DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 40 I 14-125

DIST. 2 REGION

W.P. No. 91-84-03

CONT. No. 97-12

W. O. No.

STR. SITE No. 5-65

HWY. No. 4

LOCATION Hwy 4 & Kettle Creek Bridge (North)

No OF PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

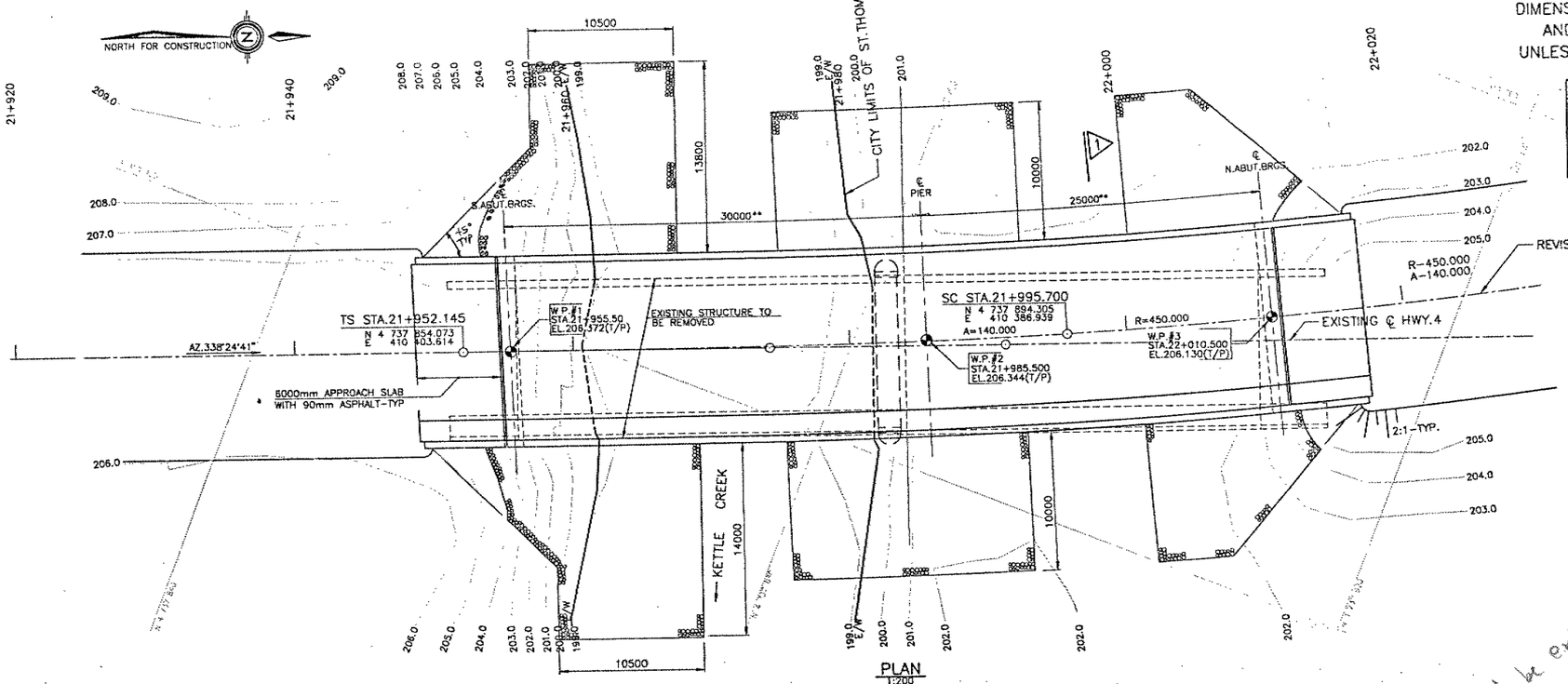
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

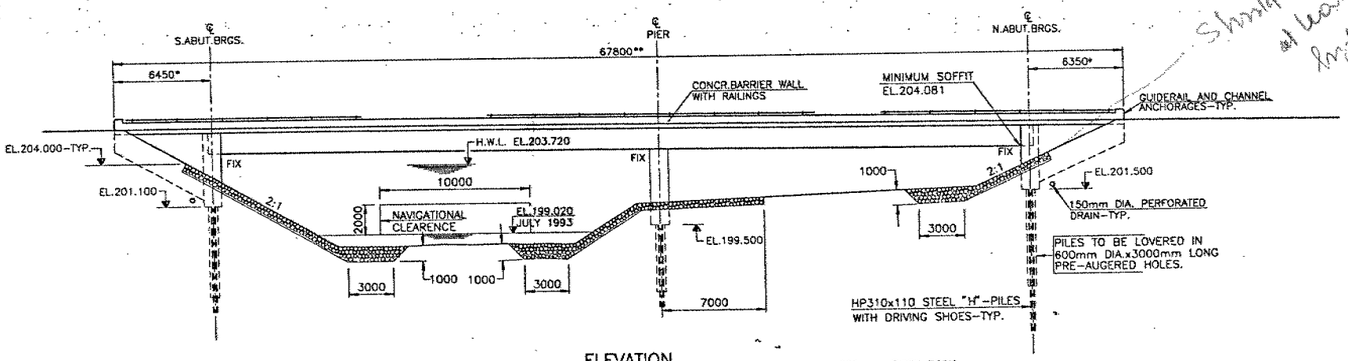
DIST 2
CONT No
WP No 91-84-03

KETTLE CREEK BRIDGE
(NORTH)
GENERAL ARRANGEMENT

SHEET
95

WORKING POINT DATA		
W.P's	CO-ORDINATES	
	NORTH	EAST
1	4737857.193	410402.379
2	4737884.970	410391.049
3	4737907.684	410380.613

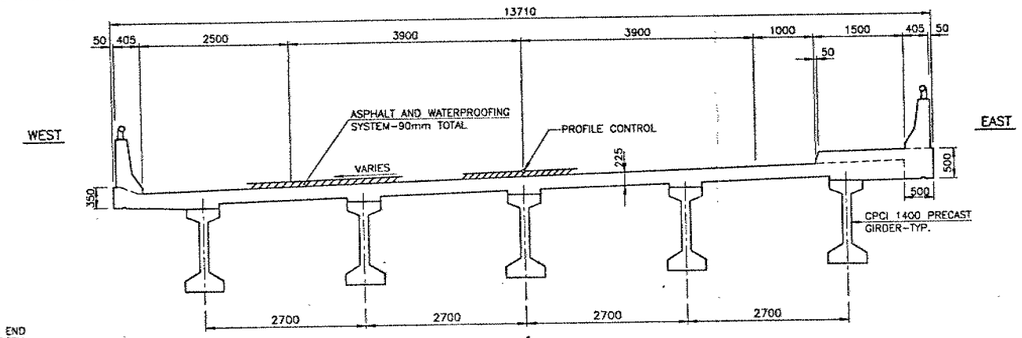




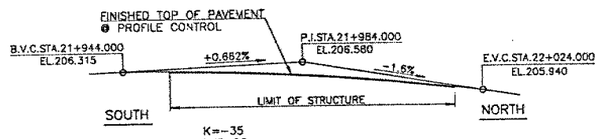
ELEVATION
1:200

*-MEASURED OUTSIDE FACE OF BARRIER WALL
**-MEASURED ALONG ℄ HWY.#4

NOTES:
1. SHOULDER WIDTH VARIES FROM 2650 @ STA.21+952.145 TO 2500 @ STA.21+995.700.
2. TRAFFIC LANES VARIES FROM 3750 @ STA.21+95 TO 3900 @ STA.21+995.700.



1
1:50



PROFILE OF HWY.#4
N.T.S.

BM 205.998
CC ON SE CORNER OF CSW S END
CONC. BRIDGE OVER KETTLE CREEK
5.8 RT 21+952.5

GENERAL NOTES:

CLASS OF CONCRETE:

PRECAST GIRDERS. 40MPa
REMAINDER
UNLESS OTHERWISE NOTED 30MPa

CLEAR COVER TO REINFORCING STEEL:

FOOTINGS . . . . . 100±25
DECK
TOP. . . . . 70±20
BOTTOM. . . . . 40±20
REMAINDER . . . . . 70±20
UNLESS OTHERWISE NOTED.

REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.
BAR MARKS WITH PREFIX "C" DENOTE COATED BARS.

CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
2. NO BACKFILL SHALL BE PLACED UNTIL DECK CONCRETE HAS REACHED 75% OF ITS SPECIFIED STRENGTH. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. ONLY WHEN THE SHORT ABUTMENT HAS BEEN FULLY BACKFILLED THEN THE REMAINING BACKFILL ON THE HIGH ABUTMENT CAN BE PLACED.

LIST OF DRAWINGS:

Should be entirely at least from shaw with land

LICENSED PROFESSIONAL ENGINEER
Province of Ontario
Nicolas C. Theodor
Feb. 97

REGISTERED PROFESSIONAL ENGINEER
Province of Ontario
N.J. PATEL
Feb. 97

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DESCRIPTION		
DESIGN N.C.T. CHK	CODE OH8DC'91	LOAD CL.-A	DATE MAY 1996
DRAWN J.O. CHK	SITE 5-65	STRUCT	SCHEME DWG 1

AutoCAD Drawing: /data7/users/podluski/wp918404/kett-nga.DWG updated: FEB 19/1997 2:47 PM

AutoCAD Drawing: /data7/users/podluski/wp918404/kett-nga.DWG updated: FEB 19/1997 2:47 PM

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

DIST
CONT No
WP No 91-84-03

KETTLE CREEK BRIDGE (NORTH)
SOUTH ABUTMENT AND WINGWALLS

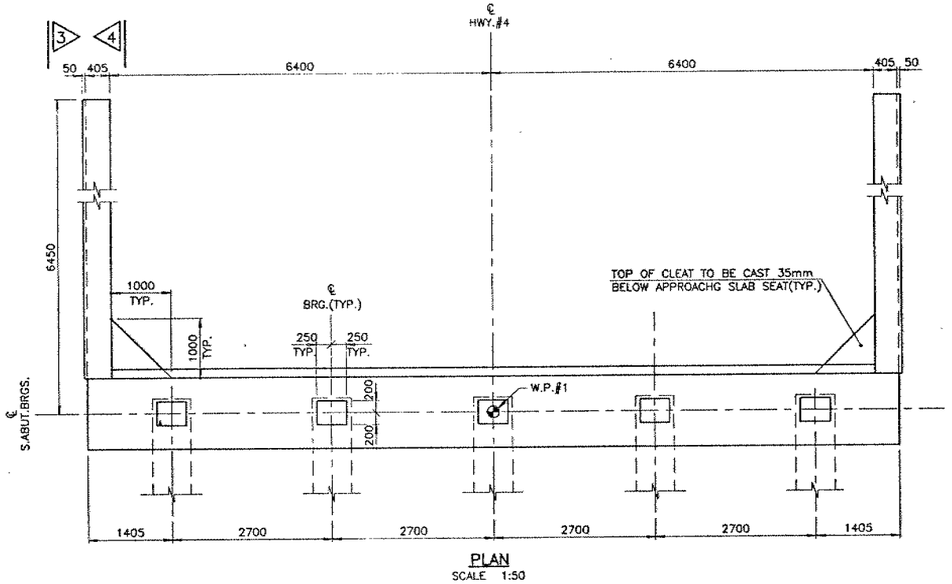
SHEET 97

96

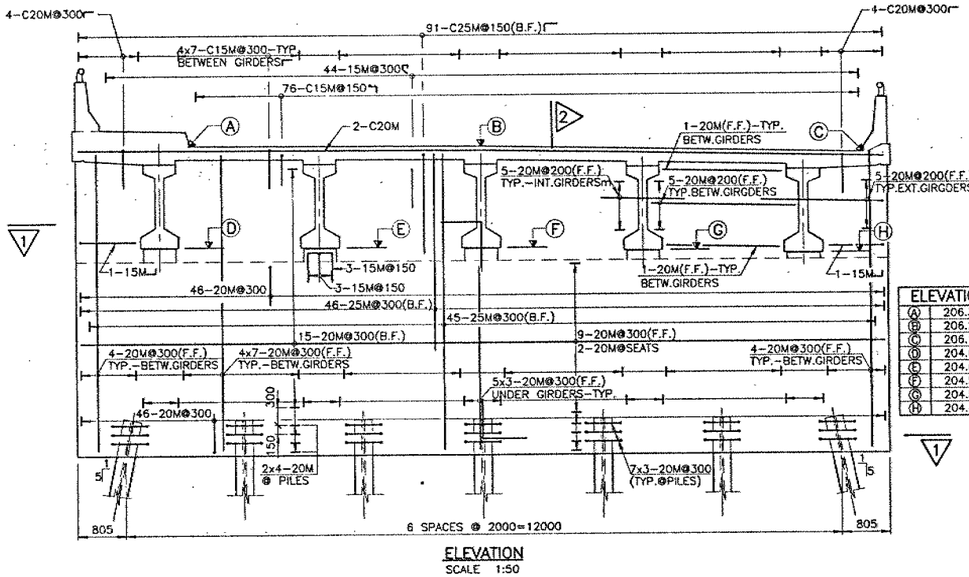
CONSTRUCTION NOTES:

1. CONSTRUCT PIER AND ABUTMENTS INCLUDING WINGWALLS TO THE BEARING SEAT ELEVATIONS. TO PROVIDE STABILITY DURING CONSTRUCTION THE CONTRACTOR SHALL SUPPLY TEMPORARY LATERAL BRACING FOR THE PIER,ABUTMENTS AND WINGWALLS. FORMWORK AND LATERAL BRACING SHALL NOT BE REMOVED UNTIL DECK CONCRETE HAS REACHED 75% OF ITS SPECIFIED STRENGTH.
2. ERECT PRECAST GIRDER.
3. CAST DECK AND TOP PORTION OF ABUTMENTS,PIER AND WINGWALLS INTEGRALLY.

NOTE:
•THIS DRAWING TO BE READ IN CONJUNCTION WITH DWG.4,5&8.

