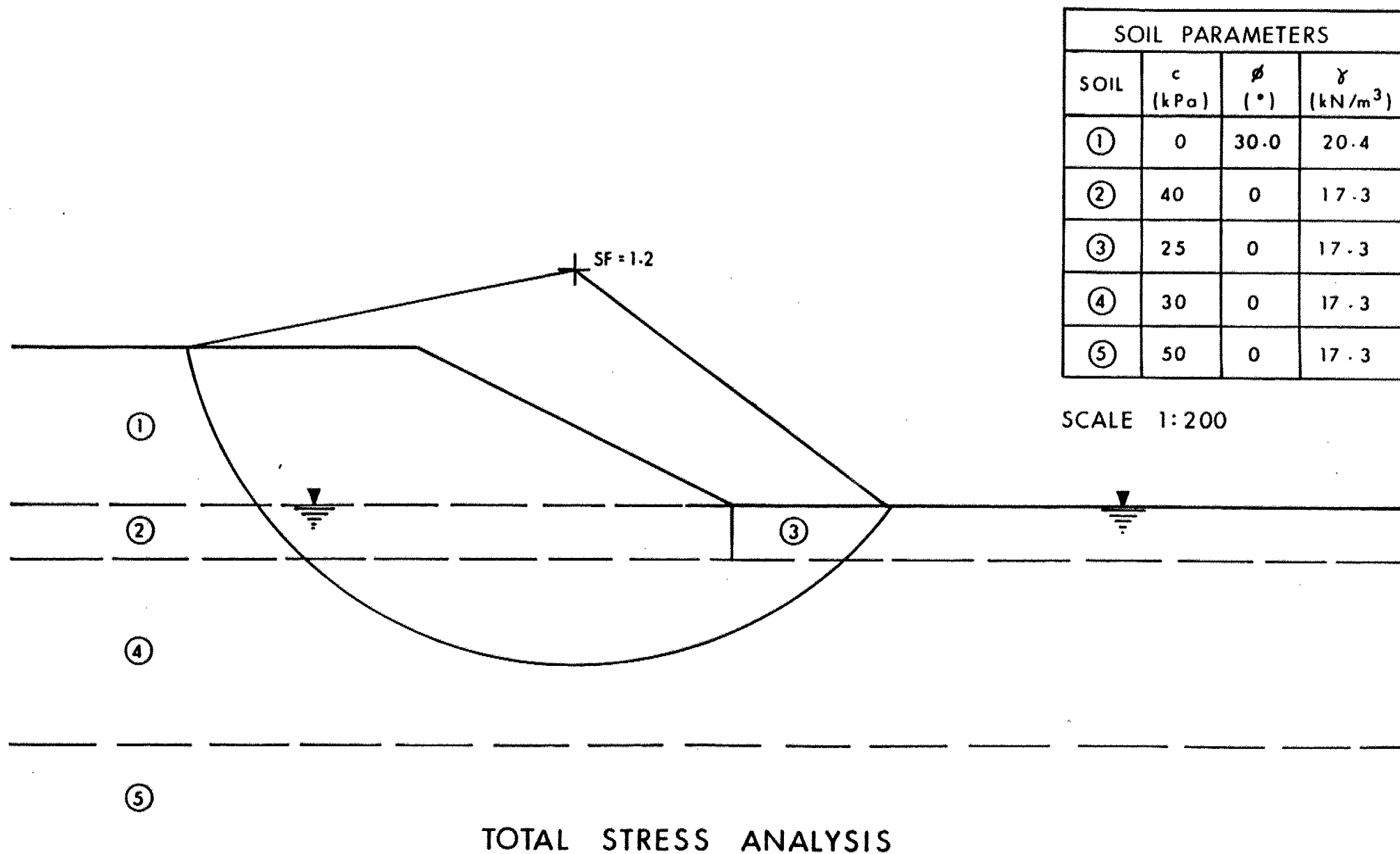
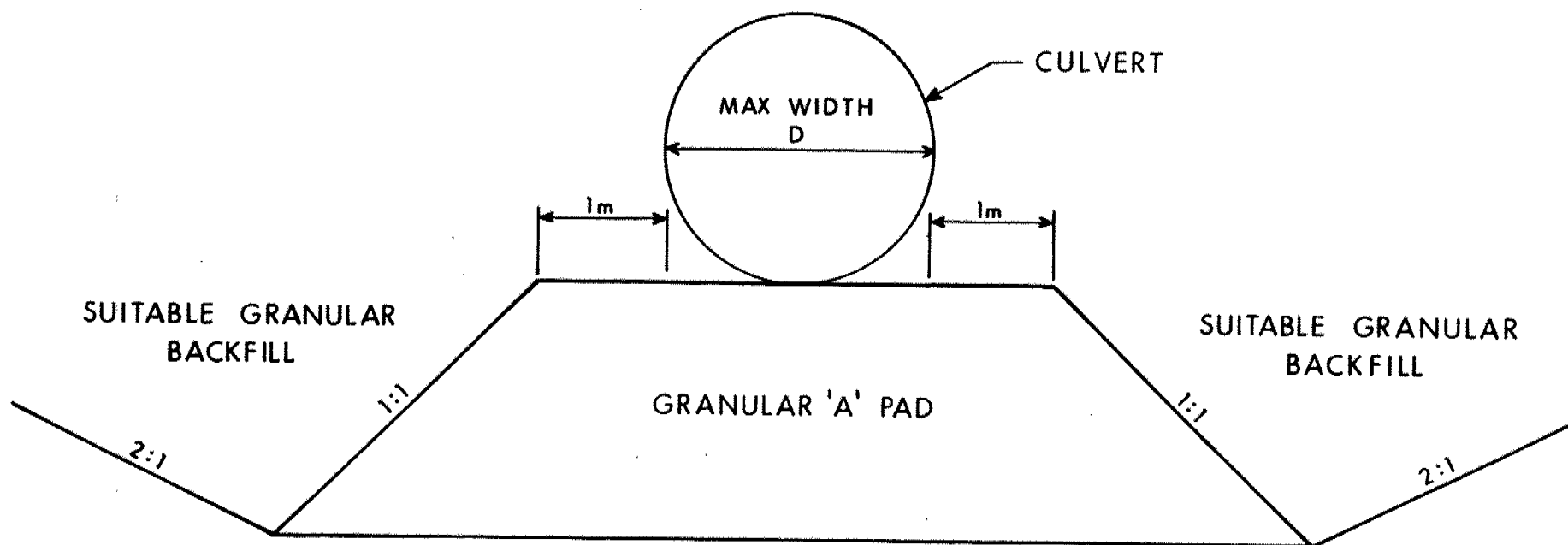


