

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 31E-94

DIST. 11 REGION

W.P. No. 32-79-01

CONT. No. 82-71

W. O. No.

STR. SITE No. 40-25

HWY. No. 519

LOCATION GULL RIVER

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82-71



Ministry of
Transportation and
Communications



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	Gull River Culvert
	W.P. 32-79-01 Site 40-25

NOTE: For purposes of the contract this report supercedes all other foundation reports prepared by or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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/0.3 m)	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

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH T W ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM T W ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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

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^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

For

Hwy. 519 at Eagle Lake

Gull River Culvert

W.P. 32-79-01 Site 40-25

District 11, Northern RegionINTRODUCTION:

Morton & Partners Limited, consulting geotechnical engineers, were retained to carry out a foundation investigation for the proposed culvert at the re-alignment of Highway 519 where it crosses the Gull River, just west of Eagle Lake, Ontario.

The field work for this investigation was carried out during the period of July 13 to 22, 1981, inclusive and consisted of six boreholes advanced at the locations shown on Sheet 19 of the Contract Drawings. The boreholes were advanced with a truck mounted CME 75 drilling machine using both standard and hollow stem augers.

SITE DESCRIPTION

The site is located just below the Eagle Dam which also serves as the present crossing of Highway 519. The Gull River is about 22 m wide at the proposed crossing. Its flow is controlled by the operation of the dam. At the time of the investigation the water depth was less than 1 m. The river bed is densely covered with boulders up to about 1 m in size. The land on either side slopes gently. It is covered with trees and scrub bush, with numerous surficial boulders evident.

The boundaries between the various subsurface conditions, insitu and laboratory test results, as well as, ground water levels, are shown on the attached Record of Borehole Sheets.

The elevations of the ground surface at the borehole locations are related to a local benchmark consisting of a nail in a tree located about 1 m right of centre line at chainage 16 + 181 m. The nail is about 300 mm above ground level and was assumed as elevation 100.00 m. These local (assumed) elevations are used on the attached Borehole Records. For the

purpose of discussion, these local elevations were related to geodetic datum by assuming the ground level at Borehole 2 (local elevation 99.8 m) to be equivalent to geodetic elevation 339.5 m. The converted elevations for the boreholes are used in the profile on the attached drawing.

SUBSURFACE CONDITIONS

The soil at the site is part of an outwash moraine and consists essentially of heterogeneous, relatively coarse, granular material with surficial cobbles and boulders. Cobbles and boulders also occur at random depths. The relative density of the granular deposits is variable. Because of the content of large sizes the Standard Penetration Tests do not always give reliable results, but it is considered that the deposit is generally in a compact to dense state of relative density.

Grain size analyses were carried out on typical samples from the deposit and the resulting grain size distribution curves are shown on Figure 1. They show the generally coarse nature of the material and indicate that it is not or only marginally frost susceptible.

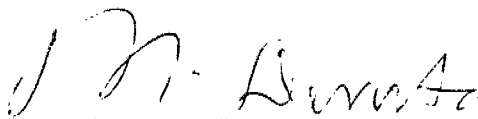
Bedrock was core drilled in Borehole 2 for a depth of 1.5 m and identified as hard white crystalline marble with occasional flakes of mica.

GROUNDWATER CONDITIONS

The groundwater level is directly influenced by the river level and consequently by the operation of the dam. At the time of the investigation, the river level was at about elevation 338.7. The groundwater level measured at the borehole locations was at river level or within 200 to 500 mm above river level.



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No1

5

W P 32-79-01 LOCATION CHAINAGE 16 + 268 - 1 m Lt ± ORIGINATED BY _____
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY _____
DATUM Assumed DATE 81-07-13 CHECKED BY _____

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
339.7	Ground Level																
0.0	Organic matter																
0.3	Boulders																
338.5																	
1.2	Silty sand and gravel dense grey		1	SS	42												
337.2																	
2.5	Sand and gravel some cobbles very dense grey		2	SS	82												41 56 3
			3	SS	81												
333.7																	
5.8	End of borehole		4	SS	81/ 152mm												11 58 31
			5	SS	>100												32 50 18
			6	SS	72/102 mm												
328.7			7	SS	>100	191 mm											
11.0	End of borehole																

