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GEOCRES No. 317-102

DIST. 9 REGION

W.P. No. 86-81-01

CONT. No. ~~81-46009~~ 82-316

W. O. No. 81-46009

STR. SITE No. 29-39

HWY. No. 62

LOCATION Harzley Bay Bridge  
Hwy 62, North of Pembroke

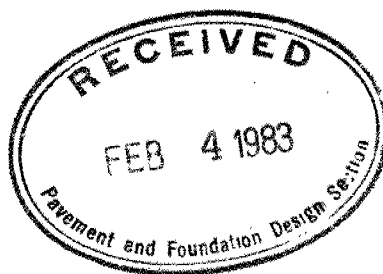
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82 - 3/6



Ministry of  
Transportation and  
Communications

INDEX

<u>Page</u>	<u>Description</u>
1	Index
2	Abbreviations & Symbols
3 - 16	Foundation Investigation Report Hazley Bay Bridge Wingwalls W.P. 86-81-01, Site 29-39 Hwy. 62, District 9, Ottawa

- NOTE: 1. For purposes of the contract this report supersedes all other foundation reports prepared by or for the Ministry in connection with the above-mentioned project.
2. All dimensions & elevations referred to in this Report are given in Imperial units.

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

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

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

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

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

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

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

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

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

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

### ABBREVIATIONS & SYMBOLS

#### LABORATORY TESTING

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

#### FIELD SAMPLING

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

#### EARTH PRESSURE TERMS

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

#### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_L - w_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

#### STRENGTH PARAMETERS

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

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

#### HYDRAULIC TERMS

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

## GEOTECHNICAL INVESTIGATION

For

Hazley Bay Bridge Wingwalls  
W.P. 86-81-01, Site 29-39  
Highway 62, District 9, Ottawa

### INTRODUCTION

This report presents the results of a foundation investigation carried out at the site of the Hazley Bay bridge on Highway Number 62 at Pembroke, Ontario, by the geotechnical consultant Golder Associates.

The fieldwork for this investigation was carried out from October 26 to 30, 1981 at which time six boreholes numbered 1 to 6 and one test pit number 7 were put down at the site. Boreholes 1 to 5 were drilled vertically through the bridge wingwalls and borehole 6 was put down through the fill materials behind the northeast wingwall. The boreholes were advanced using electric powered wash boring and rock coring equipment supplied and operated by a specialist drilling contractor. The test pit was excavated using a rubber tire mounted backhoe supplied and operated by a local excavating contractor.

The boreholes were cored through the wingwall and footing concrete and underlying bedrock using a 1-3/4 inch diameter core bit. At borehole 6 sampling of the overburden materials in conjunction with standard penetration testing was carried out using drive open split barrel sampling equipment. Chunk samples of the materials comprising the walls of the test pit were obtained during excavating.

### SITE DESCRIPTION

The Hazley Bay bridge is located on Highway Number 62 about 4 miles southeast of Pembroke, Ontario. The bridge provides part of the link between the provinces of Ontario and Quebec and carries traffic

over a branch of the Ottawa River. It is understood that the bridge was built in 1956. Movement of the wingwalls was first reported in 1958 and by 1967 the southwest wingwall was observed to have moved outwards 4 to 5 inches and was tilted about 1 to 1½ inches. From 1975 to 1977 all four wingwalls were tied back by ½ inch diameter steel cables attached to deadmen installed in the roadway shoulder fill or by steel plates reacting against the abutments. Movement of the walls was arrested for several years following the above anchoring operation. However, in 1981 the southwest wingwall moved outward a further 4 inches apparently breaking the tie-back cables.

Available structural drawings indicate that each wingwall was designed as a free-standing structure separate from the abutments and resting on a variable width, common footing with each abutment. The walls were to be structurally tied to the footing with one row of reinforcing and the footings were to be keyed into the solid bedrock a minimum of 1 foot.

#### SUBSURFACE CONDITIONS

The location of the boreholes and test pit and sections showing the borehole stratigraphy at the wingwalls are shown on Sheet No. 6 of the Contract Drawings.

The ground surface elevations have been referred to a point on the southwest wingwall the elevation of which was indicated in the field as being 376.47 feet. It is assumed that this point is referred to geodetic datum.

The detailed subsurface conditions encountered in the boreholes and test pit are given on the Record of Borehole and Record of Test Pit sheets following the text of this report. Following is a summarized account of the subsurface conditions encountered at the site.

### WINGWALLS AND FOOTINGS

Boreholes 1 to 5 put down vertically through the wingwalls encountered relatively sound, well cemented concrete throughout the full depth of the wingwalls and the underlying footings. At boreholes 1 and 2 put down through the southwest wingwall a 1.5 to 2.4 inch thick void was encountered between the underside of the wingwall and the footing. At boreholes 3, 4 and 5 put down in the southeast, northeast and northwest wingwalls, respectively, no void was encountered at the joins between the wingwalls and footings.

### FOUNDING MATERIALS

Beneath the concrete footing at boreholes 2, 4 and 5, the boreholes encountered a 0.4 to 1.3 foot thick layer of overburden materials. At boreholes 2 and 5 the materials consisted of grey sandy silt till. At borehole 4 the material consisted of sand, gravel and cobbles, probably glacial till modified by river action. Due to the relative thinness of the till layer no standard penetration tests were carried out in this material. However, based on resistance to drilling it is considered that the glacial till materials are in a compact to dense state of packing.

Beneath the concrete footings at boreholes 1 and 3 and the glacial till materials at boreholes 2, 4 and 5, the boreholes encountered bedrock. The recovered bedrock cores consisted of sound to fractured, white to dark green diorite gneiss and white and pink granitic gneiss. The measured rock core recoveries typically varied from 83 to 100 percent and the measured R.Q.D. values ranged from 0 to 61 percent.

### WINGWALL BACKFILL MATERIALS

Borehole 6 and test pit 7 were put down behind the northeast and southwest wingwalls, respectively, in order to determine the nature of the wingwall backfill materials.

At borehole 6 the wingwall backfill materials consisted of about a 3.5 foot thickness of very stiff grey-brown sandy silt from the surface overlying brown sand which was encountered to a depth of about 11.5 feet, the upper surface of the footing. At test pit 7 a 4.5 foot thick layer of sand fill materials were encountered from the surface overlying about a 3.5 foot thick layer of sandy silt. Beneath the sandy silt layer the sand fill materials were encountered to a depth of about 9 feet, the full depth of exploration. Standard penetration 'N' values measured in the sand fill materials ranged from 3 to 17 blows per foot and indicate that the sand fill is in a very loose to compact state of packing. The results of grain size distribution analysis carried out on representative samples of the sand and sandy silt fill materials are shown on Figures 1 and 2, respectively. These results indicate that the sandy silt materials are very susceptible to frost heave action and that the sand fill materials may be slightly susceptible to frost action.