Fig 3



MINIMUM DIMENSIONS FOR GRANULAR PAD

Fig 4

TABLE 1

DESCRIPTION OF ROCK CORE

W.P. 300-87-01

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
1	15.85-17.63	32	0	15.85-21.18	SHALE, dark grey to black; very fine grained, very thinly laminated; weak to medium strong rock; slightly weathered; very close spaced fractures, extremely close spaced fractures from 15.85 to 17.04 m.
	17.63-19.41	71	19		
	19.41-21.18	70	0		
2	16.46-16.94	77	0	16.46-20.12	SHALE, dark grey to black; very fine grained, very thinly laminated; weak to medium strong rock; slightly weathered, close to very close spaced fractures, extremely close spaced fractures from 16.46 to 16.69 m.
	16.94-18.29	73	0		
	18.29-20.12	81	7		
3	12.07-13.97	36	0	12.07-18.14	SHALE, dark grey to black; very fine grained, very thinly laminated; weak to medium strong rock; slightly weathered; extremely close to very spaced fractures.
	13.97-16.05	22	0		
	16.05-18.14	61	0		
4	10.92-11.73	41	0	10.92-16.51	SHALE, dark grey to black; very fine grained, very thinly laminated; weak to medium strong rock; slightly weathered; very close spaced fractures, extremely close spaced fractures from 10.92 to 11.40 m.
	11.73-13.82	27	0		
	13.82-14.43	100	0		
	14.43-16.51	63	0		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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



Ministry of
Transportation and
Infrastructure
Ontario

RECORD OF BOREHOLE No 1

METRIC

W P 300-87-01 LOCATION Sta. 10 + 255.0: 4.3 m E. of Hwy. 34 E
DIST 9 HWY 34 BOREHOLE TYPE Cone Test, H-S Auger, B-Core
DATUM Geodetic DATE 87 08 25 - 26
ORIGINATED BY DP
COMPLETED BY MS
CHECKED BY DD

