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W.P. No. 65-78-02

CONT. No. 84-206

W. O. No.

STR. SITE No. 39W-3

HWY. No. 11

LOCATION Cochrane Fraser River

No OF PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 84 - 206

Ontario
Ministry of
Transportation and
Communications

INDEX

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

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

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

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

EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES

(EXCLUDING PARTICLES LARGER THAN 75 mm AND BASING FRACTIONS ON ESTIMATED MASS)

				GRP SYMB	TYPICAL NAMES
COARSE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS LARGER THAN 75 μm)	GRAVELS (MORE THAN HALF OF COARSE FRACTION IS LARGER THAN 4.75 mm)	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVEL WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS (MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN 4.75 mm)	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			PLASTIC-FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS SMALLER THAN 75 μm. 75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μm				
	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 35%	DRY STRENGTH (CRUSHING CHARACTERISTICS): NONE	DILATANCY (REACTION TO SHAKING): QUICK	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT): NONE	ML	INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR
			MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL	CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS
			SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS
		LIQUID LIMIT BETWEEN 35% AND 50%	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MH	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS
			HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY
			SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
		LIQUID LIMIT GREATER THAN 50%	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY SILTS, ELASTIC SILTS
			HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
			MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY
HIGHLY ORGANIC SOILS			READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE			Pt	PEAT & OTHER HIGHLY ORGANIC SOILS

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS. FOR EXAMPLE GW-GC, WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

INFORMATION REQUIRED FOR DESCRIBING SOILS

GIVE TYPE; NAME, IF NECESSARY, INDICATE APPROX. % OF SAND & GRAVEL; MAX. SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESS OF THE COARSE GRAINS; LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION; & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS.

GIVE TYPE; NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS ADD INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS

USE GRAIN SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION

LABORATORY CLASSIFICATION CRITERIA

DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 μm). COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

LESS THAN 5%	GW, GP, SW, SP
MORE THAN 12%	GM, GC, SM, SC
5% TO 12%	BORDERLINE CASES REQ. USE OF DUAL SYMBOLS

$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4

$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

NOT MEETING ALL GRADATION REQUIREMENTS FOR GW

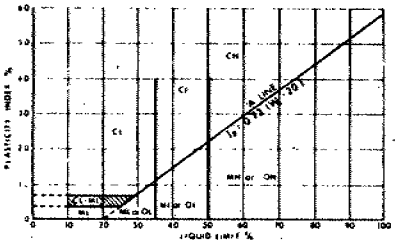
ATTERBERG LIMITS BELOW A-LINE, OR I_p LESS THAN 4	ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
ATTERBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7	

$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6

$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

NOT MEETING ALL GRADATION REQUIREMENTS FOR SW

ATTERBERG LIMITS BELOW A-LINE OR I_p LESS THAN 4	ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
ATTERBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7	



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

FOUNDATION INVESTIGATION REPORT
for
W.P. 65-78-02 Structure Site 39W-3
Frazer River Bridge, Hwy. 11
District 16 (Cochrane), Northern Region

INTRODUCTION

Warnock Hersey Professional Services Limited have been retained by the Ontario Ministry of Transportation and Communications, under Agreement No. 4242-9081-18, to provide geotechnical services in connection with the above project. The terms of reference were to carry out an investigation of sufficient scope to provide recommendations for either repair and restoration of the existing structure or for its replacement by a new structure.

SITE CONDITIONS

The topography is flat. Frazer River is a meandering stream, some 20 metres in width and is bordered by marshy flood plains. The physiography of the area is typical of a till peneplain.

Highway 11 has a tangent alignment within a 91 metre right-of-way. The grades are minimal. The bridge is aligned more or less perpendicular to the main channel of the river. The river flow is towards the north.

FIELD AND LABORATORY WORK

Subsurface conditions were investigated by means of four boreholes, two of which were accompanied by dynamic cone penetration tests. The locations and elevations of the boreholes are shown on Drawing No. 2 of the Contract Documents. The boreholes were drilled with a bombardier mounted 89 mm I.D. hollow stem auger machine (MTC type 5.3.i).

FIELD AND LABORATORY WORK (Cont'd

Soil Samples were obtained at regular intervals of depth in each borehole. Standard penetration resistance N values were noted. The samples were re-examined in the laboratory for classification and confirmatory testing. Results of laboratory and field tests are given on the accompanying Records of Boreholes 1 to 4 and Figures 1 and 2 in the Appendix.

SUBSURFACE CONDITIONS

General

The subsoil conditions are generally uniform across the site. The highway fill is underlain by a thin silt or sand deposit, overlying the predominant stratum which is a slightly cohesive silt glacial till. Elsewhere, the surficial soil consists of organic silt, peat and other organically contaminated granular soils.

FILL MATERIAL

The highway approach fill is about 2-3 m high and consists of fairly clean well graded sand and gravel, in a compact state (See Figure 1). The surface is covered with recycled asphalt pavement fragments from a recent resurfacing project (Contract 80-214). At the toes of the fill, some loose or soft to firm organically contaminated sands and silts are present.

Where the fill spills through the terminal bents of the structure, it is covered with rounded boulders, up to 0.5 m in size, serving as rip rap.

ORGANIC SOILS

The flood plain consists of surficial organic silts and peats. Both soil types are present near the structure site and are partly trapped beneath the approach fills, especially at the toe line of the embankment. N values ranged from 2 to 8 blows per 0.3 m indicating a loose density or soft to firm consistency. Moisture contents are in the 30 to 50 percent range.

SILT AND SAND

Sandwiched between the surficial organic soils and the glacial till deposit, there is a 2 to 3 meter thick alluvial deposit of fine to coarse sand which grades into a silt at the east approach. These non-cohesive, alluvial flood plain, soils are in a compact state with N values ranging from 9 blows to 20 blows per 0.3 m.

SILT (GLACIAL TILL)

The chief geological deposit at the site is a silt with some sand, traces of clay and gravel and occasional cobble and boulder sizes (glacial till). Its surface occurs between elevations 243.0 and 244.3 across the bridge site.

This deposit is slightly cohesive (CL-ML). Although no boulders were encountered in this deposit during drilling, field evidence points to the probability of cobbles and boulders being present at random. One such evidence was the nature of a recent earth spoil bank from a ditch excavation on the southern right-of-way of the highway. Several cobble and some boulder sized stones were noted in the spoil material.

Below about elevation 242, this deposit is in a very dense state throughout or, where cohesive, exhibits a hard consistency, with N values in excess of 90 blows/0.3 m. The nature moisture content is less than 15 percent, typical of glacial tills. A grain size distribution curve is shown in Figure 2. The silt content is close to 60 percent. Therefore, the soil is extremely susceptible to frost action. Due to its low plasticity, the soil is also considered fairly susceptible to erosion.

GROUNDWATER CONDITIONS

The river level at the time of this investigation was at elevation 245.3, close to the normal high water mark for this stream. The water level in the boreholes corresponded to this elevation. Due to the presence of the alluvial silts and sands, it is presumed that prevailing stream levels influence and control the ground water regime at this site.

GROUNDWATER CONDITIONS (Cont'd)

Frazer River streamflow was measured at a velocity of 0.6 m/second and an estimated discharge rate of 15 m^3/second. The water ran clear, indicating very little sediment load and a stabilized stream bed and bank domain upstream of the bridge. The river channel at the bridge location is flat-bottomed. Soundings every 2 metres across the channel width did not reveal any incised subchannels within the river bed. The river bed is partly covered with cobbles and occasional boulders.

NOTE: This report is a part of a report prepared for the Ministry by Warnock Hersey Professional Services Ltd. dated June, 1981. The original report was signed by C. Mirza, P. Eng.