3, 5: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 2

6

W P 32-79-01 LOCATION CHAINAGE 16 + 149.5 - 1 m Rt ± ORIGINATED BY _____
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers, BXL core COMPILED BY _____
DATUM Assumed DATE 81-07-14, 16, 17 CHECKED BY _____

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH							WATER CONTENT (%)
339.5	Ground level															
0.0	Organic cover															
0.3	Silty sand with cobbles and boulders		1	AS	-		339									
337.8			2	SS	75/85		mm	338								
1.7	Bedrock															
336.9	Weathered Sound		3	RC BXL	100%		337									
2.6							336									
335.4																
4.1	End of borehole															

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 3

7

W P 32-79-01 LOCATION CHAINAGE 16 + 189 ± ORIGINATED BY
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers, BXL, core COMPILED BY
DATUM Assumed DATE 81-07-17, 20, 21 CHECKED BY

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	20	40	60	80					
339.0	Ground level															
0.0	Boulders and cobbles mixed with organic material															
338.1	Silty sand and gravel compact grey-brown															
0.9			1	SS	20											
			2	SS	30											
	Cobbles															
			3	RC BXL	100%											
			4	RC BXL	99%											
			5	RC BXL	98%											
333.1	Boulders		6	SS	100/127 mm											
5.9	End of borehole Refusal															

RECORD OF BOREHOLE No 4

8

W P 32-79-01 LOCATION CHAINAGE 16 + 219.7 - 15.8 m Rt E ORIGINATED BY _____
 DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY _____
 DATUM Assumed DATE 81-07-12 CHECKED BY _____

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH								
338.9	Ground level															
0.0	Boulders															
337.4																
1.5	Sand and gravel compact to very dense grey		1	SS	100/50 mm											
	Occasional cobbles		2	SS	20											
			3	SS	50											
332.6			4	SS	100/152 mm											
6.2	End of borehole Refusal															

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

RECORD OF BOREHOLE No 5

9

W P 32-79-01 LOCATION CHAINAGE 16 + 227 ± ORIGINATED BY
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY
DATUM Assumed DATE 81-07-21, 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
338.8	Ground level																
0.0	Boulders and cobbles mixed with organic material																
337.9																	
0.9	Sand and gravel compact to very dense grey		1	SS	83												
	Occasional cobbles																
			2	SS	100												
			3	SS	16												
333.8																	
5.0	End of borehole Refusal																
	Water level not established																