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
76.1	Ground Surface												
0.0	Silty Sand Some/with Gravel Trace Clay Occ. Silt Zones Compact to Very Dense (Fill) Occ. Boulders Dense to Very Dense		1	SS	37								
			2	SS	46								
			3	SS	19								
			4	SS	18								
			5	SS	31								
			6	SS	100/15 cm								
			7	SS	31								
69.4			8	SS	12								
6.7	trace organics		9	SS	10								
	Clay (CH) Some/with Silt Trace Sand Occ. Silt Seams Very Soft to Stiff (Marine)		10	SS	6								
			11	TW	PM								
			12	TW	PM								
61.2			13	SS	1								
14.9	Silty Sand with Gravel		14	SS	44								
60.3	Dense (Glacial Till)												
15.8	Weathered with Clayey Seams Unweathered Bedrock Shale		15	RC	REC 30%								
			16	RC	REC 71%								
			17	RC	REC 70%								
54.9													
21.2	End of Borehole												

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 300-87-01 LOCATION Sta. 10 + 245.9; 3.9 m Rt. of Hwy. 34 E
DIST 9 HWY 34 BOREHOLE TYPE H-S Auger, B-Core
DATUM Geodetic DATE 87 08 26
ORIGINATED BY DP
COMPILED BY MS
CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
76.4	Ground Surface												GR SA SI CL
0.0													
	Occ. Boulders Very Dense		1	SS	50	8 cm	76						
	Silty Sand Some/with Gravel Trace Clay Occ. Silt Zones Compact to Very Dense (Fill) Occ. Boulders Dense		2	SS	14		74						
			3	SS	47		72						
			4	SS	34		70						
70.3			5	SS	12		68						43 36 16 5
6.1	Trace Organics		6	SS	22		66						0 10 30 60
			7	SS	10		64						
	Clay (CH) Some/with Silt Trace Sand Occ. Silt Seams Very Soft to Firm (Marine)		8	SS	4		62						
			9	SS	1		60						
			10	SS	1		58						0 6 24 70
			11	SS	1								
61.2	Silty Sand with Gravel Compact (Glacial Till)		12	SS	21								
59.9			13	RC	REC 82%								
16.5	Weathered with Clayey Seams Unweathered		14	RC	REC 75%								
	Bedrock Shale		15	RC	REC 79%								
56.3													
20.1	End of Borehole												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 3

METRIC

W P 300-87-01 LOCATION Sta. 10 + 253.3; 19.4 m Rt. of Hwy. 34 E ORIGINATED BY DP
DIST 9 HWY 34 BOREHOLE TYPE Cone Test, Hollow-Stem Auger, B-Core COMPILED BY MS
DATUM Geodetic DATE 87 08 27 CHECKED BY DD

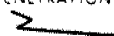













SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	WATER CONTENT (%)				
71.1 0.0	Ground Surface													
	Trace Organics		1	SS	17		70							0 1 19 80
			2	SS	9								15.9	0 1 9 90
	Clay (CH)		3	SS	3								14.9	0 15 22 63
	Some/with Silt		4	TW	PM									
	Trace Sand		5	TW	PM									
	Occ. Silt Seams		6	SS	1									
	Very Soft to Firm		7	SS	1									
	(Marine)		8	TW	PM								18.9	0 35 36 29
	(CL) with Sand													
60.4	Silty Sand with Gravel		9	SS	18		60							
10.7	Compact													
59.1	(Glacial Till)													
12.0			10	RC	REC 34%		58							
	Weathered with Clayey Seams		11	RC	REC 24%		56							
	Unweathered													
	Bedrock Shale		12	RC	REC 61%		54							
53.0														
18.1	End of Borehole													