#### GROUNDWATER CONDITIONS

Following the completion of drilling water levels were measured in the open boreholes. At this time the water levels in the boreholes varied from about elevation 366.4 to 366.6 feet. Test pit 7 was dry to a depth of about 9 feet at the completion of excavating.



A handwritten signature in black ink, appearing to read "M. Devata".

M. Devata, P. Eng.  
Senior Foundations Engineer



## APPENDIX.



RECORD OF BOREHOLE No 1

8

W P 86-81-01 LOCATION 10' West of East End of Southwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 26 & 27, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W <sub>p</sub>	W	W <sub>L</sub>		
								SHEAR STRENGTH									
374.9	Top of Wingwall																
0.0	Concrete, sound well cemented (wingwall)		1	R.C. 1 1/2"	REC. 100%												
			2	R.C. 1 1/2"	REC. 100%												
			3	R.C. 1 1/2"	REC. 100%												
			4	R.C. 1 1/2"	REC. 100%												
			5	R.C. 1 1/2"	REC. 100%												
			6	R.C. 1 1/2"	REC. 95%												
357.7	Void																
17.4	Concrete, sound well cemented (Footing)		7	R.C. 1 1/2"	REC. 100%												
355.4																	
19.5	Bedrock, fractured white to dark green diorite gneiss		8	R.C. 1 1/2"	REC. 83%												
353.4																	
21.5	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 2

9

W P 86-81-01 LOCATION 20' West of East End of Southwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 26 & 27, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
370.8	Top of Wingwall																
0.0	Concrete, sound well cemented (Wingwall)		1	R.C. 1 1/2"	REC. 100%		370										
			2	R.C. 1 1/2"	REC. 100%												
			3	R.C. 1 1/2"	REC. 100%		365										
			4	R.C. 1 1/2"	REC. 100%		360										
357.9																	
13.0	Void		5	R.C. 1 1/2"	REC. 93%												
355.4	Concrete, sound well cemented (Footings) poorly cemented																
15.4	Glacial till, sandy silt grey		6	R.C. 1 1/2"	REC. 0%		355										
15.9	Bedrock, sound white to dark green diorite gneiss		7	R.C. 1 1/2"	REC. 100%												
			8	R.C. 1 1/2"	REC. 0%	ROD 61%											
349.9							350										
20.9	End of Borehole																

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

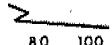

20  
15 0.5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 3

10

W P 86-81-01 LOCATION 15' East of West End of Southeast Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 28 & 29, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE								
372.9	Top of Wingwall															GR SA SI CL			
0.0	Concrete, sound well cemented  (Wingwall)	▲	1	R.C. 1 1/2"	REC. 100%		370												
		▲	2	R.C. 1 1/2"	REC. 100%														
		▲	3	R.C. 1 1/2"	REC. 100%		365												
		▲	4	R.C. 1 1/2"	REC. 100%														
		▲	5	R.C. 1 1/2"	REC. 100%		360												
		▲	6	R.C. 1 1/2"	REC. 100%														
	(Footing)	▲	7	R.C. 1 1/2"	REC. 100%														
355.9		▲	8	R.C. 1 1/2"	REC. 100% ROD 28%		355									Borehole pen- etrated near verti- cal bedrock joint			
17.0	Bedrock, fairly sound pink to dark grey granite gneiss	▲																	
352.6		▲																	
20.3	End of Borehole																		

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









20  
15  5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 4

11.

W P 86-81-01 LOCATION 15' East of West End of Northeast Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 28 & 29, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										SHEAR STRENGTH ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE		
372.5	Top of Wingwall																			
0.0	Concrete, sound well cemented  (Wingwall)		1	R.C. 1 1/2"	REC. 100%															
			2	R.C. 1 1/2"	REC. 100%															
			3	R.C. 1 1/2"	REC. 100%															
			4	R.C. 1 1/2"	REC. 100%															
	(Footing)		5	R.C. 1 1/2"	REC. 100%															
357.0																				
15.5	Sand, gravel and cobbles		6	R.C. 1 1/2"	REC. 67%															
355.7	(Modified glacial till)																			
16.8	Bedrock, fairly sound white to dark green diorite gneiss		7	R.C. 1 1/2"	REC. 92% RQD 49%															
352.6																				
19.9	End of Borehole																			

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



RECORD OF BOREHOLE No 5

12

W P 86-81-01 LOCATION 15' West of East End of Northwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 29 & 30, 1981 CHECKED BY CRM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
372.7	Top of Wingwall															
0.0	Concrete, sound well cemented  (Wingwall)		1	R.C. 1 1/2"	REC. 100%											
			2	R.C. 1 1/2"	REC. 100%											
			3	R.C. 1 1/2"	REC. 100%											
			4	R.C. 1 1/2"	REC. 100%											
	(Footings)		5	R.C. 1 1/2"	REC. 100%											
358.3	Glacial till, sandy silt Grey															
14.8	Bedrock, fairly sound white to dark green diorite gneiss		6	R.C. 1 1/2"	REC. 100% ROD 26%											
354.7																
18.0	End of Borehole															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 6

13

W P 86-81-01 LOCATION 2' North and 15' East of West End of Northwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 2" Diameter Samples COMPILED BY DN  
DATUM Geodetic DATE October 29 & 30, 1981 CHECKED BY CRM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
372.2	Ground Surface															
0.0	Fill, sandy silt trace gravel and clay Grey brown Very stiff		1	SS	2											2 32 53 13
368.7			2	SS	6											
3.5	Fill, sand some gravel trace silt Brown to Grey Compact Loose		3	SS	17											13 81 6
			4	SS	8											
			5	SS	3											
360.7			6	SS	7											
11.5	End of Borehole															

+3, x5 : Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



RECORD OF TEST PIT No 7

14

W P 86-81-01 LOCATION 8' West of East End of Southwest Wingwall Adjacent ORIGINATED BY DJS  
DIST 9 HWY 62 to South Side of Southwest Wingwall COMPILED BY DN  
DATUM Geodetic DATE October 29, 1981 CHECKED BY CRM