APPENDIX

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

RECORD OF BOREHOLE No 1

METRIC 9

W P 65-78-02 LOCATION STA 97+281.5 %s 4.4 m Rt of ℄ Hwy 11 ORIGINATED BY B D

DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY J T

DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.9	Paved Shoulder										
0.0	75mm Asphalt										
	FILL MATERIAL Sand with Gravel and some Silt, trace of Clay Compact, Yellow-Brown		1	SS	11		248				
			2	SS	11				o		16 70 (14)
246.2			3	SS	12		246		o		
2.7	SILT, trace of Clay and Fine Sand, Loose to Compact Yellow-Grey		4	SS	9	▼			o		
244.3			5	SS	17				o		
4.6	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey		6	SS	14		244		o		
	Very Dense or Hard Occasional Cobbles and Boulders at random		7	SS	48		242				
			8	SS	92						
239.6			9	SS	65/150mm		240		NP		
9.3	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 2

METRIC 10

W P 65-78-02 LOCATION STA 97+300.3 9/s 11.0 m Lt of ℄ Hwy 11 ORIGINATED BY B D

DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY J T

DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.0	Ground Surface										
0.0 / 244.8	FILL MATERIAL Sand and Gravel mixed with Organics Very Loose		1	SS	2	▼					
244.3	ORG. SILT, trace Sand Loose										
1.7 / 243.0	SAND, Fine - Medium trace of Organics, Grey Loose to Compact		2	SS	7		244				
			3	SS	20						
3.0	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occasional Cobbles and Boulders at random		4	SS	28						
			5	SS	97		242				
			6	SS	100/150 mm						
239.7			7	SS	100/150 mm		240				
6.3	End of Borehole										

+3, x5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No. 3

METRIC 11

W P 65-78-02 LOCATION STA 97+321.2 % 11.9m Rt of ℄ Hwy 11 ORIGINATED BY B D
DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY J T
DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
245.9	Ground Surface										
0.0	ORGANIC SILT, seams of Silty Clay, trace of Sand Loose or Firm		1	SS	7	▼					
243.8			2	SS	5		244				
2.1	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occasional Cobbles and Boulders at random		3	SS	31						
			4	SS	39		242				
			5	SS	92						6 28 57 9
			6	SS	100/75 mm		240				
	SANDY GRAVEL Very Dense		7	SS	100/150 mm		238				
236.6			8	SS	100/120 mm						
9.3	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 4

METRIC 12

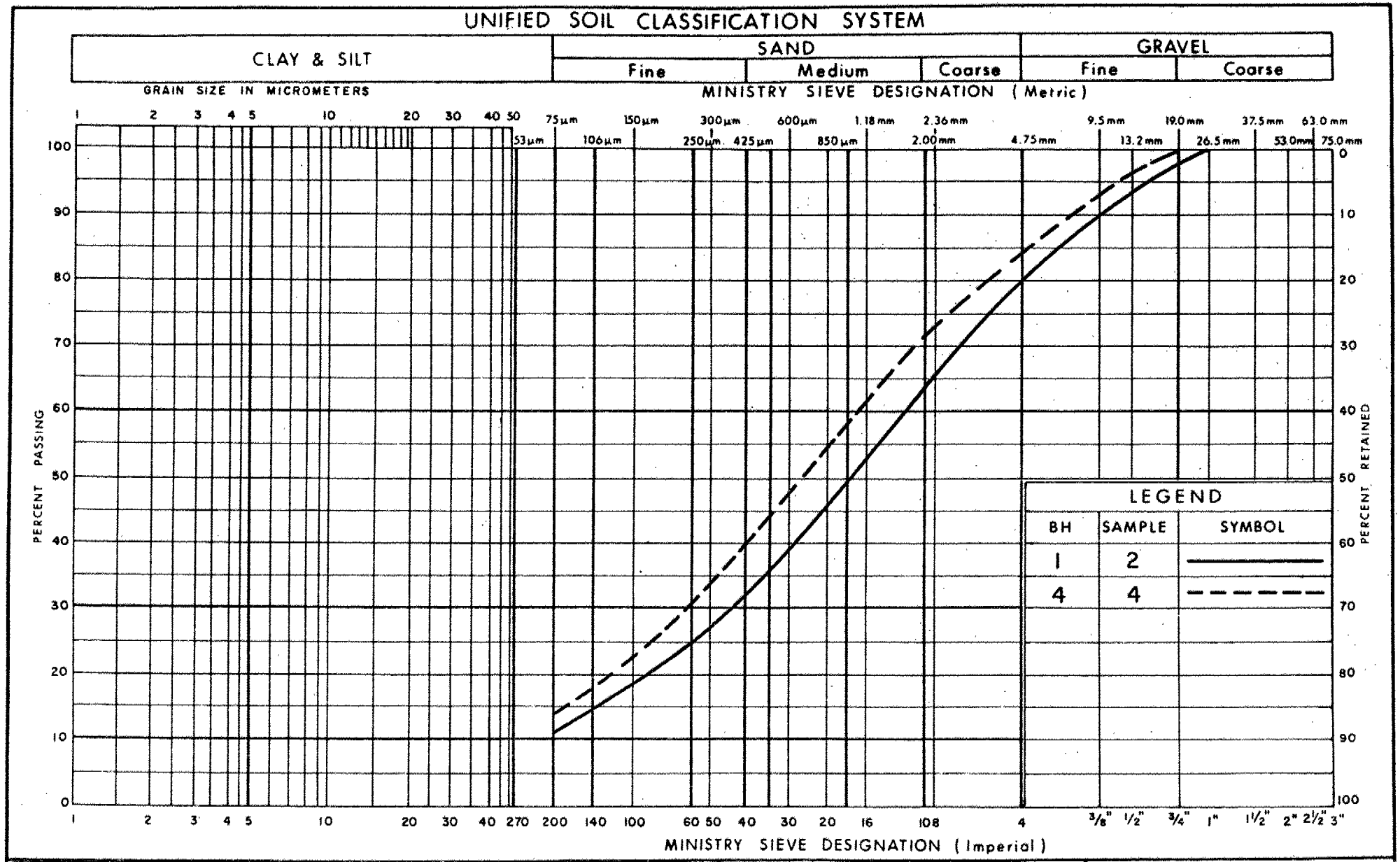
W P 65-78-02 LOCATION STA 97+337.9 9/s 4.6m Lt of ℄ Hwy 11 ORIGINATED BY B D
DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY J T
DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.0	Paved Shoulder										
0.0	75mm Asphalt										
	FILL MATERIAL Sand and Gravel, trace of Silt, Compact		1	SS	16		248				
			2	SS	19						
	Contaminated with Organic Silt		3	SS	10						
245.7	Yellow - Grey		4	SS	22	▼	246		o		21 68 (11)
3.3	SAND, Medium - Coarse with trace Clay and Gravel Occ. Organic Silt pockets Compact Grey		5	SS	19						
			6	SS	16		244				
243.0									o		
6.0	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occ. Cobbles and Boulders		7	SS	42		242	100/150 mm			
241.1			8	SS	92				o		
7.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION



Warnock Hersey
Professional Services
Limited

GRAIN SIZE DISTRIBUTION

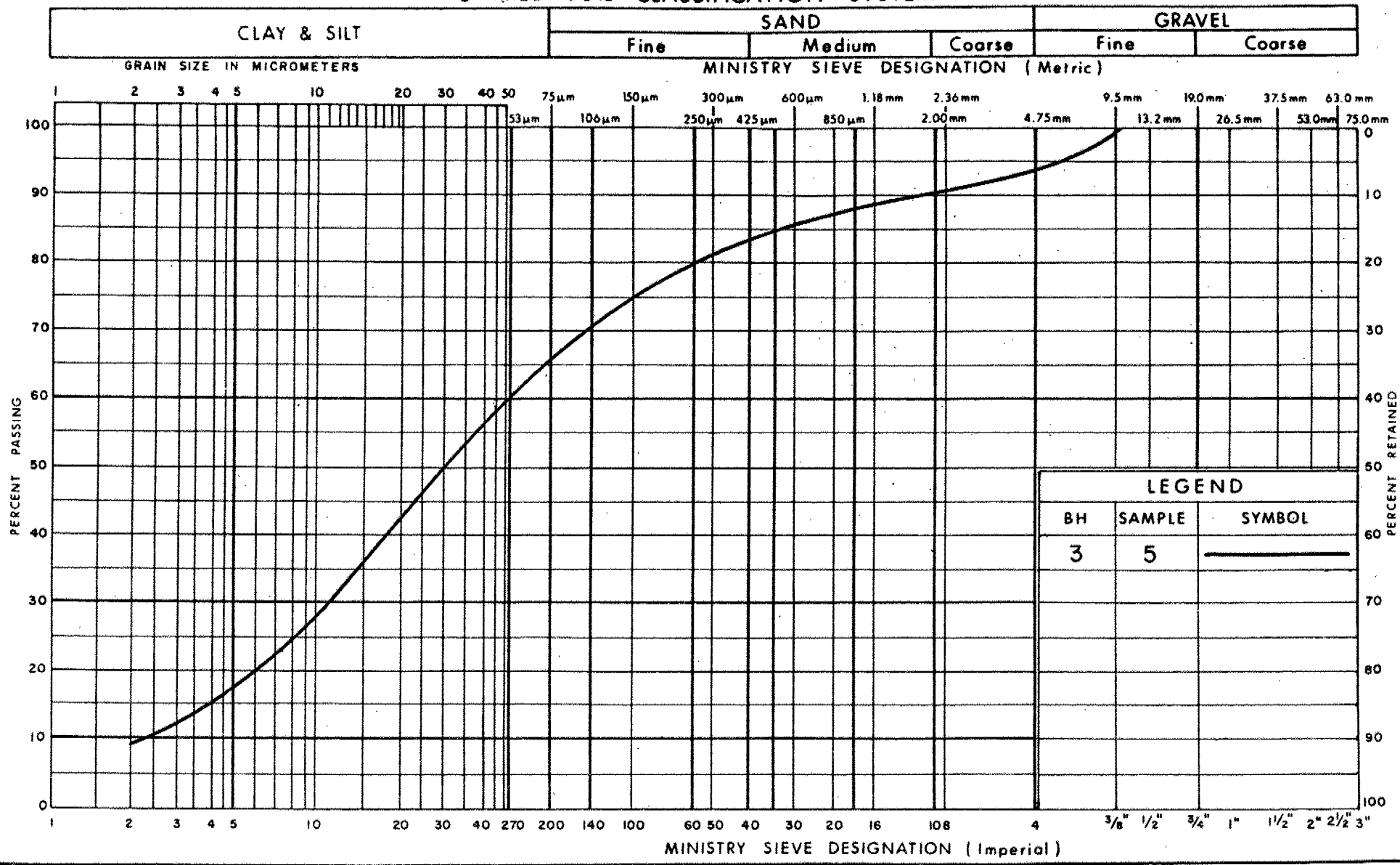
FILL MATERIAL, SAND AND GRAVEL

FIG No 1

W P 65-78-02

13

UNIFIED SOIL CLASSIFICATION SYSTEM



Warnock Hersey Professional Services Limited

GRAIN SIZE DISTRIBUTION

SILT (Slightly Cohesive) WITH SAND AND GRAVEL

(Glacial Till)

FIG No 2

W P 65-78-02

14

FOUNDATION INVESTIGATION REPORT

for

W.P. 65-78-02 Structure Site 39W-3

Fraser River Bridge, Hwy. 11

District 16 (Cochrane), Northern Region

FOUNDATION INVESTIGATION REPORT
for
W.P. 65-78-02 Structure Site 39W-3
Fraser River Bridge, Hwy. 11
District 16 (Cochrane), Northern Region

INTRODUCTION

Warnock Hersey Professional Services Limited have been retained by the Ontario Ministry of Transportation and Communications, under Agreement No. 4242-9081-18, to provide geotechnical services in connection with the above project. The terms of reference were to carry out an investigation of sufficient scope to provide recommendations for either repair and restoration of the existing structure or for its replacement by a new structure.

SITE CONDITIONS

The topography is flat. Frazer River is a meandering stream, some 20 metres in width and is bordered by marshy flood plains. The physiography of the area is typical of a till peneplain.

Highway 11 has a tangent alignment within a 91 metre right-of-way. The grades are minimal. The bridge is aligned more or less perpendicular to the main channel of the river. The river flow is towards the north.

FIELD AND LABORATORY WORK

Subsurface conditions were investigated by means of four boreholes, two of which were accompanied by dynamic cone penetration tests. The locations and elevations of the boreholes are shown on the accompanying drawing 657802-A. The boreholes were drilled with a bombardier mounted 89 mm I.D hollow stem auger machine (MTC type 5.3.i).

FIELD AND LABORATORY WORK (Cont'd)

Soil samples were obtained at regular intervals of depth in each borehole. Standard penetration resistance N values were noted. The samples were re-examined in the laboratory for classification and confirmatory testing. Results of laboratory and field tests are given on the accompanying Records of Boreholes 1 to 4 and Figures 1 and 2 in the Appendix.

SUBSURFACE CONDITIONS

General

The subsoil conditions are generally uniform across the site. The highway fill is underlain by a thin silt or sand deposit, overlying the predominant stratum which is a slightly cohesive silt glacial till. Elsewhere, the surficial soil consists of organic silt, peat and other organically contaminated granular soils.

FILL MATERIAL

The highway approach fill is about 2-3 m high and consists of fairly clean well graded sand and gravel, in a compact state (See Figure 1). The surface is covered with recycled asphalt pavement fragments from a recent resurfacing project (Contract 80-214). At the toes of the fill, some loose or soft to firm organically contaminated sands and silts are present.

Where the fill spills through the terminal bents of the structure, it is covered with rounded boulders, up to 0.5 m in size, serving as rip rap.

ORGANIC SOILS

The flood plain consists of surficial organic silts and peats. Both soil types are present near the structure site and are partly trapped beneath the approach fills, especially at the toe line of the embankment. N values ranged from 2 to 8 blows per 0.3 m indicating a loose density or soft to firm consistency. Moisture contents are in the 30 to 50 percent range.

SILT AND SAND

Sandwiched between the surficial organic soils and the glacial till deposit, there is a 2 to 3 meter thick alluvial deposit of fine to coarse sand which grades into a silt at the east approach. These non-cohesive, alluvial flood plain, soils are in a compact state with N values ranging from 9 blows to 20 blows per 0.3 m.

SILT (GLACIAL TILL)

The chief geological deposit at the site is a silt with some sand, traces of clay and gravel and occasional cobble and boulder sizes (glacial till). Its surface occurs between elevations 243.0 and 244.3 across the bridge site.

This deposit is slightly cohesive (CL-ML). Although no boulders were encountered in this deposit during drilling, field evidence points to the probability of cobbles and boulders being present at random. One such evidence was the nature of a recent earth spoil bank from a ditch excavation on the southern right-of-way of the highway. Several cobble and some boulder sized stones were noted in the spoil material.

Below about elevation 242, this deposit is in a very dense state throughout or, where cohesive, exhibits a hard consistency, with N values in excess of 90 blows/0.3 m. The natural moisture content is less than 15 percent, typical of glacial tills. A grain size distribution curve is shown in Figure 2. The silt content is close to 60 percent. Therefore, the soil is extremely susceptible to frost action. Due to its low plasticity, the soil is also considered fairly susceptible to erosion.