RECORD OF BOREHOLE No 4

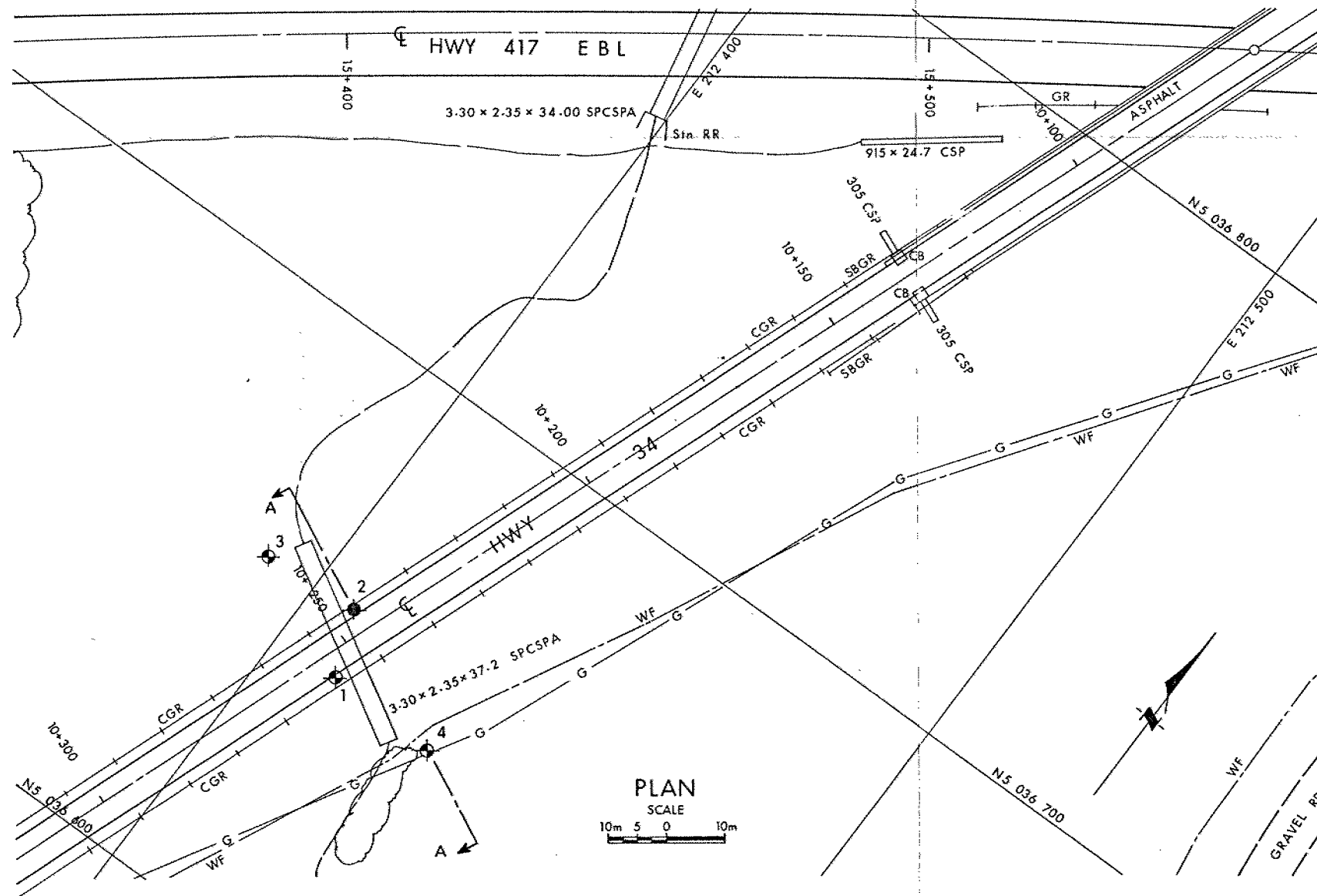
METRIC

W P 300-87-01 LOCATION Sta. 10 + 249.0; 23.3 m Lc. of Hwy. 34 ORIGINATED BY DP
DIST 9 HWY 34 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MS
DATUM Geodetic DATE 87 08 28 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
71.3	Ground Surface					○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%) 20 40 60						
0.0	Trace Organics		1	SS	16		70							0 2 28 70			
	Clay (CH)		2	SS	9		68										
	Some/with Silt		3	SS	4												
	Trace Sand		4	SS	1												
	Occ. Silt Seams		5	SS	1										0 7 28 65		
	Very Soft to Stiff (Marine)		6	SS	1												
			7	SS	1												
62.2																	
9.1	Silty Sand with Gravel Dense (Glacial Till)		8	SS	40		62							37 32 29 2			
60.3																	
11.0	Weathered with Clayey Seams		9	RC	REC 34%		60										
	Unweathered		10	RC	REC 28%		58										
	Bedrock		11	RC	REC 100%												
	Shale		12	RC	REC 59%		56										
54.8																	
16.5	End of Borehole																
	* Groundwater Elevation Not Stabilized																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