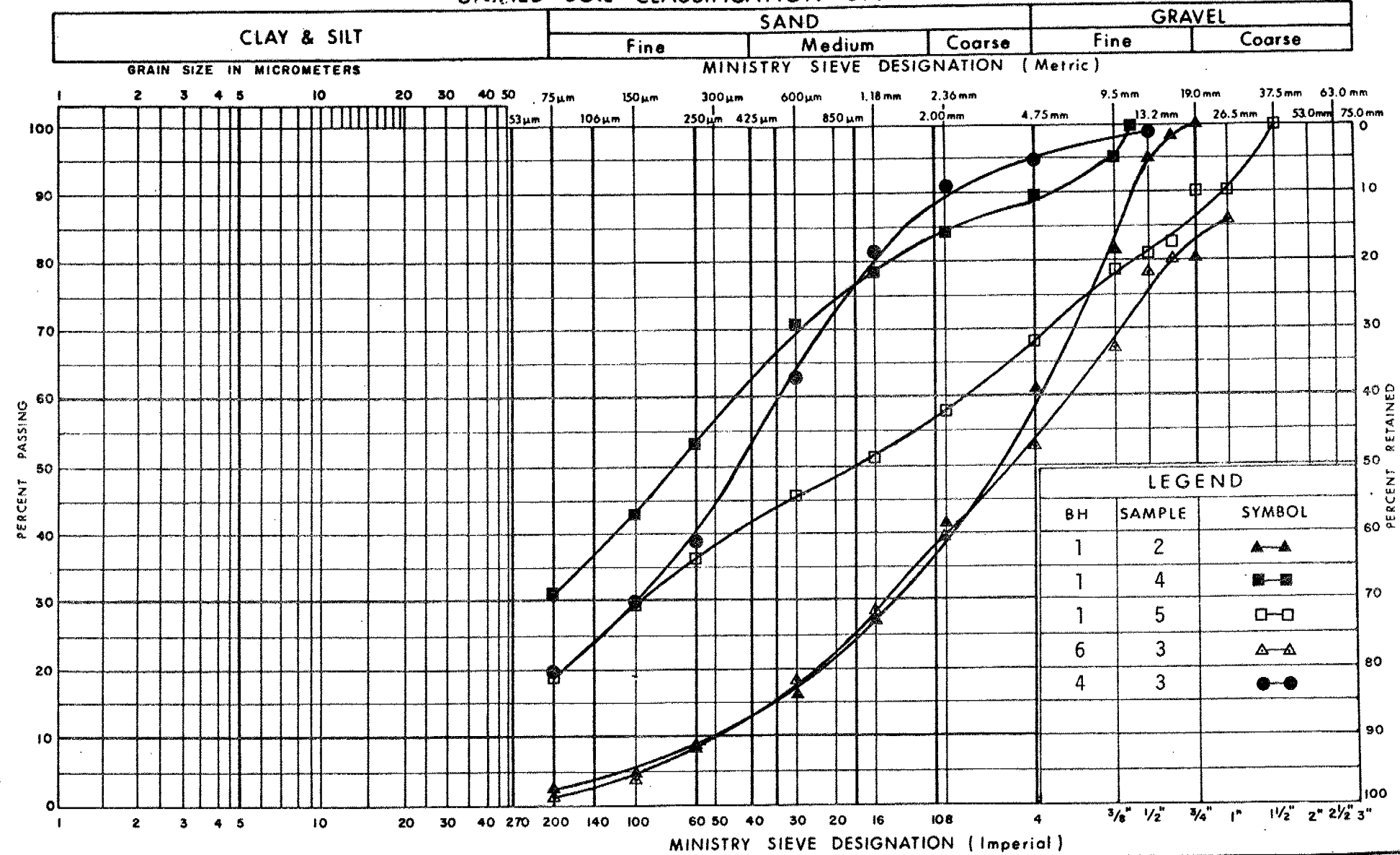
RECORD OF BOREHOLE No 6

10

W P 32-79-01 LOCATION CHAINAGE 16 + 215 - 16 m Lt & ORIGINATED BY
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY
DATUM Assumed DATE 81-07-22 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
338.9	Ground level												
0.0	Sand trace of silt black mixed with boulders												
337.4													
1.5	Sand and gravel occasional cobbles compact to very dense dark brown to grey		1	SS	22								
			2	SS	79								
			3	SS	100/152 mm								
			4	SS	53								
331.0			5	SS	100/76 mm								
7.9	End of borehole Refusal Water level not established												

UNIFIED SOIL CLASSIFICATION SYSTEM



FOUNDATION INVESTIGATION REPORT

HIGHWAY 519 AT EAGLE LAKE.

GULL RIVER CULVERT

W.P. 32-79-01 SITE 40-25

DISTRICT 11 NORTHERN REGION

01.81.074

AUGUST, 1981

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2 COPIES MORTON & PARTNERS LIMITED

Prepared by:

MORTON & PARTNERS LIMITED
215 CARLINGVIEW DRIVE
REXDALE, ONTARIO, M9W 5X8

GEOCRES N° 31E-94

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GRAIN SIZE DISTRIBUTION

Fig. No 1

BOREHOLE LOCATIONS AND SOIL STRATA

1.0 INTRODUCTION

Morton & Partners Limited has been retained by the Ministry of Transportation and Communications to carry out a foundation investigation at the site of the re-alignment of Highway 519 where it crosses the Gull River, just west of Eagle Lake, Ontario.

2.0 SITE DESCRIPTION

The site is located just below the Eagle Lake Dam which also serves as the present crossing of Highway 519. The Gull River is about 22 m wide at the proposed crossing. Its flow is controlled by the operation of the dam. At the time of the investigation the water depth was less than 1 m. The river bed is densely covered with boulders up to about 1 m in size. The land on either side slopes gently. It is covered with trees and scrub bush and numerous surficial boulders are evident.

3.0 FIELD WORK

The field work for this investigation was carried out during the period of July 13 to 22, 1981, inclusive and consisted of six boreholes at the locations shown on the attached drawing. The boreholes were advanced with a truck mounted CME 75 drilling machine using both standard and hollow stem augers.