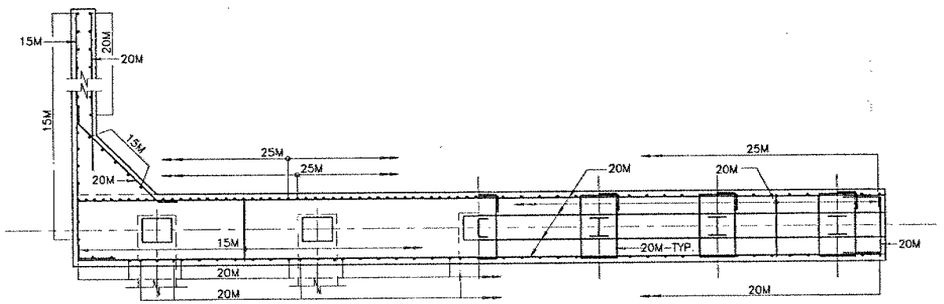


PLAN
SCALE 1:50



ELEVATION	
(A)	206.301
(B)	206.283
(C)	206.155
(D)	204.610
(E)	204.600
(F)	204.590
(G)	204.536
(H)	204.482

ELEVATION
SCALE 1:50



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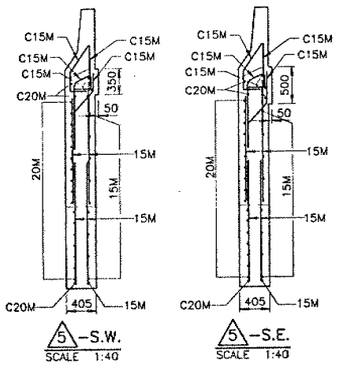
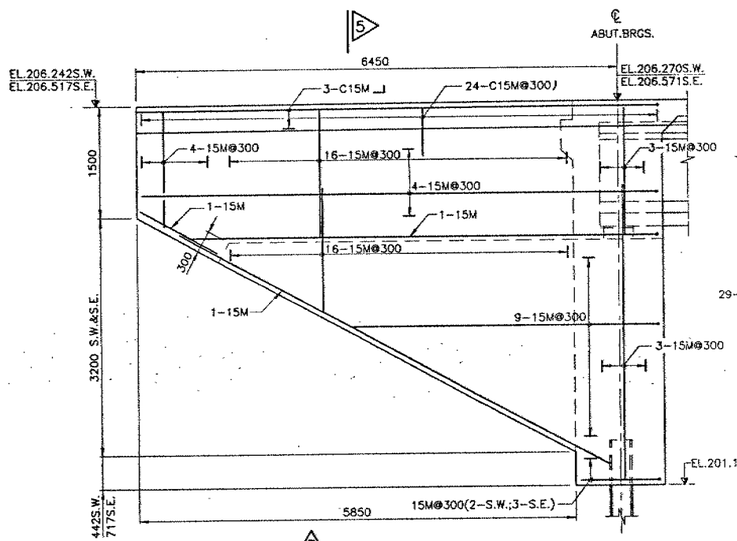
SCALE 1:50





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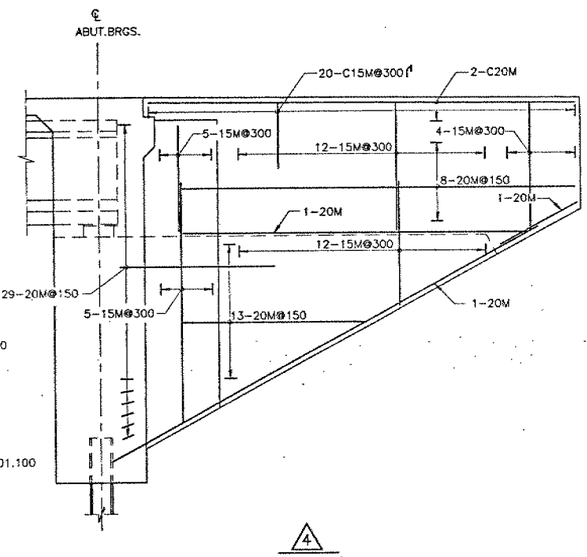
SCALE 1:40



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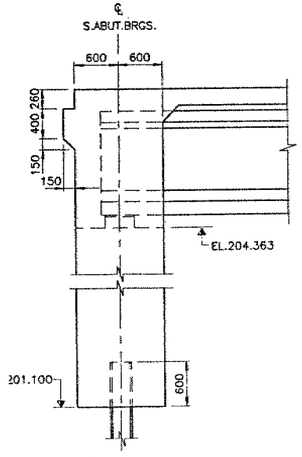
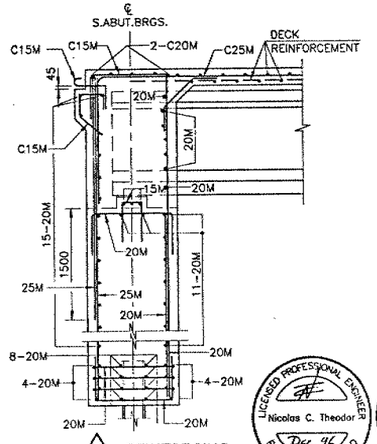
SCALE 1:40



2-DIMENSIONS
SCALE 1:40



2-REINFORCING
SCALE 1:40

LICENSED PROFESSIONAL ENGINEER Nicolas C. Theodor DEC. 96 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER N.J.PATEL DEC 96 PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DESCRIPTION					
DESIGN N.C.T.	CHK N.J.P.	CODE OHBDC'91	LOAD CL.-A	DATE MAY1996		
DRAWN J.O.	CHK	SITE 5-65	STRUCT	SCHEME	DWG 3	

METRIC

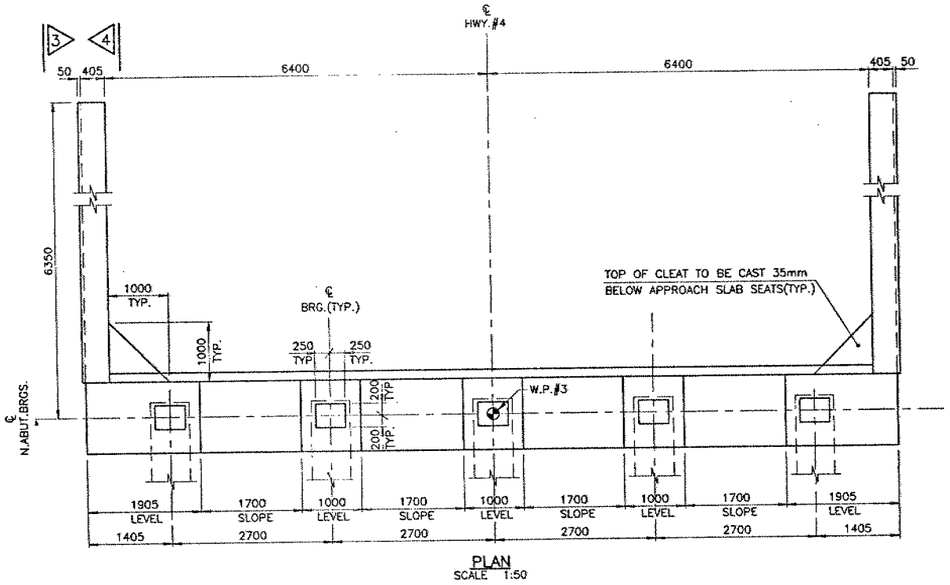
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST
CONT No
WP No 91-84-03

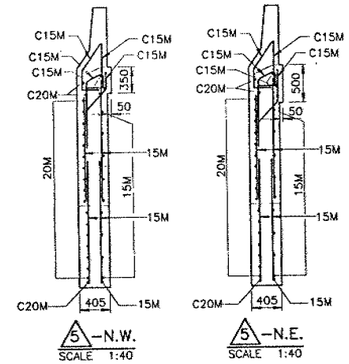
KETTLE CREEK BRIDGE (NORTH)
NORTH ABUTMENT AND WINGWALLS

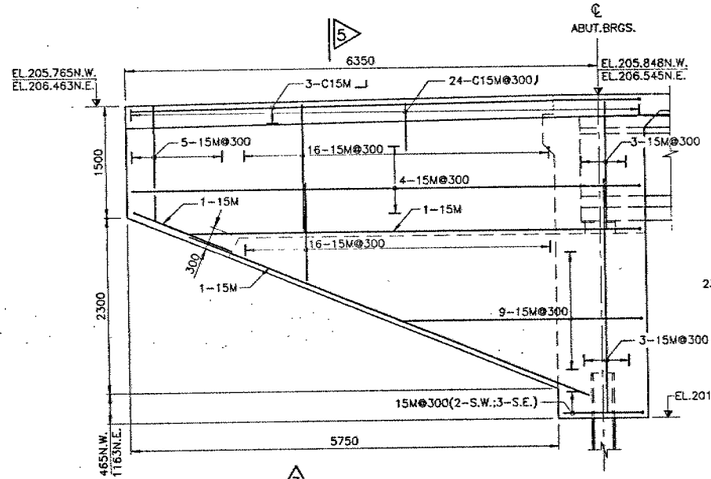
SHEET 98

NOTE:
•THIS DRAWING TO BE READ IN CONJUNCTION WITH DWG.3,5&8.