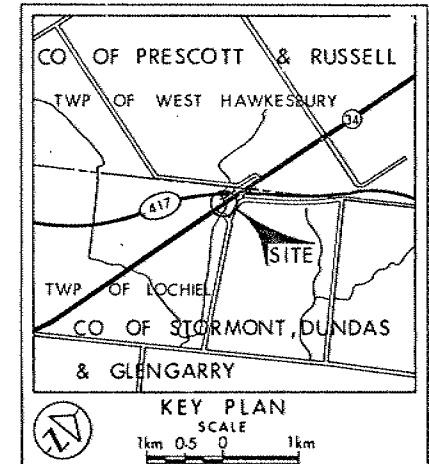


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 300-87-01
CULVERT DISTRESS HWY 34
(STA 10+250)
BORE HOLE LOCATIONS & SOIL STRATA



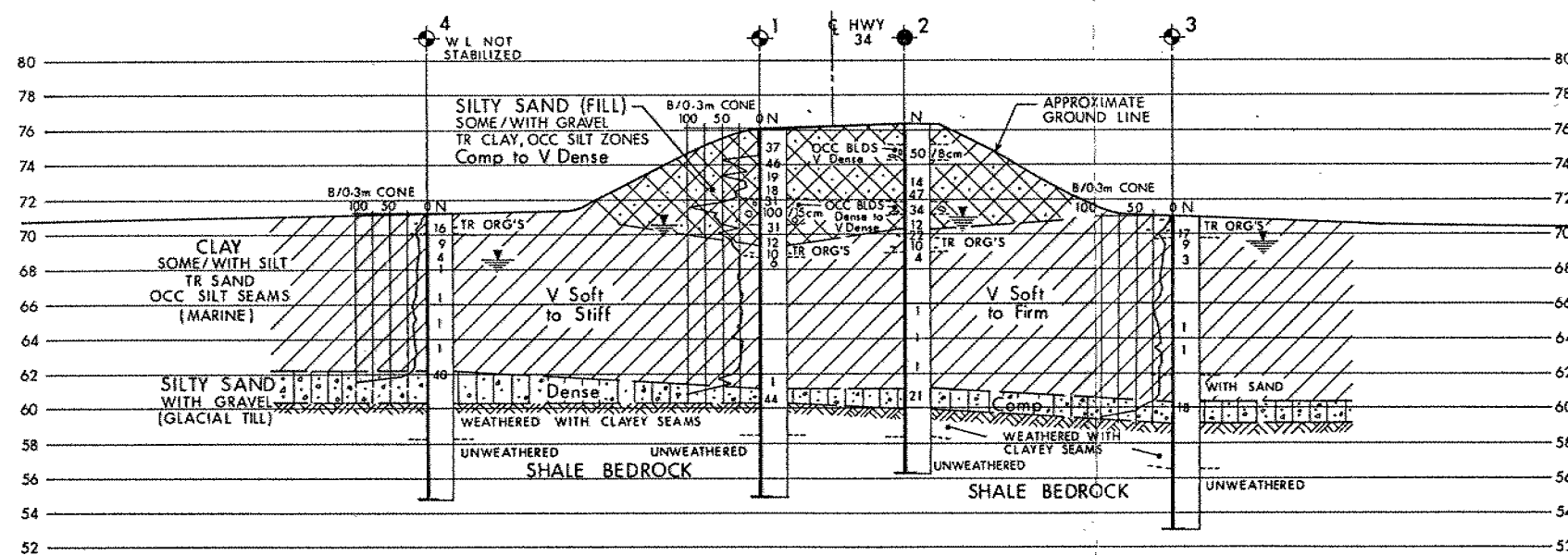
SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 87 08

No	ELEVATION	STATION	OFFSET
1	76.1	10+255.0	4.3m Lt
2	76.4	10+245.9	3.9m Rt
3	71.1	10+253.3	19.4m Rt
4	71.3	10+249.0	23.3m Lt