It was originally intended to locate one borehole at the downstream end of the culvert. However, very large boulders in this area made access virtually impossible and the hole (Borehole 6) was consequently offset as shown on the drawing.

Samples were taken using the Standard Penetration Test method. Bedrock (and, where necessary, boulders) was core drilled in BXL size. All samples were brought to our laboratory for further examination and testing. Samples remaining after testing will normally be stored for a period of three months following the date of this report and then discarded, unless other instructions are received.

3.0 FIELD WORK (continued)

The elevations of the ground surface at the borehole locations are related to a local benchmark consisting of a nail in a tree located about 1 m right of centre line at chainage 16 + 181 m. The nail is about 300 mm above ground level and was assumed as elevation 100.00 m. These local (assumed) elevations are used on the attached Borehole Records. For the purpose of discussion, these local elevations were related to geodetic datum by assuming the ground level at Borehole 2 (local elevation 99.8 m) to be equivalent to geodetic elevation 339.5 m. The converted elevations for the boreholes are used on the profile on the attached drawing.

4.0 SOIL CONDITIONS

The soil at the site is part of an outwash moraine and consists essentially of heterogeneous, relatively coarse, granular material with surficial cobbles and boulders. Cobbles and boulders also occur at random depths. The relative density of the granular deposits is variable. Because of the content of large sizes the Standard Penetration Tests do not always give reliable results, but it is considered that the deposit is generally in a compact to dense state of relative density.

Grainsize analyses were carried out on typical samples from the deposit and the resulting grainsize distribution curves are shown on Figure 1. They show the generally coarse nature of the material and indicate that it is not or only marginally frost susceptible.

Bedrock was core drilled in Borehole 2 for a depth of 1.5 m and identified as hard white crystalline marble with occasional flakes of mica.

5.0 GROUNDWATER CONDITIONS

The groundwater level is directly influenced by the river level and consequently by the operation of the dam. At the time of the investigation, the river level was at about elevation 338.7. The groundwater level measured at the borehole locations was at river level or within 200 to 500 mm above river level.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to construct a culvert at the site. The culvert is to be 6.7 m wide and 2.1 m in height. It is understood that the culvert invert is to be at about elevation 338 and that the grade of Highway 519, at the crossing, will be at about elevation 346. In this configuration, the culvert will be covered with about 6 m of fill and the culvert will be about 40 m long.

6.2 Culvert Foundation

Design details for the culvert are not available at the present time, but it is assumed that it will either be founded on footings or designed as a box culvert and founded on a raft.

The river bed is covered by cobbles and boulders, extending to a depth of about 1 to 1.5 m. It is understood that a flow of water has to be maintained to satisfy downstream water supply requirements. Consequently, any significant excavation for foundations will have to deal with the presence of cobbles and boulders as well as with the possible need for dewatering of highly pervious material. It would therefore be advantageous to keep excavations for foundations to a minimum. However, locally deeper excavation may be required for scour protection at the upstream and the downstream end of the culvert. An evaluation of these requirements is outside the scope of this report.

6.0 DISCUSSION AND RECOMMENDATIONS (continued)

The soil at the culvert location is not frost susceptible and moreover, the anticipated presence of water flow throughout the year would seem to make any significant penetration of frost unlikely. However, in footing design, it is standard procedure to place footings below the depth of potential frost penetration which, in the area of investigation, is about 1.7 m. Footings, furthermore, should not bear on cobbles or boulders to avoid both point loading as well as the possibility of future settlement resulting from boulders, under the weight of the embankment, shifting into cavities which may either exist or be created after construction due to piping.

Consequently, if a footing design is adopted, the footings should be placed at about elevation 336.3. If, upon excavation to this elevation, boulders protrude or are evident at shallow depth, such boulders should be removed and replaced with compacted material of a quality at least equivalent to Granular B. Because the density of the in situ granular material is inherently variable, it is further recommended that the subgrade, exposed in the footing excavation, be thoroughly and uniformly compacted. For footings founded at or below elevation 336.3 an allowable bearing pressure of 300 kPa may be used in design, provided that the subgrade is compacted as recommended and provided that point loadings will not occur. If, during construction, it appears that removal of boulders below elevation 336.3 is not practical in certain locations and if, consequently, some point loading cannot be avoided, the footings should be widened and deepened and/or extra reinforced at such locations.