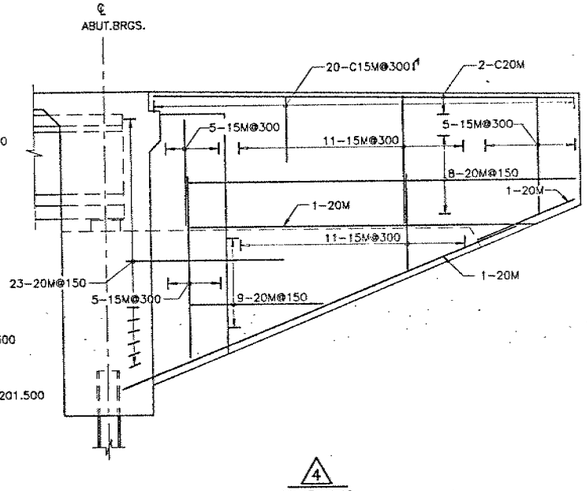


PLAN
SCALE 1:50





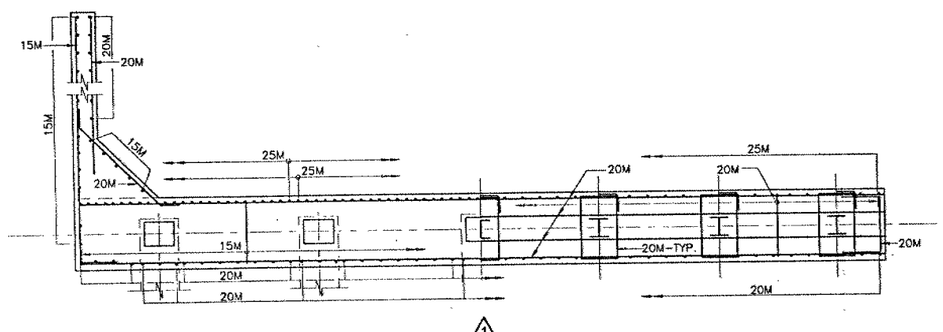
3 SCALE 1:40



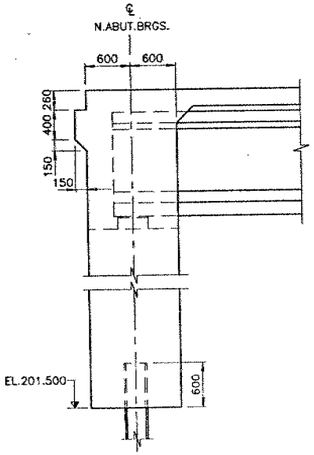
4 SCALE 1:40

ELEVATION	
Ⓐ	205.733
Ⓑ	206.040
Ⓒ	206.275
Ⓓ	204.088
Ⓔ	204.218
Ⓕ	204.347
Ⓖ	204.477
Ⓗ	204.606

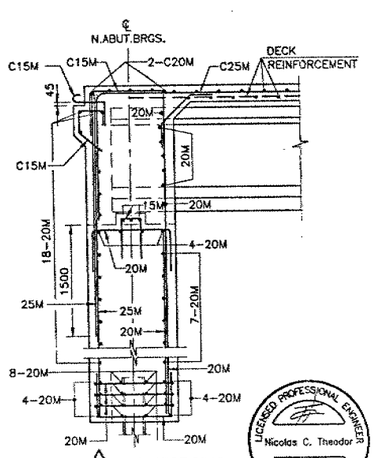
ELEVATION
SCALE 1:50



1 SCALE 1:50



2 -DIMENSIONS
SCALE 1:40



2 -REINFORCING
SCALE 1:40

LICENSED PROFESSIONAL ENGINEER
Nicolas C. Theodor
Dec. 96
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
N.J.PATEL
DEC. 96
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

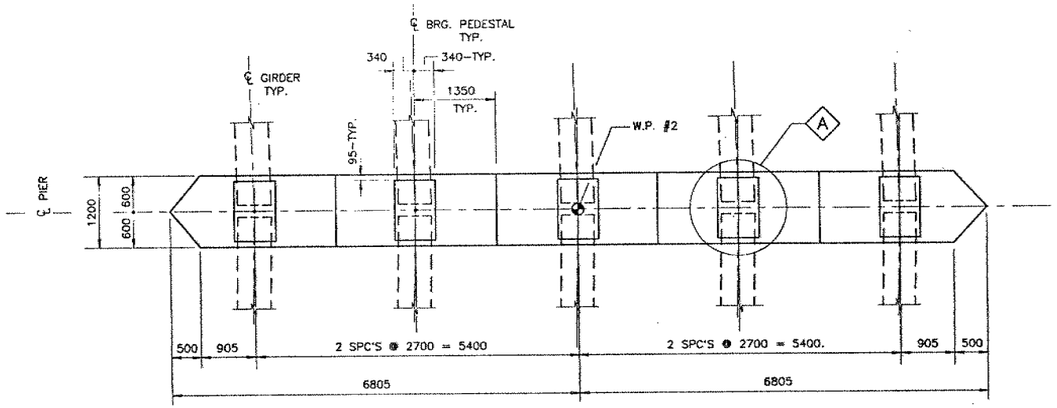
REVISIONS	DESCRIPTION					
DESIGN N.C.T.	CHK N.J.P.	CODE OHBDC'91	LOAD CL.-A	DATE MAY 1996		
DRAWN J.O.	CHK N.C.T.	SITE 5-85	STRUCT	SCHEME	DWG 4	

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

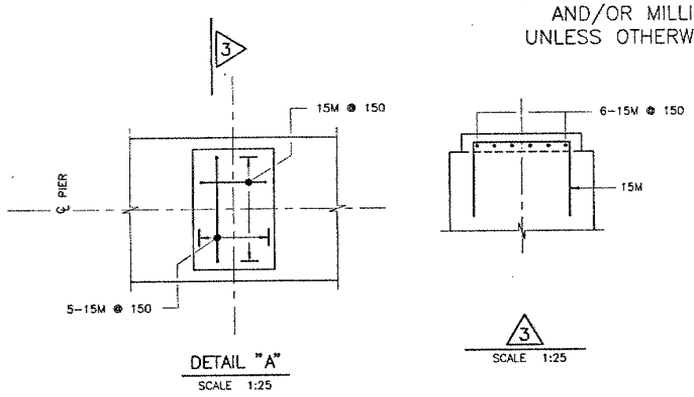
DIST
CONT No
WP No 91-84-03

KETTLE CREEK BRIDGE
(NORTH)
PIER

SHEET
99



PLAN
SCALE 1:50



DETAIL "A"
SCALE 1:25

3
SCALE 1:25

PILE NOTES:

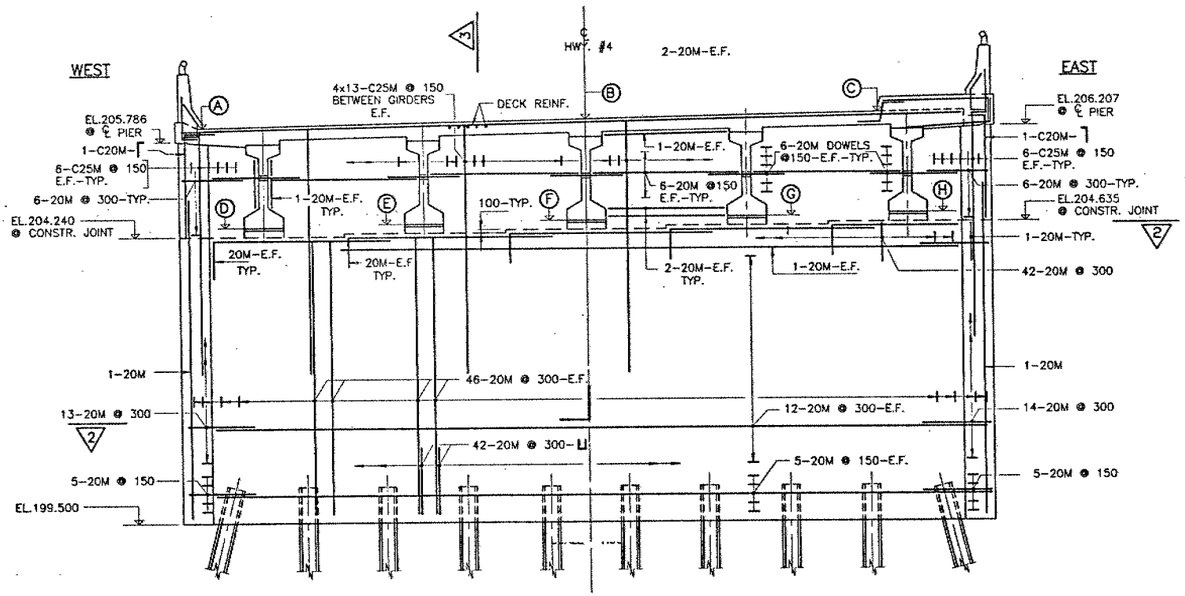
1. ALL PILES TO BE HP310x110 STEEL 'H' PILES.
2. PILES TO BE ORIENTED WITH THE STRONG AXIS IN THE DIRECTION OF BENDING AT THE ABUTMENTS AND WITH THE WEAK AXIS IN THE DIRECTION OF BENDING AT THE PIER.
3. PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS103-11 USING AN ULTIMATE CAPACITY OF 3450kN/PILE FOR THE SOUTH ABUTMENT, PIER AND NORTH ABUTMENT.
4. PILES TO BE LOWERED INTO 600mm DIA. PRE-AUGERED HOLES TO ELEVATION 195.000 AND THEN DRIVEN TO ELEVATION SHOWN.
   THE ANNULAR SPACE BETWEEN ELEVATION 195.000 AND ELEVATIONS 198.100, 196.500 AND 198.500 FOR THE SOUTH ABUTMENT, PIER AND NORTH ABUTMENT RESPECTIVELY SHALL BE FILLED WITH CONCRETE.
   THE REMAINING ANNULAR SPACE TO BE FILLED WITH FINE TO MEDIUM GRAINED UNIFORMLY GRADED LOOSE SAND.
5. NO ATTEMPT SHALL BE MADE TO DRIVE PILES BELLOW EL.190.000. — Not required
6. PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTH BELLOW CUT-OFF ELEVATION.
7. ALL PILES TO HAVE DRIVING SHOES.
8. PILE SPACING TO BE MEASURED AT UNDERSIDE OF ABUTMENTS OR PIER.

PILE DATA

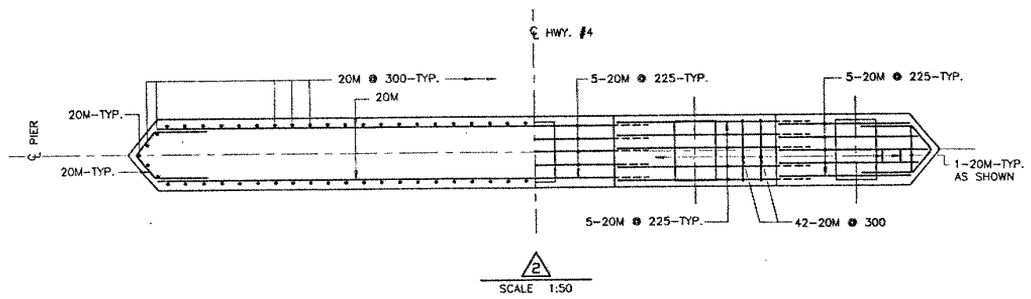
LOCATION	NO. REQ'D.	BATTER	CUT-OFF ELEV.	LENGTH
SOUTH ABUT.	2	1:5	EL.201.700	7900 ✓
	5	VERT.		7700 ✓
PIER	2	1:5	EL.200.100	6300 ✓
	8	VERT.		6100 ✓
NORTH ABUT.	2	1:5	EL.202.100	10300 ✓
	5	VERT.		10100 ✓

PILE DESIGN DATA

LOCATION	CAPACITY @ SLS(kN)	CAPACITY @ ULS(kN)
SOUTH ABUT.	1150	1600
PIER	1150	1600
NORTH ABUT.	1150	1600



ELEVATION
SCALE 1:50



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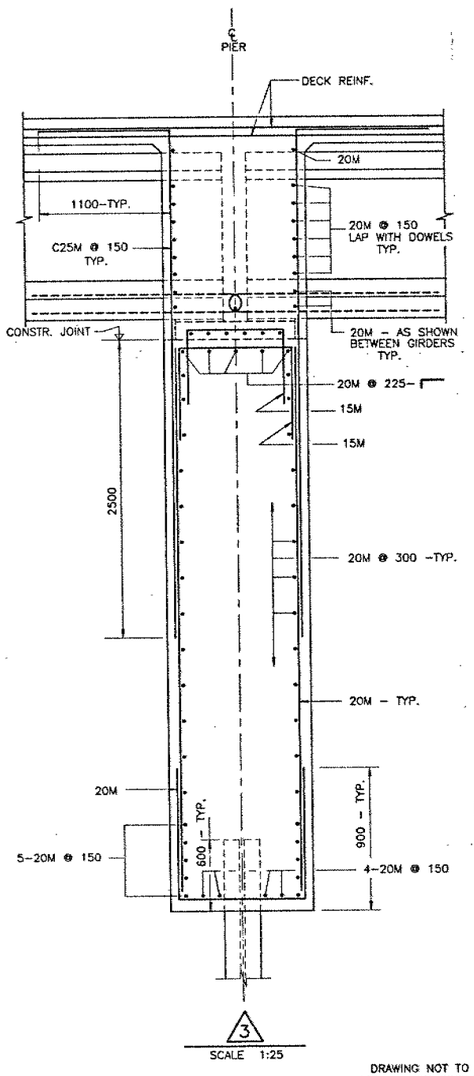


SCALE 1:25

LICENSED PROFESSIONAL ENGINEER
Nicolas C. Theodor
Dec. 96
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
N.J.PATEL
DEC. 96
PROVINCE OF ONTARIO

	ELEVATIONS	
A	EL.206.021	@ TOP OF CONC. DECK
B	EL.206.256	
C	EL.206.437	
D	EL.204.365	@ UNDERSIDE OF GIRDERS
E	EL.204.464	
F	EL.204.563	
G	EL.204.663	
H	EL.204.762	

APPLICABLE STANDARD DRAWINGS:

OPSD-3301.00 SPLICE AND DRIVING SHOE DETAILS FOR STEEL 'H'-PILES.

OPSD-3923.00 SUPPORTS FOR REINFORCING STEEL

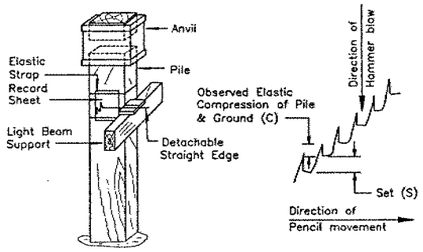
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING.

REVISIONS | DESCRIPTION

DESIGN N.C.T. | CHK N.J.P. | CODE OH3DC-'91 | LOAD | DATE MAY,1996
DRAWN A.A. | CHK N.C.T. | SITE 5-65 | STRUCT | SCHEME | DWG 5

HAMMERS		
TYPE	MASS OF RAM W Kilograms	MAXIMUM ENERGY Joules/blow
9B3	726	12419
10B3	1361	16948
50C	2268	20337
11B3	2268	26005
D12	1250	30506
B225	1360	39300
LB520	2300	40675
B300	1700	46100
D22	2200	53826
B400	2268	62400
D22-02	2200	67000
D22-13	2200	67000
D30-02	3000	91000
D30-13	3000	91000
B500	3129	107100
D36-02	3600	115000
D36-13	3600	115000

NOTE:
Ram may also be referred to as Piston



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 91-84-03

KETTLE CREEK BRIDGE
(NORTH)
PILE DRIVING-STEAM & DIESEL HAMMERS

SHEET 107

METHOD OF APPLYING THE HILEY FORMULA

$R = \frac{nWgh}{S + c/2}$ (Hiley Formula) g = 9.80665 m/s

Where R = Ultimate pile capacity in kilonewtons
S = Measured penetration of pile per hammer blow in millimetres
C = Measured rebound of pile per hammer blow in millimetres
Wgh = Energy of hammer blow in joules
n = Efficiency of blow = $\frac{W + Pe^2}{W + P}$
where e = 0.32 for steel (These values of e have been
= 0.25 for timber determined by experiment)
P = Mass of pile + anvil in kilograms
W = Mass of ram (piston) in kilograms
The P/W curves form the required reduction of total energy of the hammer blow according to the value of P/W