GROUNDWATER CONDITIONS

The river level at the time of this investigation was at elevation 245.3, close to the normal high water mark for this stream. The water level in the boreholes corresponded to this

GROUNDWATER CONDITIONS (Cont'd)

elevation. Due to the presence of the alluvial silts and sands, it is presumed that prevailing stream levels influence and control the ground water regime at this site.

Frazer River streamflow was measured at a velocity of 0.6 m/second and an estimated discharge rate of 15 m^3/second. The water ran clear, indicating very little sediment load and a stabilized stream bed and bank domain upstream of the bridge. The river channel at the bridge location is flat-bottomed. Soundings every 2 metres across the channel width did not reveal any incised subchannels within the river bed. The river bed is partly covered with cobbles and occasional boulders.

DISCUSSION AND RECOMMENDATIONS

Existing Structure

The present structure was built under contract 55-602, some 25 years ago. It has a longitudinally laminated timber deck supported on eight timber bents. The deck dimensions are about 11 metres in width and 33 metres in length. Each bent consists of seven piles, the two outer ones being battered out 1:6. All the piles are cross-braced in each bent except the terminal bents. At the terminal bents, two 203 mm X 203 mm timbers are nailed to the back of the piles and serve as a road fill retaining barrier at the approaches. The fill spills through below these timbers.

From an appearance point of view, the bridge is in good condition. The deck lamination timbers are loose in some locations and sag below the general underside level of the deck. It is understood that strengthening of the deck is proposed by means of tranverse post tensioning.

The piles were pressure creosote treated. The exposed portions were found to be drier than normal, indicating perhaps inadequate plant treatment at the time of installation. Some of the piles have checks due to the drying out. Maintenance reports since 1964 indicate that some split piles had to be collared. Hence, the piles are suspected to be quite brittle in their present condition.

The original design drawing for the structure (#D3673-1, Jan. 26, 1956) required the piles in the middle four bents to be driven 3 metres below the stream bed, using steel shoes if necessary. To meet this requirement the pile tips would have to reach elevation 241 within the very dense or hard silt glacial till deposit. Given N values in excess of 90 blows/0.3 m below elevation 242, it is suspected that these piles probably could not be driven to the specified tip elevation.

Existing Structure (Cont'd)

Normal to the stream flow, bents 3 and 4 and 5 and 6 are cross braced above about elevation 246. Since high water level occurs at about elevation 245.5, these cross members catch floating debris such as felled or uprooted trees and shrubs, which subsequently restrict stream flow.

Maintenance inspection reports indicate pile movements, both up and down, at various times since 1964. Erosion of the approach spill-through fills and settlement at the deck approaches has also been noted in these reports.

Most of the intermediate pile bents have been shimmed at the pile head. Drawing 657802-A shows the location and extent of shimming as of the spring of 1981. The most severe shimming is at bent No. 4.

At the surface of the deck, the asphalt wearing surface shows tranverse cracking adjacent to each of bents 2, 3, 4, 6 and 7.

In all other respects, the deck surface appears to be in excellent condition. There was no visible sag or hog in the deck surface at the time of this investigation.

The as-constructed and present fill cross-sections (in profile) are shown on Drawing 657802-A. It is evident that considerable loss of fill has occurred at the two end spans since the structure was built.

Remedial Measures

The previously observed and reported pile movement is probably occurring due to frost action and ice heaving. It is suspected that the pile tips could not originally be driven below about elevation 242.5. Hence they are likely located within the frost active zone of the stream bed.

Remedial Measures (Cont'd)

Ice guard piles are located on the upstream side of the bents within the river channel. How effective these are in preventing ice binding to the pile bents and subsequent heaving or down-dragging with fluctuations in the river level is not known.

The relatively dry and brittle nature of the existing piles rules out redriving. Hence, remedial measures should accommodate and stabilize the existing condition. In addition, the effectiveness of the proposed transverse post-tensioning of the laminated timber deck can be assured only by minimizing future deck movements.

The existing pile bents may be stabilized by structurally connecting them to an unyielding anchorage system. The anchorage may consist of deep ground anchors (installed at elevation 241 or below) or steel piles driven to elevation 240 or below.

An alternative solution would be to replace the existing timber bents with steel bents consisting of girders spanning the width of the deck and resting at their ends on steel columns. Steel H piles are recommended as columns since they can be driven into the glacial till for good anchorage. H piles such as 310HP @110 steel piles, with reinforced tips, could be driven to attain their safe capacities of about 1 MN between about elevations 239 and 240 with a minimum driving energy of 50kJ.

If steel bents are installed, consideration should be given to reducing the number of spans so as to allow freer stream flow. Larger spans will result in deeper girders, but there appears to be sufficient head room above high water level to provide the clearance to the underside of such deeper girders.

Remedial measures should include reshaping and protection of the spill-through fill. The existing rip-rap boulders are too large and heavy for manual labour to handle. At the end spans, space is rather limited for machines to operate. For this reason, bents 2 and 7 may have to be removed to enable machinery to regrade the fill slopes below the deck.

Remedial Measures (Cont'd)

The fill should be regraded and recompacted to a 2:1 slope in the forward direction. The existing boulders are too large to provide protection against the erosion of the finer fill material under highwater conditions. Therefore, consideration should be given to stabilizing the forward slopes, up to about elevation 246.0, with a paved apron, or gobimats. Gabion protection could also be considered. However, gabions should be started at or below stream bed level. They should be stepped back and up to provide a 300 mm minimum base width clearance below the toes of each course of gabion baskets. If the current bouldery rip-rap is re-used, it should be placed on fill sloped at 2.5:1 or flatter which has been covered with a coarse geotextile to prevent erosion of the approach fill material.

Replacement Structure

The foundation conditions are suitable for the construction of conventional structures founded on spread footings or piles.

Footings may be located either within the alluvial silt and sand deposit, or at or within the underlying silt glacial till deposit. The following design parameters are suggested:

Spread Footings in Alluvial Sand or Silt at or Below Elevation 244.0

Capacity at S.L.S. Type II	150 kPa
Net Safe Pressure	150 kPa
Factored Capacity at U.L.S.	500 kPa
Friction coefficient between soil and base	tan 25°

Spread Footings in Glacial Till at or Below Elevation 243.0

Capacity at S.L.S. Type II	400 kPa
Net Safe Pressure	400 kPa
Factored Capacity at U.L.S.	1,000 kPa
Adhesion between soil and base	100 kPa

Piled Foundations

If steel H piles are used, the capacities may be assumed to be proportional to the cross-sectional area. For 310HP @ 110 steel piles, driven with a minimum energy of 50 kJ per blow to or below elevation 240.0, the following design parameters may be used.

Safe capacity	1,100 kN
Factored capacity at U.L.S.	1,500 kN
Capacity at S.L.S. Type II	1,100 kN

Earth Pressures

If the design of the new bridge incorporates closed abutments and or wing walls, earth pressures should be computed as per subsection 6.6.1.2.2 of the O.H.B.D.C.

Dewatering

Construction below the prevailing stream level will require dewatering, particularly within the alluvial silt and sand stratum. The glacial till deposit is not expected to yield water readily and pumping from sumps may be sufficient to control seepage.

Stability

During regrading of the existing fill or if new fill is added to the present flood plain, care should be taken to excavate all surficially loosened or softened soils and any flood plain organic deposits from within the plan area of the fill. No stability problems are foreseen for fills constructed with standard 2:1 side slopes.