If the culvert is to be of the box type, founded on a raft, it is recommended that the cobbles and boulders be removed to such depth that the raft will rest on at least 300 mm of well compacted, selected granular material preferably of Granular A quality, in order to avoid point loading. Following the removal of boulders

6.0 DISCUSSION AND RECOMMENDATIONS (continued)

and prior to placing the granular mat, the subgrade should be levelled or thoroughly and uniformly compacted.

6.3 Dewatering

As noted earlier, it is understood that some flow will have to be maintained to satisfy downstream needs, but the amount of flow can be controlled by the dam and, for limited periods, it can be totally stopped. However, it will probably be necessary to divert and/or channel the river during construction. The average coefficient of permeability of the soil is estimated to be of the order of 10^{-2} to 10^{-3} cm/sec. Local dewatering in granular soil, to a depth of about 1 m, can probably be achieved by pumping from sumps. However, dewatering to greater depths and to a significant lateral extent, such as required for the installation of footings, may require the use of well points or deep wells.

Because of the heterogeneous and generally coarse nature of the granular materials, it is very difficult to pre-judge the dewatering methods which may be required. It is therefore strongly recommended that this fact be recognised in the design of foundations by keeping the required depths of excavation to a minimum.

6.4 Embankment

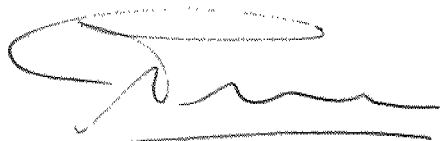
The present grade is suitable for the construction of an earth fill embankment with side slopes of 1 vertical to 2 horizontal. The base area of the embankment should be cleared of trees and scrub brush. This investigation has shown a rather limited and sporadic organic cover. This cover is generally a flood deposit. It does not necessarily have to be removed but the need for such removal will have to be determined during grubbing.

7.0 MISCELLANEOUS

The field work for this investigation was carried out under the direction of Mr. M. Merleau, P. Eng., using equipment owned and operated by Atcost Soil Drilling Inc. This report was written by Mr. A. Prior, P. Eng., and reviewed by Mr. D.J. Belshaw, p. Eng.

Respectfully Submitted,

MORTON & PARTNERS LIMITED

A handwritten signature in dark ink, appearing to be 'A. Prior', with a long horizontal flourish extending to the right.

A. Prior, P. Eng.

A handwritten signature in dark ink, appearing to be 'D.J. Belshaw', with a stylized, cursive script.

D.J. Belshaw, P. Eng.

AP/LT

RECORD OF BOREHOLE No1

METRIC

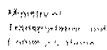
W P 32-79-01 LOCATION CHAINAGE 16 + 268 - 1 m Lt ± ORIGINATED BY _____
 DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY _____
 DATUM Assumed DATE 81-07-13 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)					
100.0	Ground level																
0.0	Organic matter																
0.3	Boulders																
98.8							99										
1.2	Silty sand and gravel dense grey		1	SS	42		98										
97.5																	
2.5	Sand and gravel some cobbles very dense grey		2	SS	82		97									41 56 3	
							96										
			3	SS	81		95										
94.2																	
5.8	Silty sand and gravel very dense grey		4	SS	81/ 152mm		94									11 58 31	
							93										
			5	SS	>100		92									32 50 18	
							91										
			6	SS	72/102 mm		90										
89.0			7	SS	>100/191 mm		89										
11.0	End of borehole Assumed elev. 100.0 m ~ geodetic elev. 339.7 m.																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



MEETING

W P 32-10-11	LOCATION CHANAO 16 4-149.5	1 m ³ d.	ORIGINATED BY
DIST 11	HWY 519	BOREHOLE TYPE Solid and hollow stem augers, BXL Core	COMPILED BY
DATUM Assumed	DATE 01-07-14, 11:32		CHECKED BY