L = R/Q kilonewtons
Where L = Design capacity of pile
Q = Factor of safety
Use Q = 3 unless otherwise authorized by the Engineer

EXAMPLE 1:

Steel tube pile, O D = 323.90mm linear density = 49.73 kg/m,
20m long plus anvil of mass 600 kg, giving P = 994.6+600 = 1594.6 kg

Delmag D12 hammer W = 1250 kg $P/W = \frac{1594.6}{1250} = 1.28$

Observed measured rebound C = 10 mm
Observed measured penetration S = 5 mm

USING CHART: With C = 10 proceed horizontally to right to cut line S = 5 then vertically down to cut curve D12 then horizontally to left to cut P/W = 1.28 then vertically down to read ultimate capacity R = 1512 kN $L = \frac{1512}{3} = 504$ kN

EXAMPLE 2:

HP 310x110, 50 m long plus anvil of mass 600 kg giving
P = 5500+600 = 6100 kg. The hammer is Delmag D22-13
W = 2200 kg, $n = \frac{W + Pe}{W + P}^2 = \frac{2200 + (6100 \times 0.32 \times 0.32)}{2200+6100} = \frac{2824}{8300} = 0.34$

Energy of hammer (Wgh) = 67000 J/blow
Observed measured rebound C = 10 mm
Observed measured penetration S = 5 mm

USING HILEY FORMULA:

Ultimate capacity $R = \frac{nWgh}{S + c/2}$ kN $= \frac{0.34 \times 67000}{10} = 2278$ kN

Design capacity $L = \frac{2278}{3} = 759$ kN

NOTE 1:

These charts are designed to cover most cases which will be encountered on normal construction projects. Occasionally it will be found that R cannot be obtained from the charts, for instance when C = 5 mm and S = 2 mm using a Delmag D22 hammer. In such cases it will be necessary to calculate R using the original equation $R = \frac{nWgh}{S + c/2}$

In cases where the energy of the hammer being used is slightly different from the hammer energy for which curves are drawn the curves may still be used but the result should be reduced or increased according to the energy ratios. Example use Linkbelt 520 curve (Energy 40675 J) for Berminghammer 225 (Energy 39300 J) but reduce result by multiplying by $\frac{39300}{40675}$

NOTE 2:

For Projects designed to the OHBDC, the ultimate capacity (R) is shown on the contract drawings and L and Q are not required.

STANDARD DRAWING JULY 1981	SS 103-11

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN STD	CHK	CODE OHBDC-'91	LOAD		DATE MAY, 1996		
DRAWN STD	CHK	SITE 5-65	STRUCT	SCHEME	DWG 13		

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 97-12

Ontario

Ministry of
Transportation

INDEX

Note: 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.

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

FOUNDATION INVESTIGATION REPORT

For

Kettle Creek Replacement Bridge (North)

W.P. 91-84-03; Site 5-65

Highway 4, District 31, London

INTRODUCTION

This report contains the results of a foundation investigation carried out at the north crossing of Kettle Creek and Highway 4. The fieldwork for the first phase of this investigation was carried out between 1994 05 03 and 1994 05 05. Upon finalization of the type of structure and the location of the bailey bridge, the fieldwork for the second phase was carried out between 1995 03 20 and 1995 03 22. The fieldwork comprised of nine sampled boreholes and Dynamic Cone Penetration Test adjacent to four of these holes. In addition, Dynamic Cone Penetration Test was carried out at one location.

Boreholes were advanced to a maximum depth of 24.3 m (El. 181.7) below the existing road level using a 82 mm I.D. continuous flight hollow stem auger.

SITE DESCRIPTION

The site under investigation is located on Highway 4, approximately 6 km south of Highway 3 at the boundary of City of St. Thomas and Township of Yarmouth in the County of Elgin.

The river valley is relatively flat on the north side, however, the south bank is about 7.5 m deep at this point. The width of the creek along the centreline of Highway 4 is approximately 26 m and during peak flood, the depth of the water is expected to be about 3.5 m at the deepest location.

A succession of ridges and valleys lies in the County of Elgin. The ridges are moraines of calcareous clay or silty clay while in the valley it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

The subsurface conditions at the bailey bridge location, with the exception of upper 2.6 m to 2.9 m, is similar to that was encountered at the structure site. The subsoil conditions are discussed separately to differentiate one from the other. The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report.

Replacement Bridge

The soil stratigraphy within upper 1.2 m to 6.6 m varies from location to location. The underlying subsoil consists of 1.2 m to 4.7 m firm to stiff clayey silt fill with varying proportions of sand and gravel overlying 4.4 m to 9.6 m very dense heterogeneous mixture of silt, sand and gravel (glacial till). However, the boreholes located on the south side of the creek indicated presence of 4.8 m to 5.8 m stiff to very stiff silty clay immediately below the fill. The boreholes located on the north side of the creek revealed presence of 1.4 m to 2.5 m compact gravelly sand immediately below the fill and topsoil. The silty clay and gravelly sand deposits are underlain by 4.5 m to 9.6 m very dense heterogeneous mixture of silt, sand and gravel (glacial till). The non cohesive glacial till layer is underlain by hard heterogeneous mixture of clayey silt, sand and gravel (glacial till) which extends to the full depth probed. For classification purposes, the soils encountered at this site can be divided into five different zones.

a) Clayey Silt/Silty Sand (Fill)
b) Silty Clay, Some Sand, Trace of Gravel
c) Gravelly Sand, Some Silt
d) Heterogeneous Mixture of Silt, Sand and Gravel (Non Cohesive Glacial Till)
e) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Cohesive Glacial Till)

A stratigraphical profile section is shown on Drawing No. 918403-A* This drawing also shows the location and elevation of the borings. Description of the strata encountered at this site are given below.

Clayey Silt/Silty Sand (Fill)

The composition of the fill which was placed to raise the finished grade of Highway 4 varies from location to location. The boreholes located near the abutments indicated presence of silty sand to sandy silt with varying proportions of gravel content. The thickness of this granular fill varies from 0.8 m to 4.0 m. The Standard Penetration Test results in this fill varies from 7 blows/0.3 m to 18 blows/0.3 m indicating loose to compact state of denseness.

However, the borehole located away from the abutments indicated the presence of clayey silt to silty clay fill with varying proportions of sand and gravel sized particles. The thickness of this clayey fill varies from 1.2 m to 4.7 m. The Standard Penetration Test values were observed to vary from 7 blows/0.3 m to 15 blows/0.3 m. The consistency may be classified as firm to stiff.

Silty Clay, Some Sand, Trace of Gravel

This silty clay deposit was encountered immediately below the fill in boreholes located on the south side of the creek. The thickness of this deposit varies from 4.8 m to 5.8 m and extends to elevations 200.0 to 199.4. The natural moisture content was observed to vary from 21% to 33% with an average value of 26.2%. The Atterberg Limits determined for the representative soil samples of this deposit are shown on Figure 1. Based on Standard Penetration Test results (N-values 8 blows/0.3 m to 22 blows/0.3 m), the consistency may be classified as stiff to very stiff.

Gravelly Sand, Some Silt

This gravelly sand deposit was encountered only in boreholes located north of the creek. The thickness of the deposit varies from 1.4 m to 2.5 m and extends to elevations 199.2 to 198.8. The Standard Penetration Test results in this deposit (10 blows/0.3 m to 11 blows/0.3 m) indicate compact state of denseness.

* Dwg. No 2, Sheet 96, of the Contract Drawings.