Stability (Cont'd)

Settlement of new fill will be negligible provided the organic materials are excavated prior to construction and the new fill is compacted to 95% of the Standard Proctor density for the material used.

Respectfully submitted,

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

Report by B. Donofrio

Encl.

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

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

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

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

RECORD OF BOREHOLE No 1

METRIC

W P 65-78-02 LOCATION STA 9+970.7 %s 4.4 m Rt of ℄ Hwy 11 ORIGINATED BY BD

DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JT

DATUM Geodetic DATE 1981 05 14 CHECKED BY CM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.9	Paved Shoulder										
0.0	75mm Asphalt										
	FILL MATERIAL Sand with Gravel and some Silt, trace of Clay Compact, Yellow-Brown		1	SS	11		248				
			2	SS	11						16 70 (14)
246.2			3	SS	12		246				
2.7	SILT, trace of Clay and Fine Sand, Loose to Compact Yellow-Grey		4	SS	9	▼					
244.3			5	SS	17						
4.6	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey		6	SS	14		244				
			7	SS	48		242				
	Very Dense or Hard Occasional Cobbles and Boulders at random		8	SS	92						
239.6			9	SS	65/150mm		240		NP		
9.3	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊙ 5 (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No 2

METRIC

W P 65-78-02 LOCATION STA 9+989.5 % 11.0 m Lt of ℄ Hwy 11 ORIGINATED BY B D

DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY J T

DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.0	Ground Surface										
0.0	FILL MATERIAL Sand and Gravel mixed with Organics Very Loose		1	SS	2	▼			○		
244.8	ORG. SILT, trace Sand Loose		2	SS	7				○		
244.3	SAND, Fine - Medium trace of Organics, Grey Loose to Compact		3	SS	20		244				
1.7			4	SS	28				○		
243.0	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occasional Cobbles and Boulders at random		5	SS	97		242		○H		
3.0			6	SS	100/150 mm						
239.7			7	SS	100/150 mm		240				
6.3	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

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

RECORD OF BOREHOLE No 3

METRIC

W P 65-78-02 LOCATION STA 10+010.5 %s 11.9m Rt of ℄ Hwy 11 ORIGINATED BY BD

DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY JT

DATUM Geodetic DATE 1981 05 14 CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
245.9	Ground Surface										
0.0	ORGANIC SILT, seams of Clayey Silt, trace of Sand Loose or Firm		1	SS	7	▼					
243.8			2	SS	5		244				
2.1	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occasional Cobbles and Boulders at random		3	SS	31						
			4	SS	39		242				
			5	SS	92						6 28 57 9
			6	SS	100/75 mm		240				
	SANDY GRAVEL Very Dense		7	SS	100/150 mm		238				
236.6			8	SS	100/120 mm						
9.3	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

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

RECORD OF BOREHOLE No 4 METRIC

W P 65-78-02 LOCATION STA 10+027.1 9/s 4.6m Lt of ℄ Hwy 11 ORIGINATED BY B D
DIST 16 HWY 11 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY J T
DATUM Geodetic DATE 1981 05 14 CHECKED BY C M

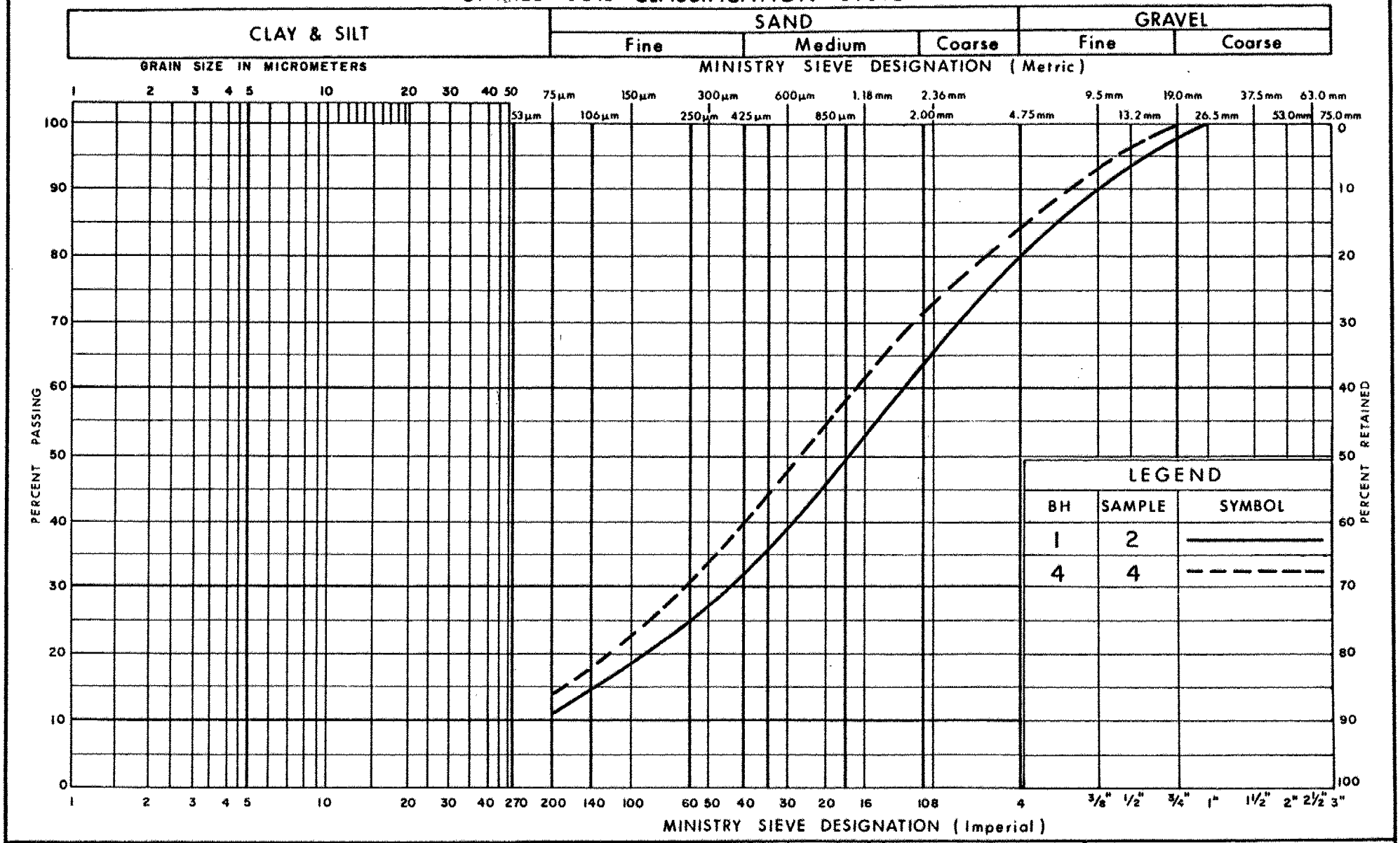
ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.0	Paved Shoulder										
0.0	75mm Asphalt										
	FILL MATERIAL Sand and Gravel, trace of Silt, Compact		1	SS	16		248				
			2	SS	19						
	Contaminated with Organic Silt		3	SS	10						
245.7	Yellow - Grey		4	SS	22	▼	246		○		21 68 (11)
3.3	SAND, Medium - Coarse with trace Clay and Gravel Occ. Organic Silt pockets Compact Grey		5	SS	19						
			6	SS	16		244				
243.0											
6.0	SILT (Slightly Cohesive) with Sand and Gravel (Glacial Till) Grey Very Dense or Hard Occ. Cobbles and Boulders		7	SS	42				○		
							242	100/150 mm			
241.1			8	SS	92				○		
7.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Warnock Hersey Professional Services Limited