SOIL PROFILE		SAMPLES		STANDARD PENETRATION TEST						PLASTIC LIMIT			NATURAL MOISTURE CONTENT (%)			UNIT WEIGHT		REMARKS	
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	N/A	Q	f _s	CORR.	W _p	W	W _L	Y	γ	γ _d	γ _t	γ _w	γ _a	γ _b	γ _c	γ _d
99.8	Ground Level																		
0.0	Organic matter																		
0.3	Silty sand with cobbles and boulders	1	AS																
0.7		2	SS	75.7 mm															
1.7	Red clay																		
2.7	Well-sorted sand																		
3.7		3	PR	100%															
4.1	End of borehole																		
Assumed elev. 100.0 m																			
Assumed elev. 330.2 m																			

3, 4, 5. Numbers refer to Spectroscopy

CHURCH ROCK: ON SOIL EXPLORATION



Ministry of
Transportation and
Communications
Government of Ontario

RECORD OF BOREHOLE No3

METRIC

W P 32-74-01 LOCATION CHAINAGE 16 + 189 ± ORIGINATED BY _____
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers, BXL Core COMPILED BY _____
DATUM Assumed DATE 01-07-17, 20, 21 CHECKED BY _____

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			70 40 60 80 100	SHEAR STRENGTH					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
98.3	Ground level													
98.0	Boulders and cobbles mixed with organic material													
98.4														
0.9	Silty sand and gravel compact grey-brown		1	SS	20									
			2	SS	30									
	Cobbles													
			3	RC BXL	100%									
			4	RC BXL	99%									
			5	RC BXL	98%									
	Boulders													
93.4			6	SS	100/	127 mm								
5.9	End of borehole Refusal													
	Assumed elev. 100.0 m = geodetic elev. 339.7 m.													



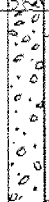
*3, *5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W.P. 31-79-21 LOCATION CHAINAGE 16 + 219.7 - 15.6 m Rt # _____ ORIGINATED BY _____
 DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem auger _____ COMPILED BY _____
 DATUM Assumed _____ DATE 81-07-21 _____ CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
99.7	Ground level													
0.0	Boulders													
97.7														
1.5	Sand and gravel compact to very dense grey		1	SS	100/	50 mm								
	Occasional cobbles													
			2	SS	20									
			3	SS	50									
93.0			4	SS	100/	152 mm								
6.2	End of borehole Refusal													
	Assumed elevation 100.0 m = geodetic elev. 339.7 m.													

+3, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5

METRIC

W P 17-79-01 LOCATION CHAINAGE 16 + 227 ± ORIGINATED BY _____
DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY _____
DATUM Assumed DATE 81-07-21, 22 CHECKED BY _____

SOIL PROFILE		STRAT PLOT	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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			'N' VALUES	20	40	60	80					
99.1	Ground level															
96.0	Boulders and cobbles mixed with organic material															
96.2																
96.9	Sand and gravel compact to very dense grey		1	SS	83											
	Occasional cobbles															
			2	SS	100											
			3	SS	16											
94.1																
5.0	End of borehole Refusal															
	Water level not established															
	Assumed elev. 100.0 m															
	= geodetic elev. 339.7 m															