Heterogeneous Mixture of Silt, Sand and Gravel (Non Cohesive Glacial Till)

The gravelly sand and silty clay deposits are underlain by this heterogeneous mixture of silt, sand and gravel strata. The thickness of this glacial till strata varies from a minimum of 4.4 m to a maximum of 9.6 m and extends to elevations 195.5 to 189.2. The Gradation Test carried out on representative soil samples are shown on Figure 2 in an envelope form. The test results indicate 3% to 28% gravel, 37% to 43% sand and 35% to 56% silt and clay sized particles. The Standard Penetration Test results indicate very dense state of denseness (N values 55 blows/0.3 m to over 100 blows/0.3 m.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Cohesive Glacial Till)

The upper boundary of this cohesive glacial till deposit was encountered between elevations 195.5 and 189.2. The natural moisture content was observed to vary from 5% to 9% with an average value of 7.4%. The Atterberg Limits determined for the representative soil samples are shown on Figure 3. The results of the Gradation Test are shown on Figure 4 in an envelope form. The results indicate 7% to 49% gravel, 22% to 38% sand and 29% to 60% clayey silt. The Standard Penetration Test values vary from 70 blow/0.3 m to over 100 blow/0.3 m indicating hard consistency. The full extent of this deposit was not proven below elevation 181.7.

Groundwater Conditions

The groundwater level measurements were taken in open boreholes during the investigation and was observed between elevation 201.5 and 199.7. Seasonal fluctuation of the groundwater level may be expected due to the influence of the creek. The groundwater level at each borehole location is as follows:

Borehole No.	Elevation
1	201.5
2	199.9
3	200.2
4	199.0
101	199.9
102	200.3
103	199.7

Bailey Bridge

The underlying subsoil at this location consists of 2.6 m to 2.9 m very loose to loose sandy silt underlain by 0.7 m to 1.1 m loose to compact gravelly sand which overlies very dense heterogeneous mixture of silt, sand and gravel (glacial till). For classification purposes, the soils encountered at this location can be divided into three different zones.

a) Sandy Silt, Occasional Sand Layers
b) Gravelly Sand, Some Silt
c) Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till)

The location of the borings is shown on Drawing No. 918403-B.* A stratigraphical section is shown on Drawing No. 918403-C.* Description of the soils encountered at this location are given below.

Sandy Silt, Occasional Sand Layers

This sandy silt layer was encountered immediately below the topsoil. The thickness of this layer varies from 2.6 m to 2.9 m and extends to elevations 199.9 to 199.6. The Standard Penetration Test results indicate this sandy silt is in a very loose to loose state of denseness (N- values 2 blows/0.3 m to 7 blows/0.3 m).

Gravelly Sand, Some Silt

The sandy silt layer is underlain by this gravelly sand deposit. The thickness of this deposit varies from 0.7 m to 1.1 m and extends to elevations 198.9 to 198.8. The Standard Penetration Test results vary from 8 blows/0.3 m to 16 blows/0.3 m indicating loose to compact state of denseness.

* Drawings are included in the Appendix.

Heterogeneous Mixture of Silt, Sand & Gravel (Non Cohesive Glacial Till)

The upper boundary of this non cohesive glacial till deposit was encountered between elevations 198.9 and 198.8. The Standard Penetration Test results of this deposit vary from 77 blows/0.3 m to over 100 blows/0.3 m indicating very dense state of denseness. The full extent of this strata was not proven at this location, however, in Borehole 105, this strata is underlain by a cohesive glacial till deposit.

Groundwater Conditions

The groundwater level mesurements were taken in open boreholes during investigation and was observed between elevations 200.0 and 199.7. Seasonal fluctuation of the groundwater level may be expected due to the influence of the creek. The groundwater level at each borehole location is as follows:

Borehole No.	Elevation
104	199.7
105	200.0

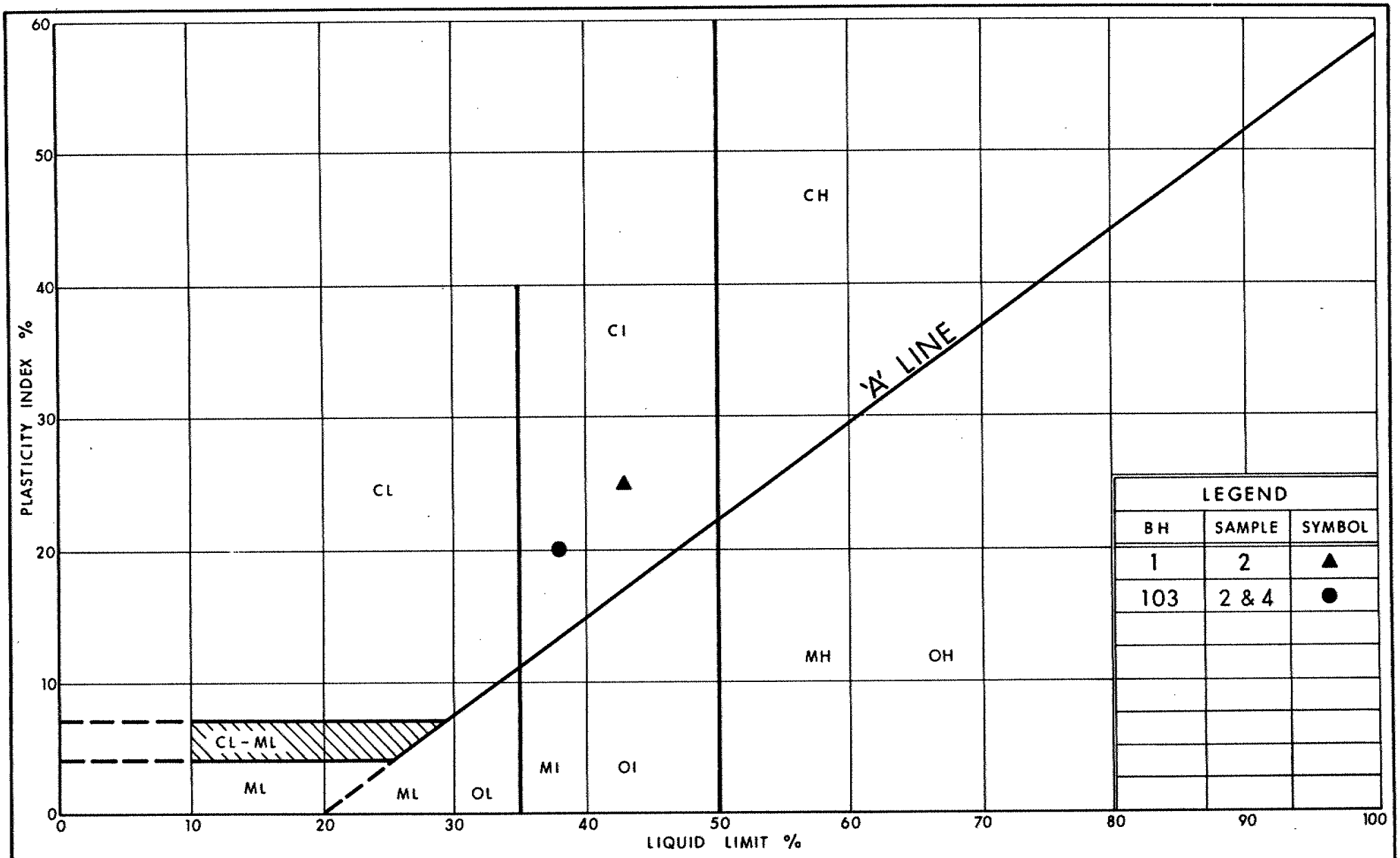
MISCELLANEOUS

The first phase of the fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer. The equipment used was owned and operated by Dominion Soil Investigation Inc.

The second phase of the fieldwork was carried out under the supervision of Tom Hickey and M. Vasavithasan. The equipment used was owned and operated by London Soil Test Ltd. This report was prepared by M. Vasavithasan, Foundation Engineer and reviewed by T.C. Kim, Senior Foundation Engineer.