GRAIN SIZE DISTRIBUTION

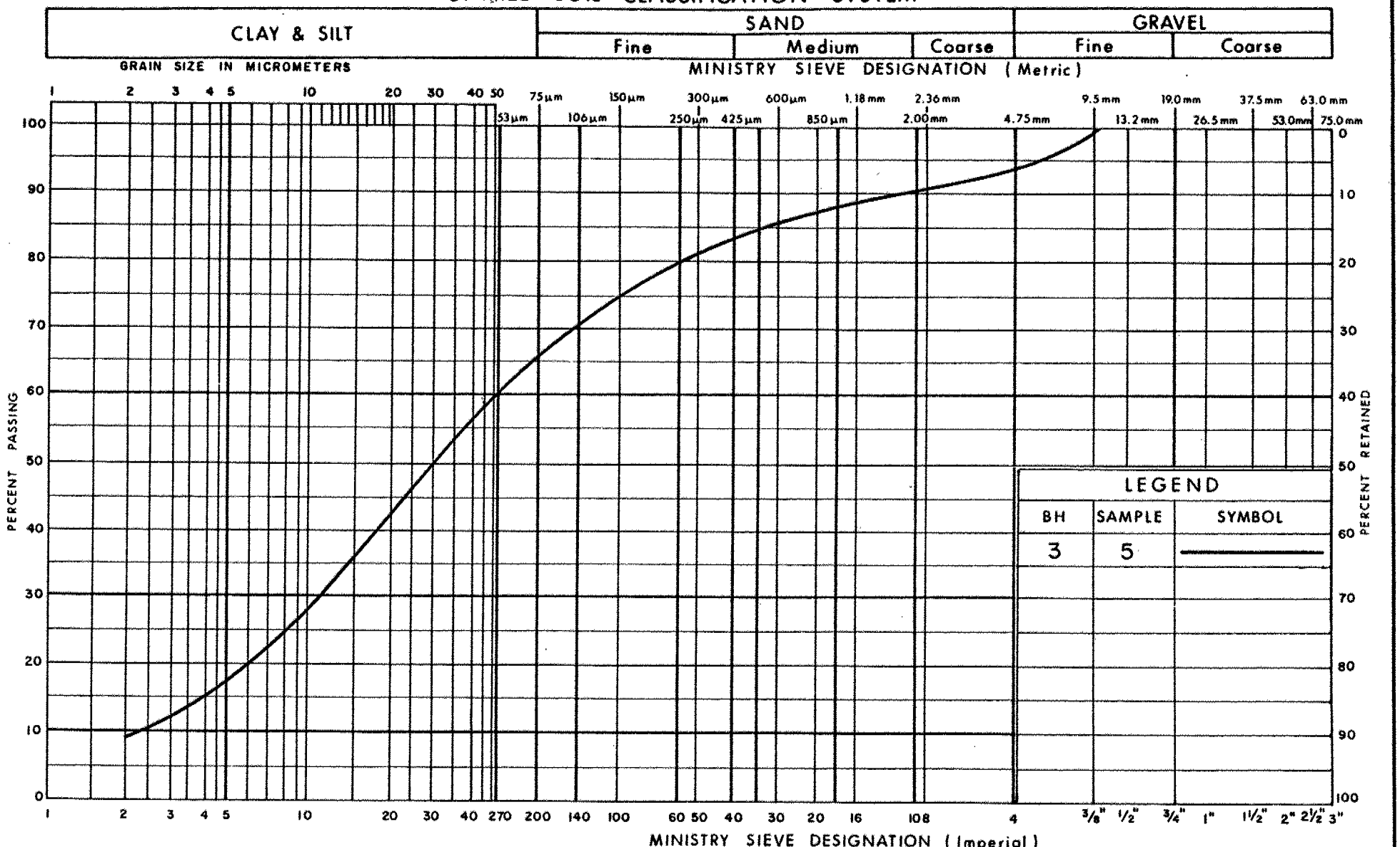
FILL MATERIAL, SAND AND GRAVEL

FIG No 1

W P 65-78-02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



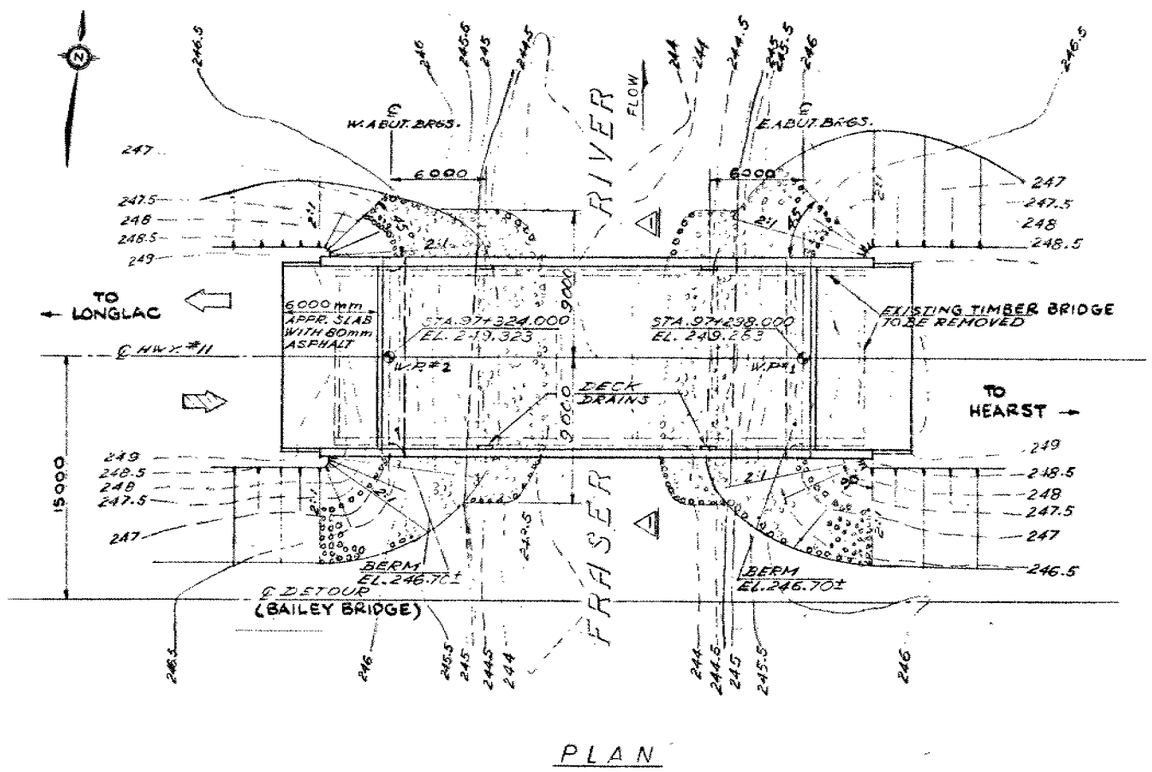
Warnock Hersey Professional Services Limited

GRAIN SIZE DISTRIBUTION

SILT (Slightly Cohesive) WITH SAND AND GRAVEL
(Glacial Till)

FIG No 2

WP 65-78-02



PLAN
1:200

METRIC

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

DIST. No. 16
CONT No
WP No 65-78-02

FRASER RIVER BRIDGE
(22.9 KM WEST OF HWY 631)
GENERAL ARRANGEMENT

SHEET

NOTES

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BARS MARKED WITH THE SUFFIX 'C' SHALL BE COATED BARS.