+3, x⁵: Numbers refer to Sensitivity

20
15
10
5
0.5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

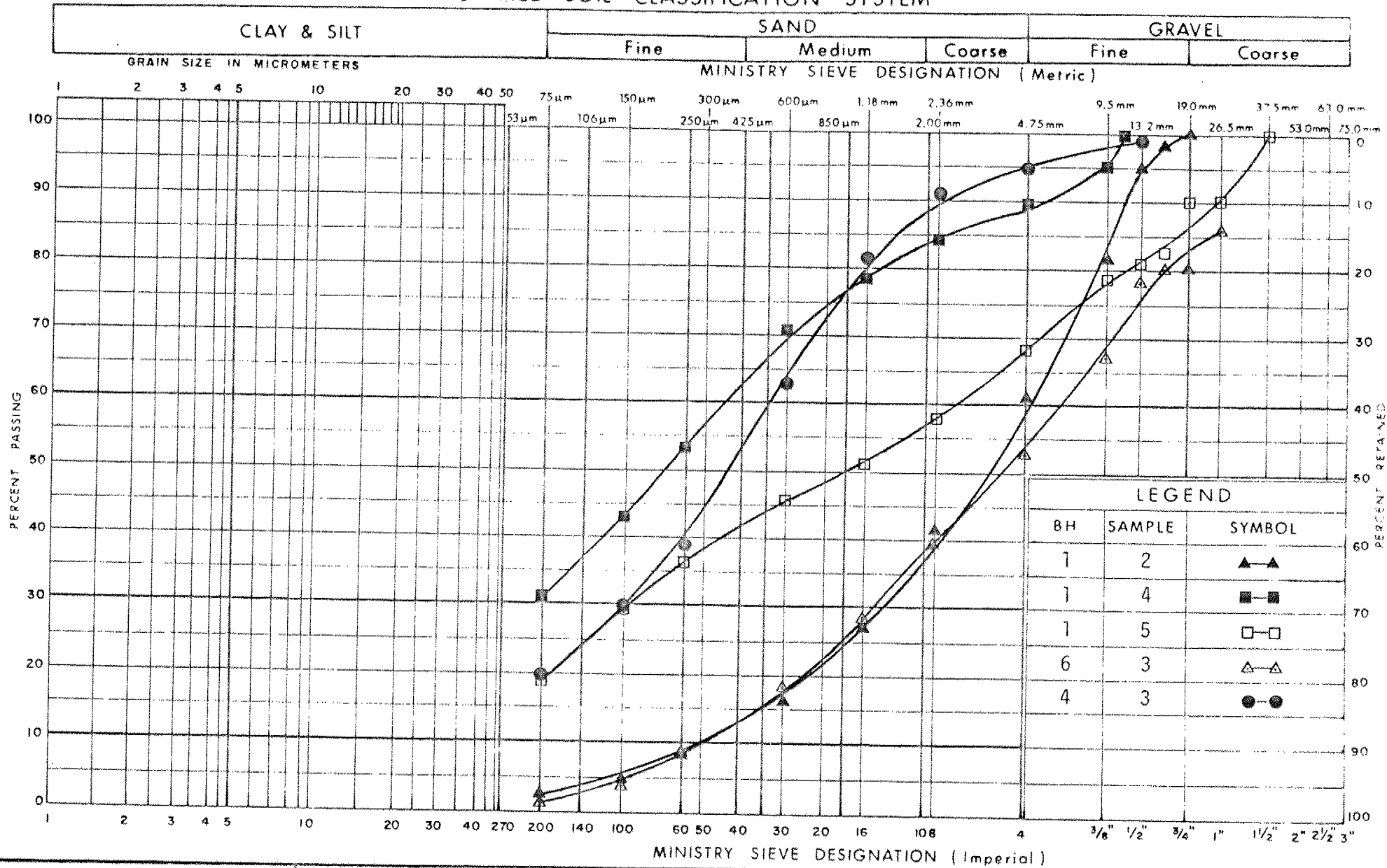
METRIC

W.P. 32-39-01 LOCATION CHAINAGE 16 + 215 - 16 m Lt & ORIGINATED BY
 DIST 11 HWY 519 BOREHOLE TYPE Solid and hollow stem augers COMPILED BY
 DATUM Assumed DATE 81-07-22 CHECKED BY

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					
99.2	Ground level															GR SA SI CL
0.0	Sand trace of silt black mixed with boulders					99										
97.7						98										
1.5	Sand and gravel occasional cobbles compact to very dense dark brown to grey		1	SS	22	97										
			2	SS	79	96										
			3	SS	100	95										
			4	SS	53	94										
			5	SS	100	93										
91.3						92										
7.9	End of borehole Refusal															
	Water level not established															
	Assumed elev. 100.0 m															
	± geodetic elev. 339.7 m															

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

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION

FIG No 1
W P 32-79-01

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 1" 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	C/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