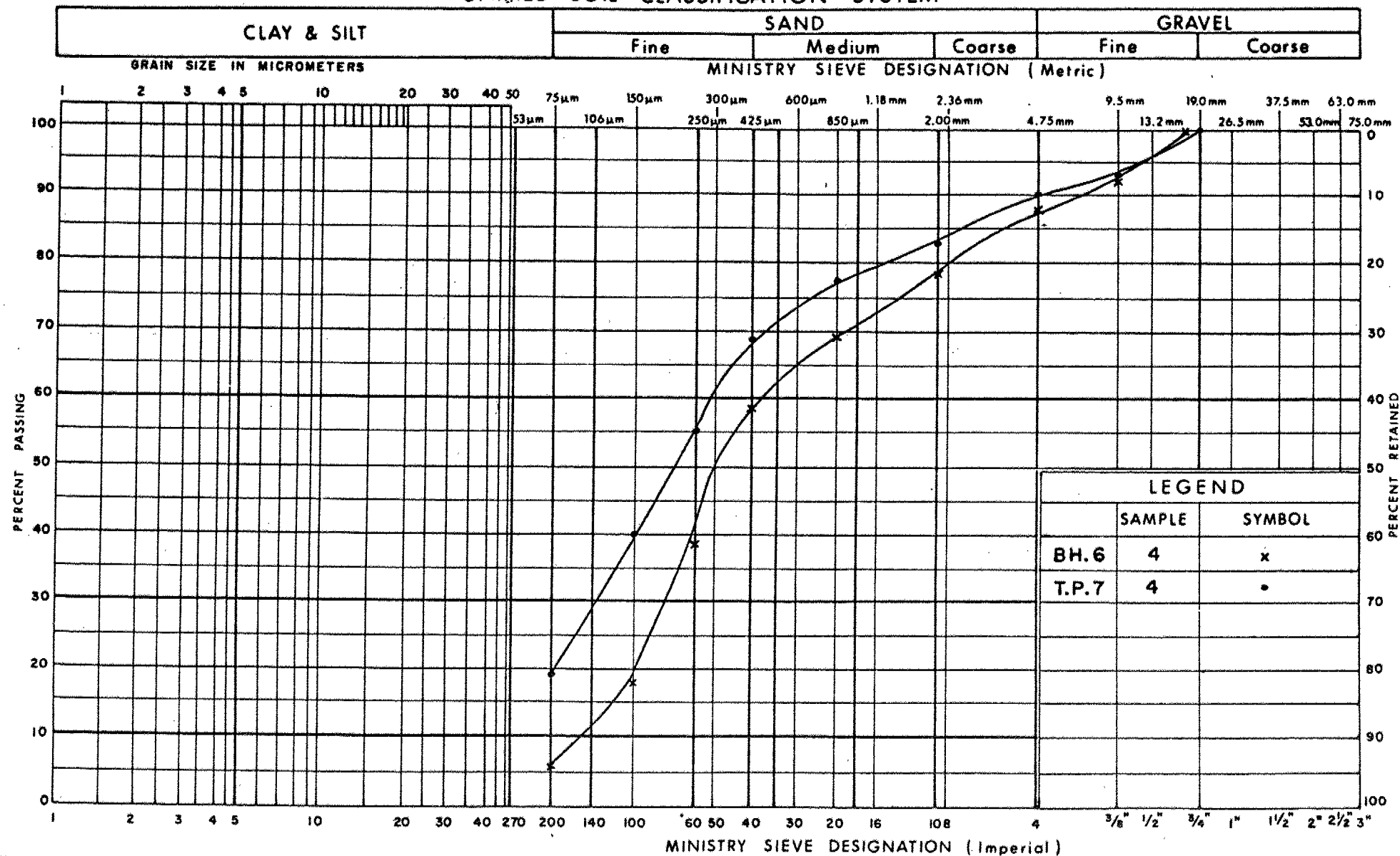
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
375.4	Ground Surface															GR SA SI CL
0.0	Fill, sand and gravel trace asphalt, sandy silt and silty clay lumps		1	CS		375										
370.9	Brown		2	CS		370										24 61 15
4.5	Fill, sandy silt some clay		3	CS												
367.4	Grey brown		4	CS												10 71 19
8.0	Fill, sand some gravel and silt															
9.0	Brown End of Test Pit															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



## UNIFIED SOIL CLASSIFICATION SYSTEM



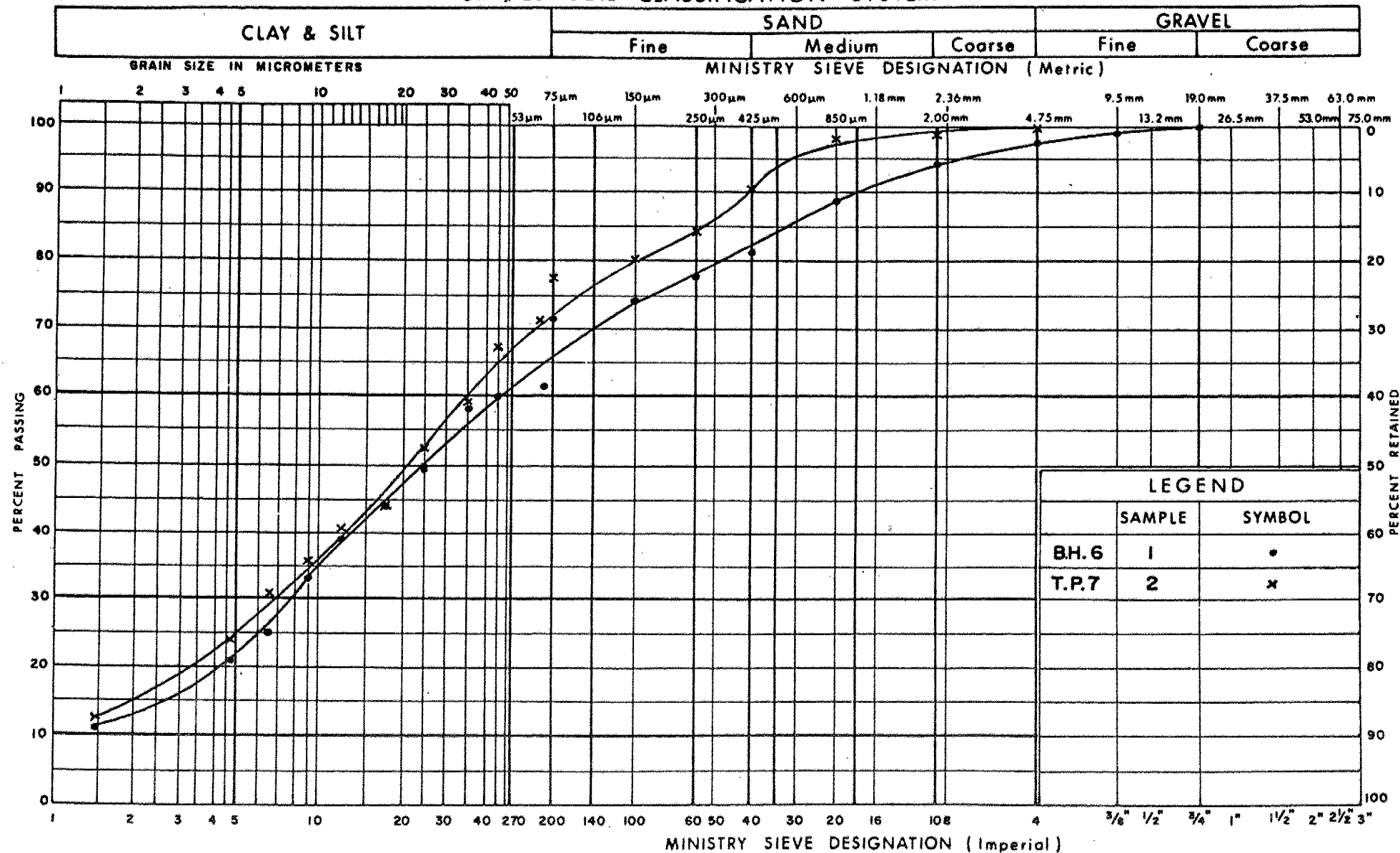
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FILL  
SAND SOME GRAVEL TRACE SILT