CLASS OF CONCRETE

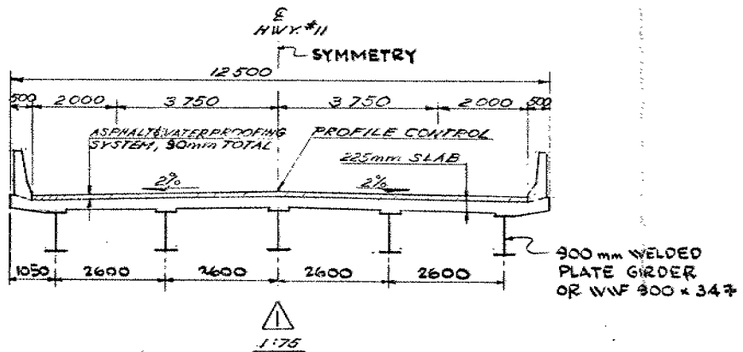
FOOTINGS & APPROACH SLABS ..... 20 MPa
REMAINDER ..... 30 MPa

CLEAR COVER TO REINFORCING STEEL (mm)

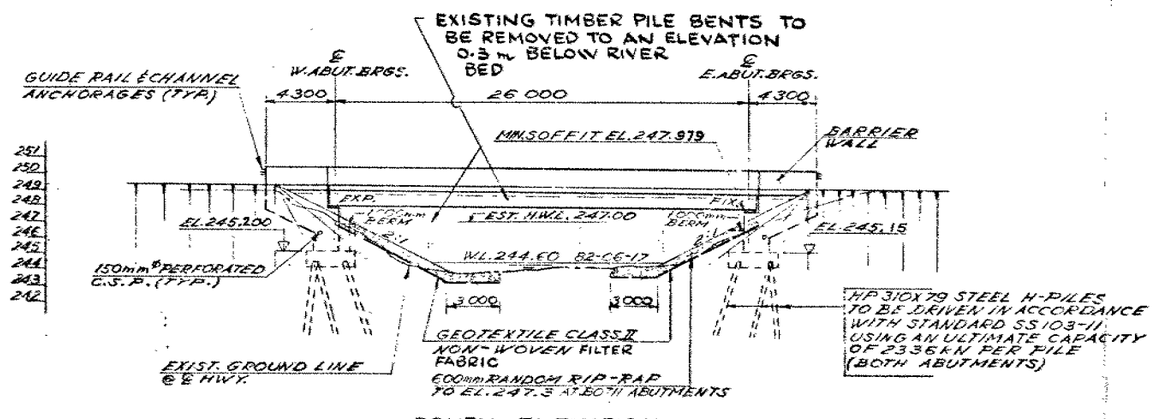
FOOTING	100 ± 25
DECK TOP	70 ± 20
DECK BOTTOM	40 ± 10
FRONT FACE OF ABUTMENT	80 ± 20
REMAINDER	70 ± 20

CONSTRUCTION NOTES

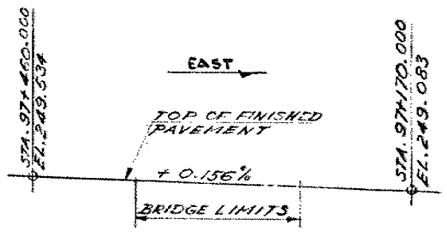
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 3mm.



1:75



SOUTH ELEVATION
1:200



PROFILE ℄ HWY. #11
N.T.S.

BM 246.756
GEODETIC DATUM
N.E.W. IN E. ROOT OF A POPLAR
21.0 RT 97+352.0

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATION & SOILS STRATA
3. FOOTINGS
4. ABUTMENTS
5. STRUCTURAL STEEL I
6. STRUCTURAL STEEL II
7. DECK & SCREED ELEVATIONS
8. BARRIER WALL
9. 6000 mm APPROACH SLAB
10. AS CONSTRUCTED ELEV. & DIM.
11. BRIDGE DATE & SITE NUMBER DATA
12. PILE DRIVING-STEAM & DIESEL HAMMERS
13. STANDARD DETAILS
14. QUANTITIES
15. QUANTITIES

81. BAILEY BRIDGE.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN JS	CHECK	LOADING	DATE JUNE '83
DRAWING	CHECK JS	SITE	DWG 1

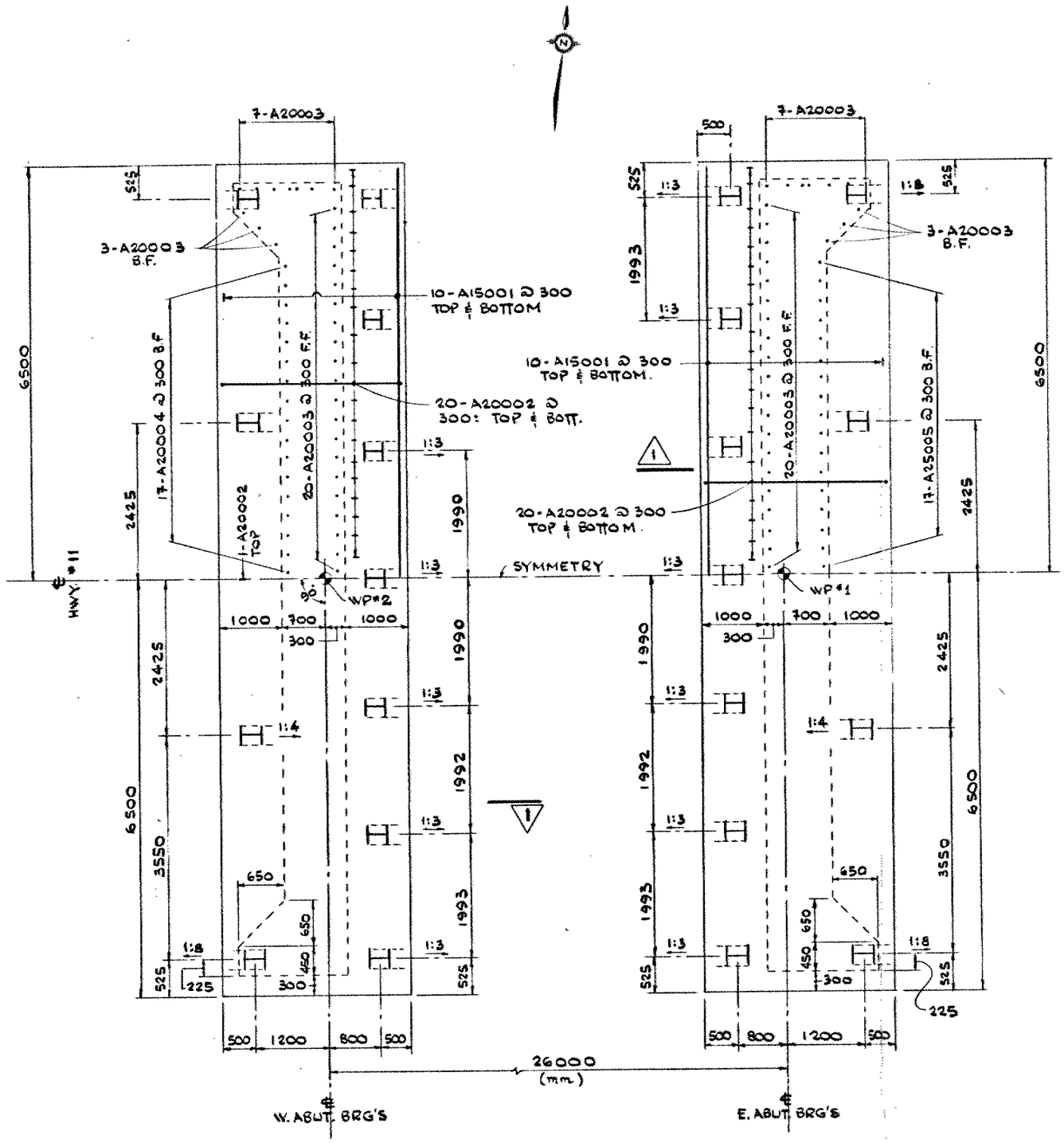
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 65-78-02