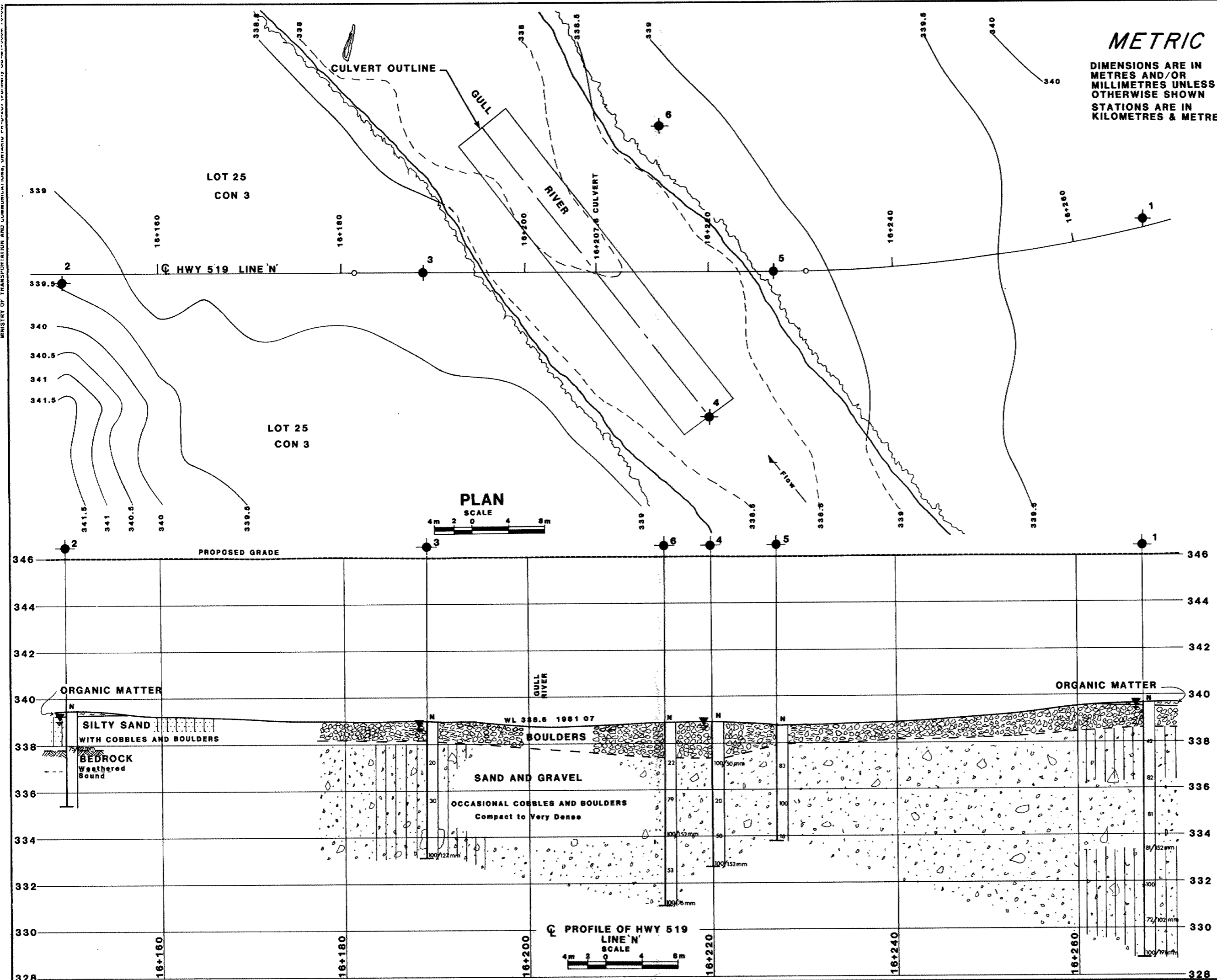
u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS 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_f	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 = $\frac{w - w_p}{I_p}$	x	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	J	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



CONT No
WP No 32-79-01

SHEET

GULL RIVER CULVERT
(Highway 519 at Eagle Lake)

BORE HOLE LOCATIONS & SOIL STRATA

MORTON & PARTNERS LTD

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)

WL at time of investigation 1981 07

WL NOT ESTABLISHED IN
BOREHOLES 5 & 6

No	ELEVATION	STATION	OFFSET
1	339.7	16-268	1m Lt
2	334.5	16-149.5	1m Rt
3	339.0	16-189	℄
4	338.9	16-219.7	15.8m Rt
5	338.8	16-227	℄
6	338.9	16-215	16m Lt

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

REVISIONS

DATE	BY	DESCRIPTION

Geocres No

HWY No 519

SUBMD

DRAWN

CHECKED

CHECKED

DATE 1981 08 17

APPROVED

DIST 11

SITE 40-25

DWG 327901-A