FIG No 1

W P 86-81-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FILL  
SANDY SILT TRACE GRAVEL & CLAY

FIG No 2

WP 86-81-01



## **Golder Associates**

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT TO  
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

### GEOTECHNICAL INVESTIGATION

WINGWALL DISTRESS

HAZLEY BAY BRIDGE

HIGHWAY 62

W.P. 86-81-01, SITE 29-39

PEMBROKE, ONTARIO

#### Distribution:

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*GOLDER NO 31F-102*

December, 1981

811-2332



## **Golder Associates**

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

December 2, 1981

Our Ref: 811-2332

The Ministry of Transportation  
and Communications  
355 Counter Street  
Postal Bag 4000  
Kingston, Ontario  
K7L 5A3

ATTENTION: Mr. W.G. Wigle  
Regional Director

RE: GEOTECHNICAL INVESTIGATION, WINGWALL DISTRESS,  
HAZLEY BAY BRIDGE, W.P. 86-81-01, SITE 29-39,  
HIGHWAY 62, DISTRICT 9, PEMBROKE, ONTARIO

Dear Sirs:

This report presents the results of a geotechnical investigation carried out at the site of the Hazley Bay bridge on Highway Number 62 at Pembroke, Ontario. The approximate location of the site is shown on the Key Plan, on the attached drawing number D-3586-1. The purpose of the investigation was to determine the conditions of the wingwall structures at the wingwall/footing/bearing surface interfaces as well as the nature of the backfill materials against the wingwalls and based on this information to determine the cause(s) of the distress of the wingwalls and to provide geotechnical engineering recommendations for rehabilitation or reconstruction of the wingwalls, including construction considerations which could influence these procedures.

### PROJECT DESCRIPTION

The Hazley Bay bridge is located on Highway Number 62 about 4 miles southeast of Pembroke, Ontario. The bridge provides

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part of the link between the provinces of Ontario and Quebec and carries traffic over a branch of the Ottawa River. It is understood that the bridge was built in 1956. Movement of the wingwalls was first reported in 1958 and by 1967 the southwest wingwall was observed to have moved outwards 4 to 5 inches and was tilted about 1 to 1½ inches. From 1975 to 1977 all four wingwalls were tied back by ½ inch diameter steel cables attached to deadmen installed in the roadway shoulder fill or by steel plates reacting against the abutments. Movement of the walls was arrested for several years following the above anchoring operation. However, in 1981 the southwest wingwall moved outward a further 4 inches apparently breaking the tie-back cables.

Available structural drawings indicate that each wingwall was designed as a free-standing structure separate from the abutments and resting on a variable width, common footing with each abutment. The walls were to be structurally tied to the footing with one row of reinforcing and the footings were to be keyed into the solid bedrock a minimum of 1 foot.

#### PROCEDURE

The field work for this investigation was carried out from October 26 to 30, 1981 at which time six boreholes numbered 1 to 6 and one test pit number 7 were put down at the site. Boreholes 1 to 5 were drilled vertically through the bridge wingwalls and borehole 6 was put down through the fill materials behind the northeast wingwall. The boreholes were advanced using electric powered wash boring and rock coring equipment supplied and operated by a specialist drilling contractor. The test pit was excavated using a rubber tire mounted backhoe supplied and operated by a local excavating contractor.

The boreholes were cored through the wingwall and footing concrete and underlying bedrock using a 1-3/4 inch diameter

core bit. At borehole 6 sampling of the overburden materials in conjunction with standard penetration testing was carried out using drive open split barrel sampling equipment. Chunk samples of the materials comprising the walls of the test pit were obtained during excavating. The field work was supervised throughout by a member of our engineering staff who directed the drilling operation, logged the boreholes and test pit and cared for the samples obtained.

A detailed log of each borehole and the test pit put down during this investigation is given on the Record of Borehole sheets and Record of Test Pit sheet following the text of this report. The location of the boreholes and test pit and sections showing the borehole stratigraphy at the wingwalls are shown on the attached drawing number D-3586-1.

All of the recovered samples were brought to our laboratory for detailed examination and representative classification testing. The locations and ground surface elevations of the boreholes and test pit were established in the field by Golder Associates. The ground surface elevations have been referred to a point on the southwest wingwall the elevation of which was indicated in the field as being 376.47 feet. It is assumed that this point is referred to geodetic datum.

#### SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in the boreholes and test pit are given on the Record of Borehole and Record of Test Pit sheets following the text of this report. Following is a summarized account of the subsurface conditions encountered at the site.

#### WINGWALLS AND FOOTINGS

Boreholes 1 to 5 put down vertically through the wingwalls encountered relatively sound, well cemented concrete throughout the full depth of the wingwalls and the underlying foot-

ings. At boreholes 1 and 2 put down through the southwest wingwall a 1.5 to 2.4 inch thick void was encountered between the underside of the wingwall and the footing. At boreholes 3, 4 and 5 put down in the southeast, northeast and northwest wingwalls, respectively, no void was encountered at the joins between the wingwalls and footings.

#### FOUNDING MATERIALS

Beneath the concrete footing at boreholes 2, 4 and 5, the boreholes encountered a 0.4 to 1.3 foot thick layer of overburden materials. At boreholes 2 and 5 the materials consisted of grey sandy silt till. At borehole 4 the material consisted of sand, gravel and cobbles, probably glacial till modified by river action. Due to the relative thinness of the till layer no standard penetration tests were carried out in this material. However, based on resistance to drilling it is considered that the glacial till materials are in a compact to dense state of packing.