FRASER RIVER BRIDGE
(22·9 KM WEST OF HWY 631)
FOOTINGS

SHEET



PLAN OF FOOTINGS

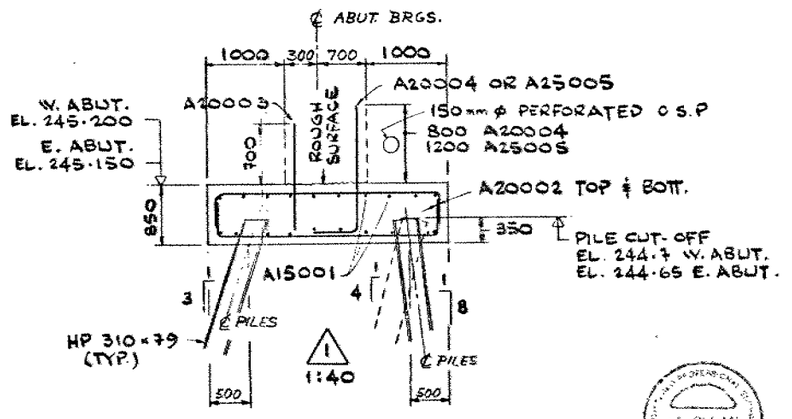
SCALE 1:40

PILE DATA				PILE DESIGN DATA (kN)		PILE CONSTRUCTION DATA (kN)
LOCATION	TYPE	QUANTITY	LENGTH	@ SLS II	@ ULS	ULTIMATE CAPACITY
W. ABUT.	HP310×79	11	5000	775	900	2336
E. ABUT.	HP310×79	11	5000	775	900	2336

PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS 103-11 USING AN ULTIMATE CAPACITY OF 2336 kN PER PILE.

NOTES

1. PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTHS BELOW CUT-OFF ELEVATIONS.
2. PILE SPACING IS MEASURED ALONG THE UNDERSIDE OF FOOTING.
3. ALL PILES SHALL HAVE DRIVING SHOES.

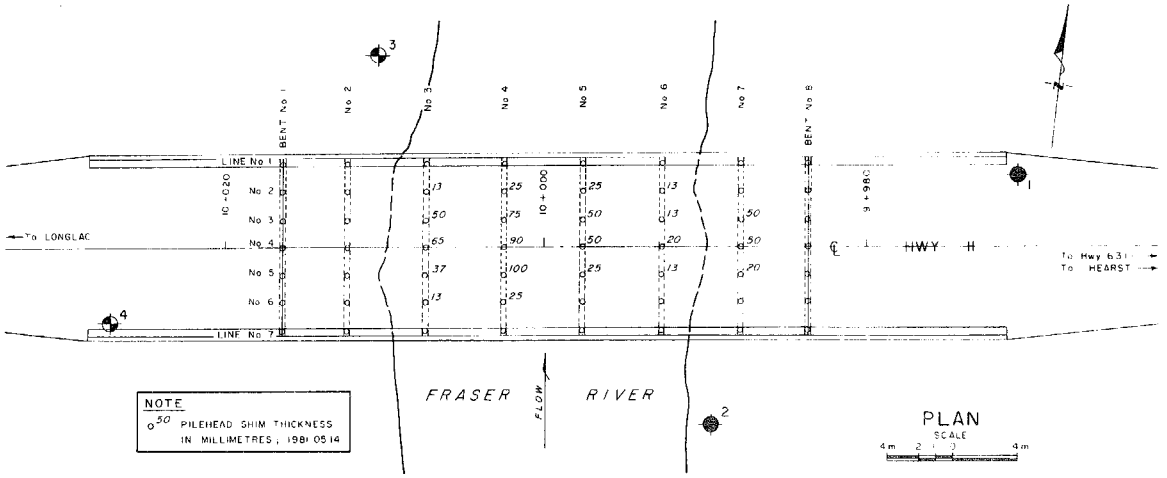


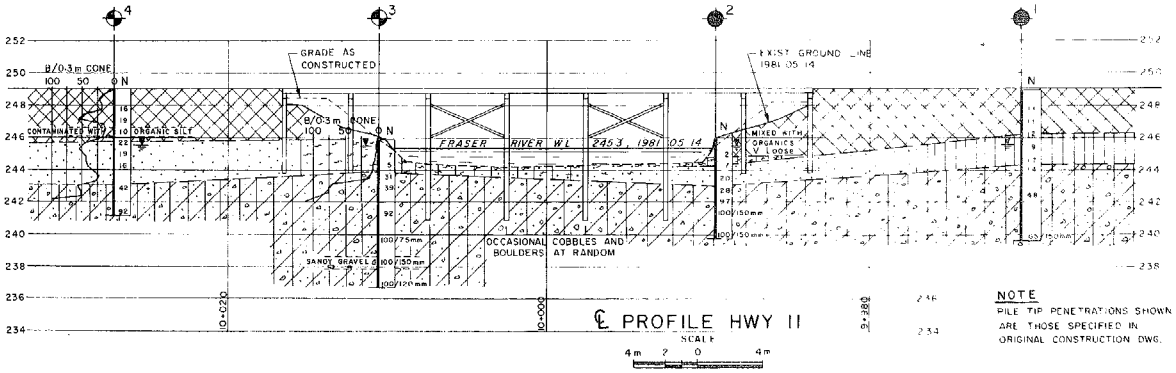
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN	CHECK	LOADING CHBDL-79	DATE JUNE'83
DRAWING	CHECK	SITE No	DWG 3

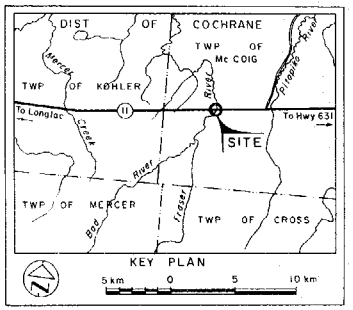
METRIC

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





NOTE
PILE TIP PENETRATIONS SHOWN ARE THOSE SPECIFIED IN ORIGINAL CONSTRUCTION DWG.



BM ELEV 249.1 Geodetic
STA 10+000 ℄ Hwy 11
STA 10+000 = STA 2864+50 OLD CHAINAGE

SOIL STRATIGRAPHY

- FILL, SAND AND GRAVEL TRACE OF SILT AND CLAY Compact
- SILT, Loose to Compact TRACE OF CLAY AND SAND
- SAND, FINE TO COARSE ORGANIC SILT INCLUSIONS TRACE OF CLAY AND GRAVEL Loose to Compact
- ORGANIC SILT, Loose OCC CLAYEY SILT SEAMS Firm
- SILT (Slightly Cohesive) WITH SAND & GRAVEL (Glacial Till) Very Dense or Hard

LEGEND

- Bore Hole
- Bore Hole and Cone
- N Blows/0.3m (Std Pen Test, 475 J/Blow)
- CONE Blows/0.3m (60° Cone, 475 J/Blow)
- WL at time of investigation 1981 05 14

No	ELEVATION	STATION	OFFSET
1	248.9	9+970.7	4.4m Rt
2	246.0	9+989.5	11.0m Lt
3	245.9	10+010.5	11.9m Rt
4	249.0	10+027.1	4.6m Lt

Warnock Hersey Professional Services Limited

DATE 1981 06 25

FRASER RIVER & HWY 11

(22.9 km West of Hwy 631)

DIST OF COCHRANE TWP OF Mc COIG
CON LOT SITE 39W3 DIST 16

WP 65-78-02

DWG No 657802-A