SECTION A-A
SCALE
4m 2 0 2 4m

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

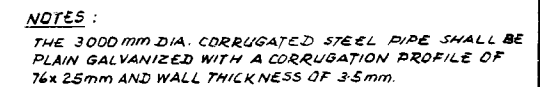
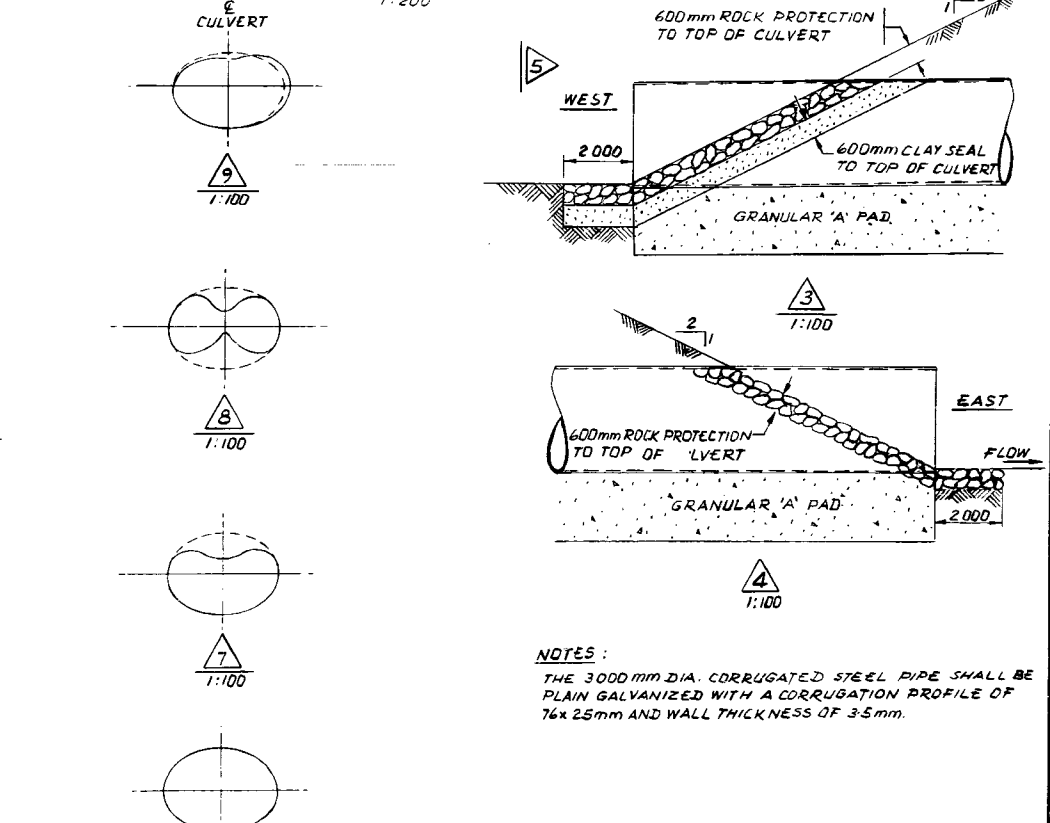
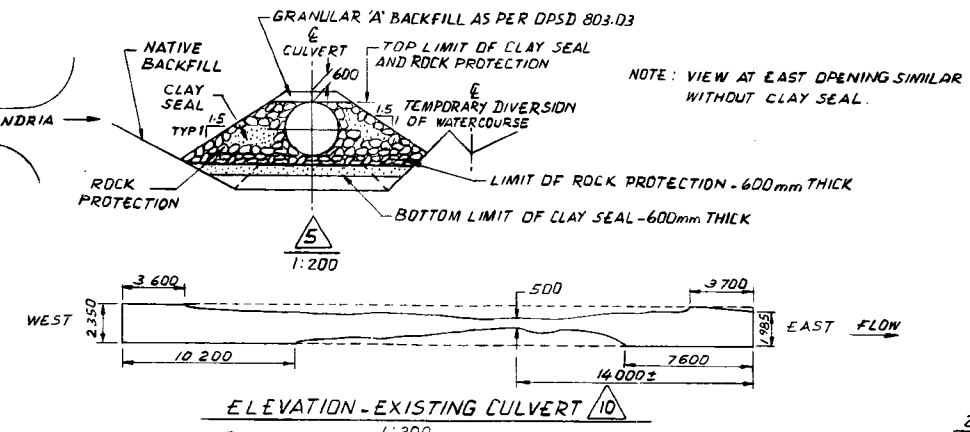
Geocres No 31G-195

HWY No 34	DATE 88 01 07	DIST 9
SUBM'D DD	CHECKED	SITE
DRAWN DT	CHECKED	DWG 3008701-A

**DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN**

N WP No 300-87-01

HWY 34 AT HWY 417



APPLICABLE STANDARD DRAWINGS
 OPSD - 802.01 — BEDDING CIRCULAR PIPE
 OPSD - 803.03 — BACKFILL FOR PIPE CULVERTS

REVISIONS									
	DATE	BY	DESCRIPTION						
	DESIGN	QI	CHECK	LOADING	QBDC - 83			DATE	MAY/88
	DRAWING	FMN	CHECK	QI	SITE No	—			DWG