Beneath the concrete footings at boreholes 1 and 3 and the glacial till materials at boreholes 2, 4 and 5, the boreholes encountered bedrock. The recovered bedrock cores consisted of sound to fractured, white to dark green diorite gneiss and white and pink granitic gneiss. The measured rock core recoveries typically varied from 83 to 100 percent and the measured R.Q.D. values ranged from 0 to 61 percent.

#### WINGWALL BACKFILL MATERIALS

Borehole 6 and test pit 7 were put down behind the northeast and southwest wingwalls, respectively, in order to determine the nature of the wingwall backfill materials.

At borehole 6 the wingwall backfill materials consisted of about a 3.5 foot thickness of very stiff grey-brown sandy silt from the surface overlying brown sand which was encountered to a depth of about 11.5 feet, the upper surface of

the footing. At test pit 7 a 4.5 foot thick layer of sand fill materials were encountered from the surface overlying about a 3.5 foot thick layer of sandy silt. Beneath the sandy silt layer the sand fill materials were encountered to a depth of about 9 feet, the full depth of exploration. Standard penetration 'N' values measured in the sand fill materials ranged from 3 to 17 blows per foot and indicate that the sand fill is in a very loose to compact state of packing. The results of grain size distribution analysis carried out on representative samples of the sand and sandy silt fill materials are shown on Figures 1 and 2, respectively. These results indicate that the sandy silt materials are very susceptible to frost heave action and that the sand fill materials may be slightly susceptible to frost action.

#### GROUNDWATER CONDITIONS

Following the completion of drilling water levels were measured in the open boreholes. At this time the water levels in the boreholes varied from about elevation 366.4 to 366.6 feet. The level of the Ottawa River was measured at the time of this investigation and was found to be at about elevation 366.6 feet. Test pit 7 was dry to a depth of about 9 feet at the completion of excavating.

#### DISCUSSION AND RECOMMENDATIONS

##### Southwest Wingwall

As mentioned above at both of the borehole locations in the southwest wingwall a 1.5 to 2.4 inch thick void was encountered between the underside of the wingwall and the concrete footing. The backfill materials encountered in the test pit put down behind the wingwall consisted of sand and sandy silt fill materials considered to be slightly to very susceptible to frost heave action. Based on the above, it is considered that the southwest wingwall has separated structurally from the footing and that the wall alone and not the footing has



tilted and moved outward from the backfill. As the backfill materials are frost susceptible it is likely that pressure from ice lense formation in the backfill materials is a major cause of the observed wall movement.

As substantial movement of the southwest wingwall has taken place and the results of this investigation indicate structural damage has occurred to the wingwall, it is recommended that the southwest wingwall be completely reconstructed. It is recommended that the replacement structure be founded on the sound to fairly sound bedrock. Footings for the wingwall founded on the sound to fairly sound bedrock may be designed using a maximum allowable bearing pressure of 20,000 pounds per square foot.

The reconstructed wingwall should be backfilled with non-frost susceptible free-draining granular materials which meet the Ministry of Transportation and Communications (M.T.C.) Granular 'C' grading specifications. The granular backfill materials should extend lateral a minimum of 5 feet behind the wingwall and should be moderately compacted to 90 percent of the standard Proctor maximum dry density using light compaction equipment. A drainage system should be provided to effectively drain the backfill materials in order to prevent the buildup of hydrostatic and ice formation pressures behind the wingwall.

The lateral earth pressures against the wingwall, backfilled with effectively drained granular material as described above, should be determined using a triangular distribution of earth pressures and calculated using the following equation:

$$p = K_a \gamma H$$

$p$  = lateral earth pressure

$K_a$  = coefficient of active earth pressure,  
use  $K_a = 0.35$

$\gamma$  = total unit weight of supported soil, assume  
130 pounds per cubic foot

$H$  = average depth of backfill from the ground  
surface to the footing level.

The construction of the wingwall could be carried out within a cofferdam consisting of sand bags or, if space exists, local glacial till materials. In order to prevent undermining of the existing roadway during the reconstruction of the southwest wingwall, braced shoring will be required on the roadway side of the excavation where space restrictions will prevent the use of excavation walls sloped at 1 horizontal to 1 vertical. The temporary shoring could consist of a soldier pile and lagging wall with the soldier piles driven to the surface of the bedrock and supported laterally by a system of wales and inclined rakers. The rakers could be founded against footings keyed into the bedrock. For rakers founded in the sound bedrock and inclined up to 45 degrees from vertical a maximum allowable bearing pressure of 5,000 pounds per square foot may be used for design of the raker footings. To prevent lateral movement of the toe of the soldier piles, the soldier piles should be keyed into the bedrock or, alternatively, the toe of the soldier piles should be secured by pins grouted into the bedrock.

It is recommended that the lateral earth pressures against the temporary soldier pile and lagging support walls be determined for a rectangular earth pressure distribution and calculated using the following equation:

$$p = K\gamma H$$

where  $p$  = lateral earth pressure

$H$  = depth below ground surface to the bottom of the excavation

$\gamma$  = total unit weight of supported soil, assume 130 pounds per cubic foot

$K$  = factored lateral earth pressure coefficient for a braced excavation,  
 $K = 0.25$

Should the reconstruction be carried out during freezing temperatures, freezing and subsequent ice lense formation in the soil behind the temporary support walls could place additional stress on the rakers and possibly cause overloading

of the support system. Accordingly, the soils behind the support walls should be protected from freezing temperature by methods such as a combination of heaters and tarpaulins.

It is considered that should the southwest wingwall fail completely and overturn a portion of the westbound lane of the roadway near the west abutment would be in danger of being undermined. Accordingly, it is recommended that a weekly survey of the condition of the wingwall be carried out until the temporary shoring for the reconstruction is installed.

#### Southeast, Northeast and Northwest Wingwalls

Outward movement of the southeast, northeast and northwest wingwalls has been measured since their construction although the magnitude of this movement has been minor in comparison to the movement of the southwest wingwall. The boreholes put down through these wingwalls encountered no evidence of structural damage at the wingwall/footing interface. However, the borehole put down within the backfill materials at the northeast wingwall encountered a layer of frost susceptible sandy silt.

As frost susceptible materials were encountered within the wingwall backfill at both of the locations investigated, it is considered likely that there exists the potential for all of the wingwalls to experience lateral pressure due to frost heave action. It is thus recommended that the existing backfill materials against the wingwalls be removed to a depth corresponding to the river water level and be replaced by free draining non-frost susceptible material meeting M.T.C. Granular 'C' grading specifications. The granular backfill materials should be placed in thin lifts and compacted to 90 percent of the standard Proctor maximum dry density using light compaction equipment. This work could be carried out as part of the contract given for the recommended reconstruction of the

southwest wingwall and could be paid on a unit cost basis for excavation, backfilling and compaction.

Prior to carrying out the replacement backfilling operation, it is recommended that it be verified that the existing walls can withstand the expected lateral earth pressures of the backfill materials. The lateral earth pressures against the wingwalls should be determined as outlined above for the design of the reconstructed southwest wingwall. Should calculations indicate that the existing wingwalls can not withstand the expected lateral earth pressures, rockfill could be placed in front of the wingwalls and abutments to provide some passive pressure to help offset the lateral backfill pressures. If the rockfill is necessary and allowable from a hydrological point of view the passive lateral pressure of the rockfill can be determined using a coefficient of lateral earth pressure,  $K_p$ , of 3.3 and a submerged unit weight of the rockfill material of 60 pounds per cubic foot.

We trust this report contains sufficient information for your present purposes. Should you have any questions concerning this report or if we may be of further service to you, please do not hesitate to contact our office.

Yours very truly,

GOLDER ASSOCIATES

*C.R. Morey*  
C.R. Morey, P.Eng.

*R.A. Montgomery*  
R.A. Montgomery, P.Eng.

CRM:RAM:rb

Att. Abbreviations & Symbols  
Record of Borehole Sheets  
Record of Test Pit Sheet



Drawing No. D-3586-1  
Figures 1 and 2

# EXPLANATION OF TERMS USED IN REPORT

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

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

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

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

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

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

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

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

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

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS & SYMBOLS




### LABORATORY TESTING

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

### FIELD SAMPLING

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

### EARTH PRESSURE TERMS

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

### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $L_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_p - w_L}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_p - w_L}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

### STRENGTH PARAMETERS

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

### HYDRAULIC TERMS

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

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



# RECORD OF BOREHOLE No 1

W P 86-81-01 LOCATION 10' West of East End of Southwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 26 & 27, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100					
374.9	Top of Wingwall																
0.0	Concrete, sound well cemented (Wingwall)		1	R.C. 1 1/2"	REC. 100%												
			2	R.C. 1 1/2"	REC. 100%		370										
			3	R.C. 1 1/2"	REC. 100%												
			4	R.C. 1 1/2"	REC. 100%		365										
			5	R.C. 1 1/2"	REC. 100%												
			6	R.C. 1 1/2"	REC. 95%		360										
357.7																	
17.4	Void		7	R.C. 1 1/2"	REC. 100%												
355.4	Concrete, sound well cemented (Footing)																
19.5	Bedrock, fractured white to dark green diorite gneiss		8	R.C. 1 1/2"	REC. 83%		355										
353.4																	
21.5	End of Borehole																



RECORD OF BOREHOLE No 2

W P 86-81-01 LOCATION 20' West of East End of Southwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 26 & 27, 1981 CHECKED BY CRM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
370.8	Top of Wingwall															
0.0	Concrete, sound well cemented (Wingwall)		1	R.C. 1 1/2"	REC. 100%											
			2	R.C. 1 1/2"	REC. 100%											
			3	R.C. 1 1/2"	REC. 100%											
			4	R.C. 1 1/2"	REC. 100%											
357.9																
13.0	Void		5	R.C. 1 1/2"	REC. 93%											
355.4	Concrete, sound well cemented (Footings) poorly cemented		6	R.C. 1 1/2"	REC. 0%											
15.4	Glacial till, sandy silt grey		7	R.C. 1 1/2"	REC. 100%											
15.9	Bedrock, sound white to dark green diorite gneiss		8	R.C. 1 1/2"	REC. 0%											
349.9																
20.9	End of Borehole															



# RECORD OF BOREHOLE No 3

W P 86-81-01 LOCATION 15' East of West End of Southeast Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 28 & 29, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH									
								○ UNCONFINED	+ FIELD VANE								
						● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)									
372.9	Top of Wingwall		1	R.C.	REC. 1 1/2" 100%		370										
0.0	Concrete, sound well cemented  (Wingwall)		2	R.C.	REC. 1 1/2" 100%												
			3	R.C.	REC. 1 1/2" 100%												
			4	R.C.	REC. 1 1/2" 100%												
			5	R.C.	REC. 1 1/2" 100%												
			6	R.C.	REC. 1 1/2" 100%												
	(Footing)		7	R.C.	REC. 1 1/2" 100%												
355.9	Bedrock, fairly sound pink to dark grey granite gneiss		8	R.C.	REC. 1 1/2" 100% ROD 28%		355									Borehole pen- etrated near verti- cal bedrock joint	
352.6																	
20.3	End of Borehole																





RECORD OF BOREHOLE No 4

W P 86-B1-01 LOCATION 15' East of West End of Northeast Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 28 & 29, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT $\Sigma$					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
372.5	Top of Wingwall																
0.0	Concrete, sound well cemented (Wingwall)	▲	1	R.C. 1 1/2"	REC. 100%		370										
		▲	2	R.C. 1 1/2"	REC. 100%												
		▲	3	R.C. 1 1/2"	REC. 100%		365										
		▲	4	R.C. 1 1/2"	REC. 100%												
	(Footing)	▲	5	R.C. 1 1/2"	REC. 100%		360										
357.0		▲															
15.5 355.7	Sand, gravel and cobbles (Modified glacial till)	○	6	R.C. 1 1/2"	REC. 67%												
16.8	Bedrock, fairly sound white to dark green diorite gneiss	■	7	R.C. 1 1/2"	REC. 92% RQD 49%		355										
352.6																	
19.9	End of Borehole																

RECORD OF BOREHOLE No 5

W P 86-81-01 LOCATION 15' West of East End of Northwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 1 1/2" Diameter Core COMPILED BY DN  
DATUM Geodetic DATE October 29 & 30, 1981 CHECKED BY CRM


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
372.7	Top of Wingwall																
0.0	Concrete, sound well cemented (Wingwall)		1	R.C. 1 1/2"	REC. 100%		370										
			2	R.C. 1 1/2"	REC. 100%												
			3	R.C. 1 1/2"	REC. 100%		365										
			4	R.C. 1 1/2"	REC. 100%												
	(Footing)		5	R.C. 1 1/2"	REC. 100%		360										
358.3	Glacial till, sandy silt Grey																
14.8	Bedrock, fairly sound white to dark green diorite gneiss		6	R.C. 1 1/2"	REC. 100% RQD 26%		355										
354.7																	
18.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 6

W P 86-81-01 LOCATION 2' North and 15' East of West End of Northwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Uncased, 2" Diameter Samples COMPILED BY DN  
DATUM Geodetic DATE October 29 & 30, 1981 CHECKED BY CRM

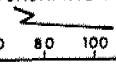







SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
372.2	Ground Surface																
0.0	Fill, sandy silt trace gravel and clay		1	SS	2		370										2 32 53 13
368.7	Grey brown Very stiff		2	SS	6												
3.5	Fill, sand some gravel trace silt		3	SS	17												
	Compact		4	SS	8		365										13 81 6
	Brown to Grey		5	SS	3												
360.7			6	SS	7												
11.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF TEST PIT No 7

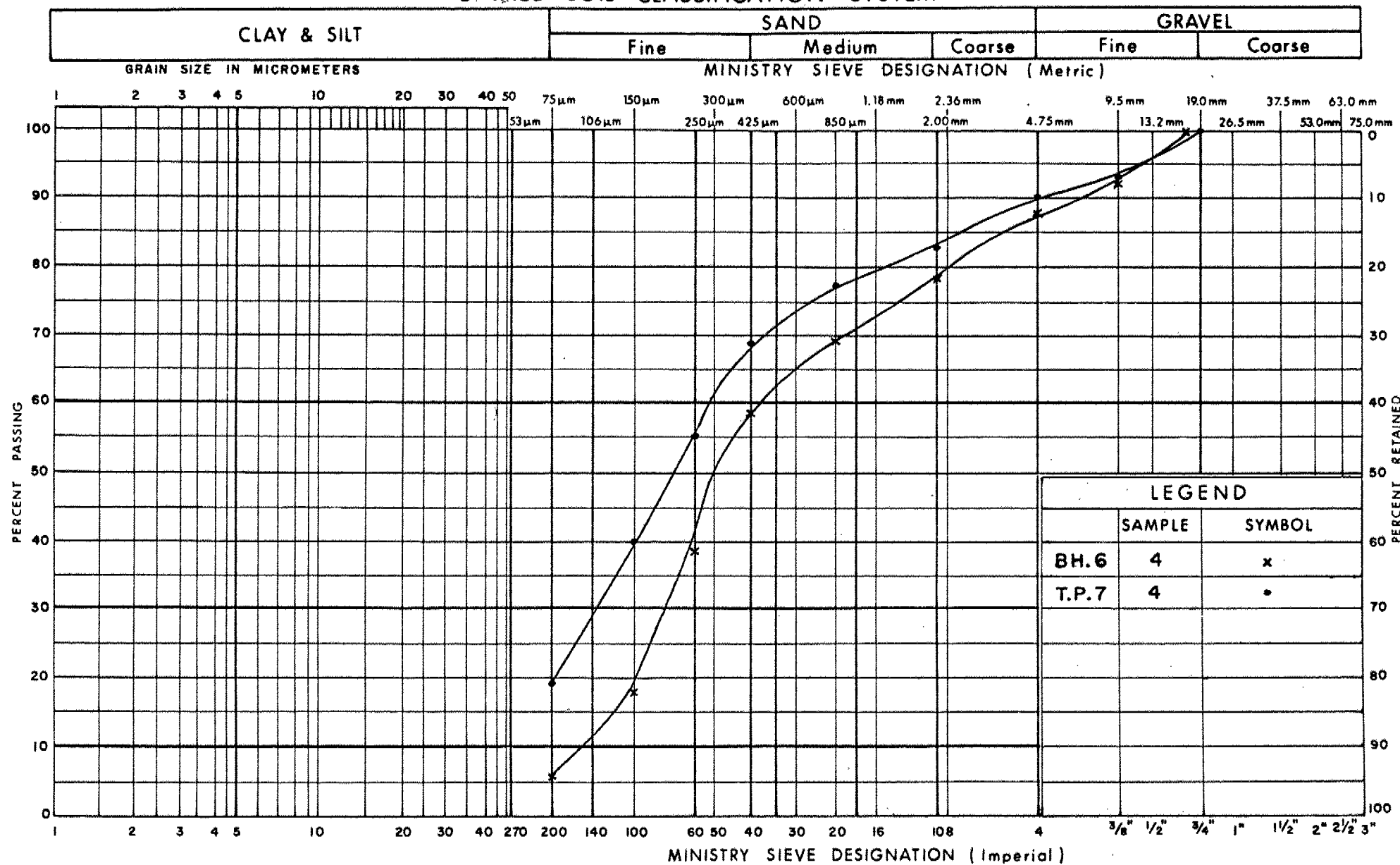
W P 86-81-01 LOCATION 8' West of East End of Southwest Wingwall Adjacent to South Side of Southwest Wingwall ORIGINATED BY DJS  
DIST 9 HWY 62 BOREHOLE TYPE Test Pit Excavated by Rubber Tire Mounted Backhoe COMPILED BY DN  
DATUM Geodetic DATE October 29, 1981 CHECKED BY CRM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
375.4	Ground Surface						375										
0.0	Fill, sand and gravel trace asphalt, sandy silt and silty clay lumps		1	CS													
370.9	Brown		2	CS			370										24 61 15
4.5	Fill, sandy silt some clay		3	CS													
367.4	Grey brown		4	CS													10 71 19
8.0	Fill, sand some gravel and silt																
9.0	Brown																
	End of Test Pit																

OFFICE REPORT ON SOIL EXPLORATION

# OVERSIZE DRAWING

## UNIFIED SOIL CLASSIFICATION SYSTEM



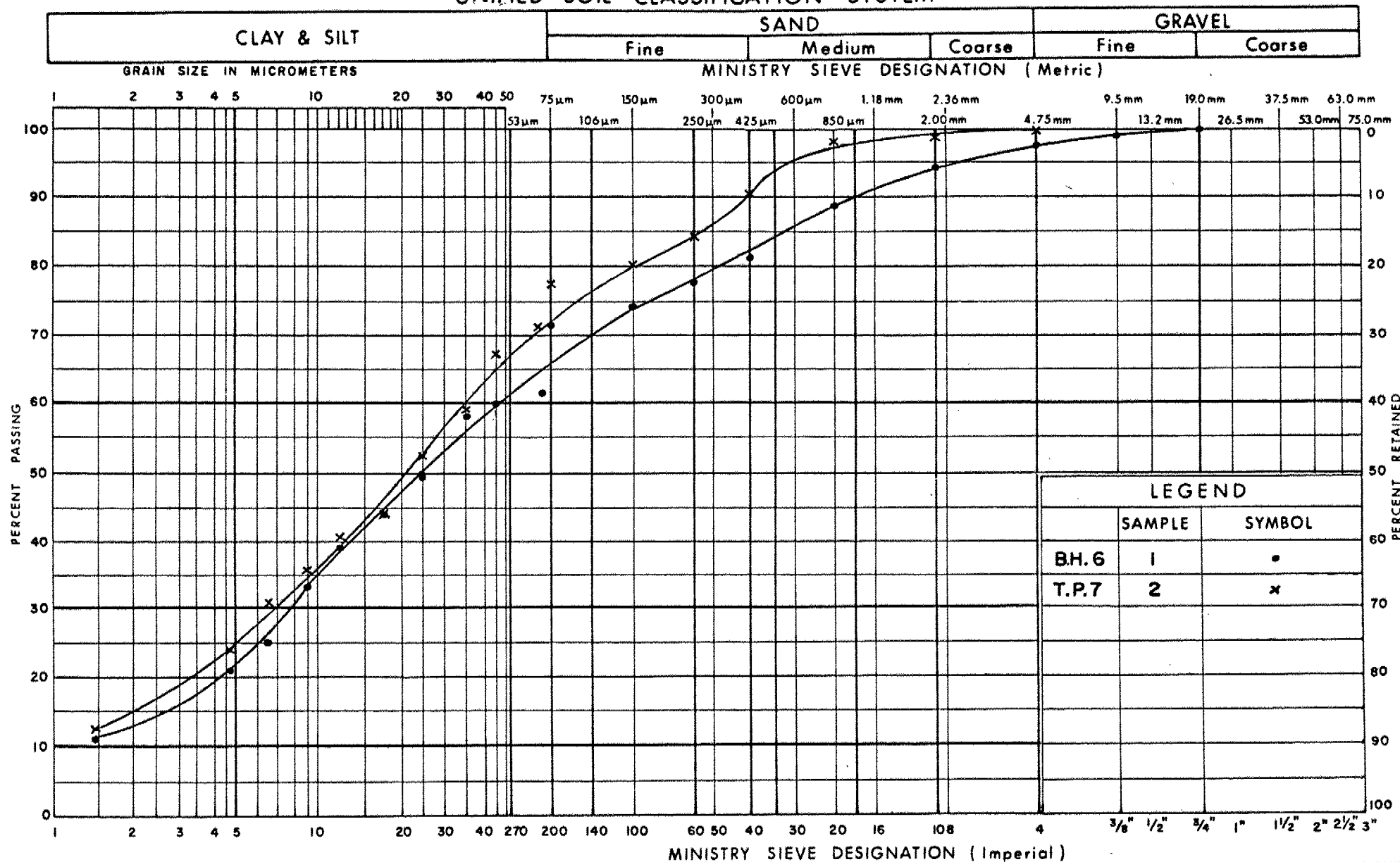
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FILL  
SAND SOME GRAVEL TRACE SILT

FIG No 1

W P 86-81-01

## UNIFIED SOIL CLASSIFICATION SYSTEM

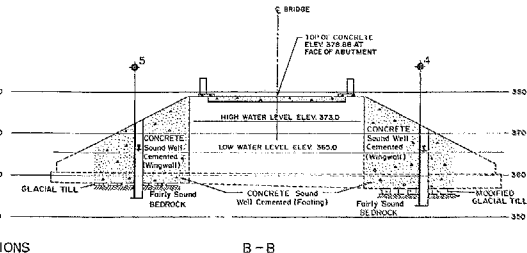
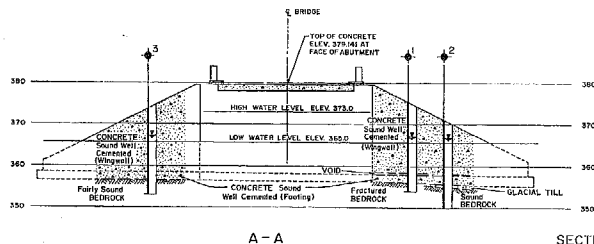
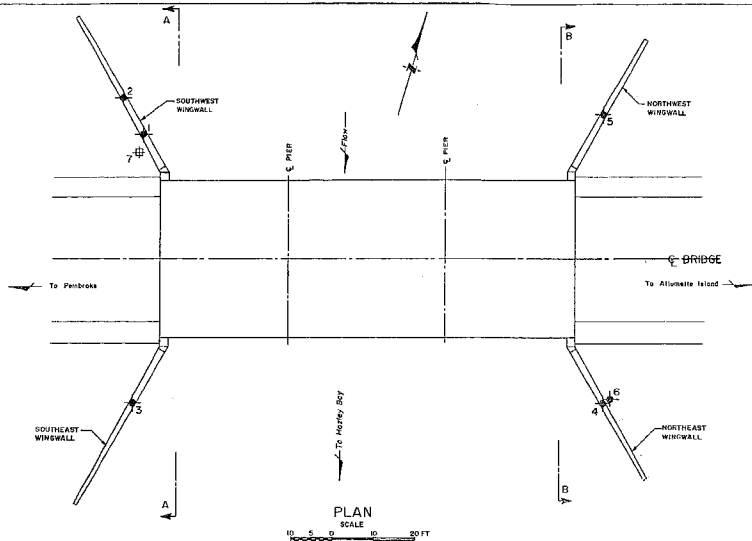


Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FILL  
SANDY SILT TRACE GRAVEL & CLAY

FIG No 2

W P 86-81-01

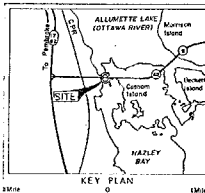


CONT No  
WP No 86-81-01

HAZLEY BAY BRIDGE  
(May 02 OR Mass East of Hwy 17)  
BOTH HOLE LOCATIONS & SOIL STRATA

SHEET

GOLDER ASSOCIATES



# LEGEND

- Core Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Core
- Bore Hole 150 ft. Test 350 ft. (no sample)
- CONE Borehole 100" Core, 350 ft. (no sample)
- WA at time of investigation
- ⊕ Test Pit

No.	ELEVATION	
1	374.9	
2	370.6	
3	372.9	
4	372.5	
5	372.7	
6	372.2	
7	370.4	

# NOTE

The following information is provided for your information only. It is not to be used for any other purpose. The information is provided for your information only.

DATE	BY	REVISION

DATE: 02 MAY 02  
BY: GOLDER ASSOCIATES  
REVISION: 01  
DATE: 02 MAY 02  
BY: GOLDER ASSOCIATES  
REVISION: 01