T.C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX



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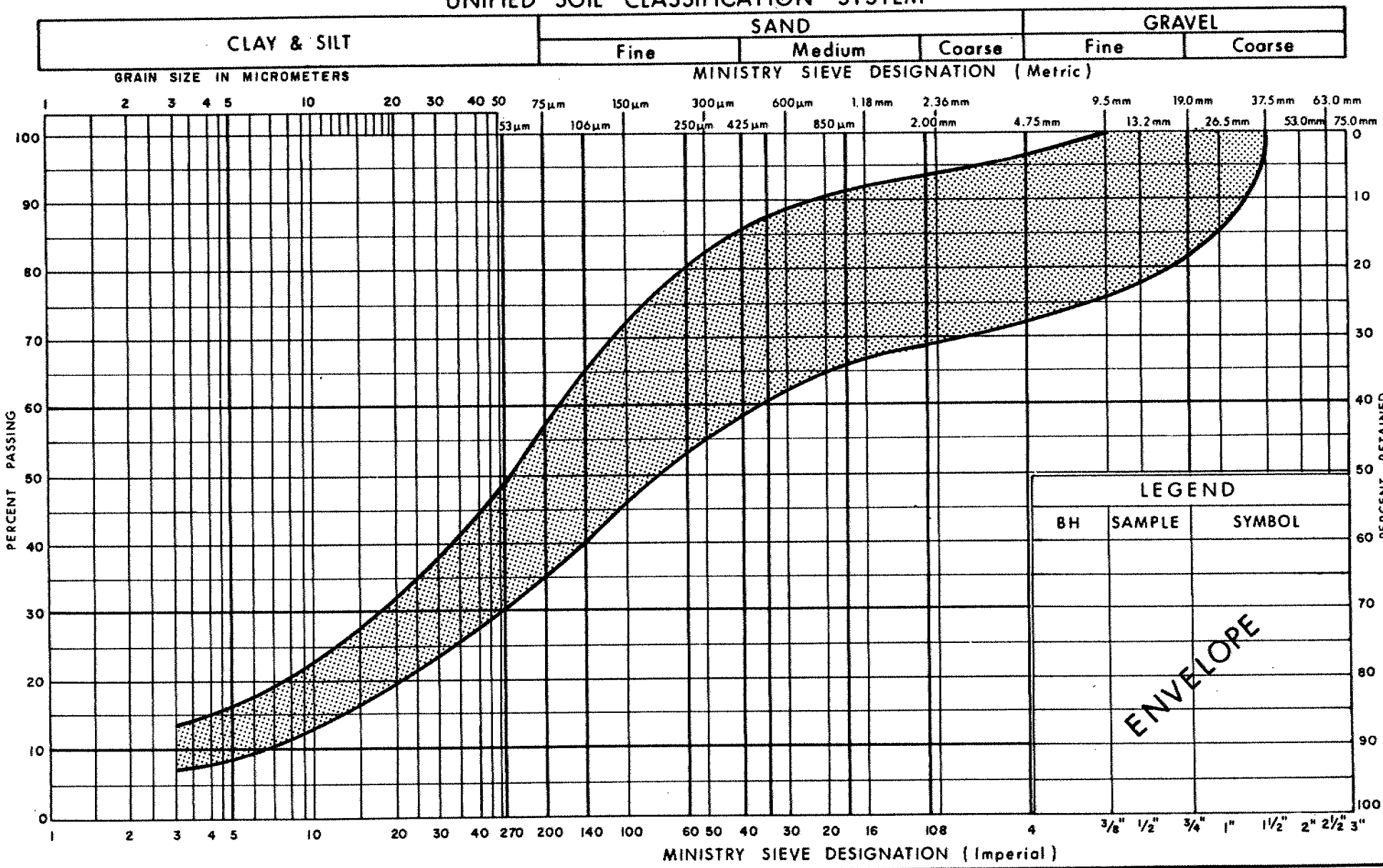
Ontario

PLASTICITY CHART
SILTY CLAY
SOME SAND, TRACE OF GRAVEL

FIG No 1
W P 91 - 84 - 03

UNIFIED SOIL CLASSIFICATION SYSTEM



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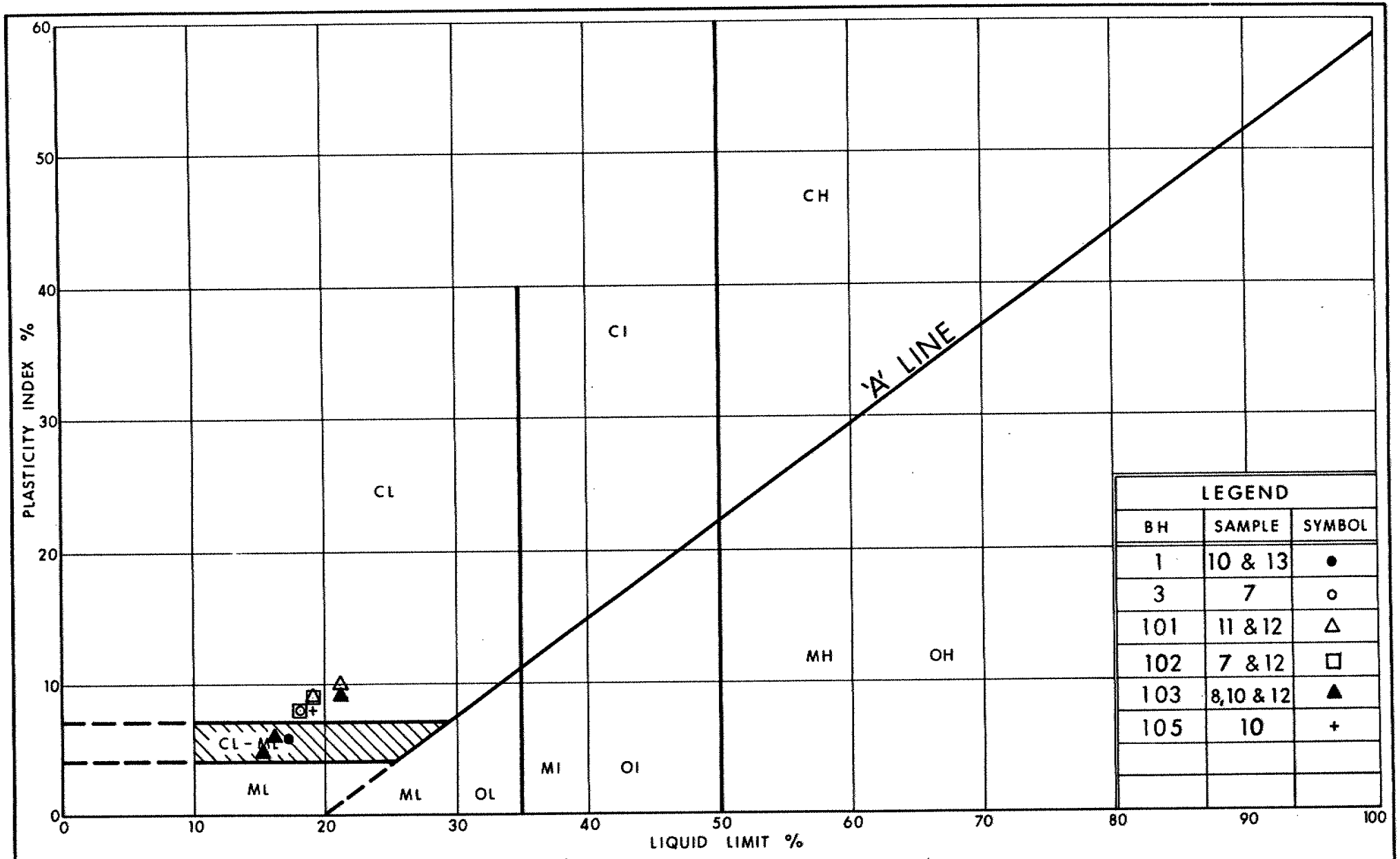
Ontario

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
SILT, SAND & GRAVEL (Glacial Till)

FIG No 2
W P 91-84-03



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PLASTICITY CHART

HETEROGENEOUS MIXTURE OF

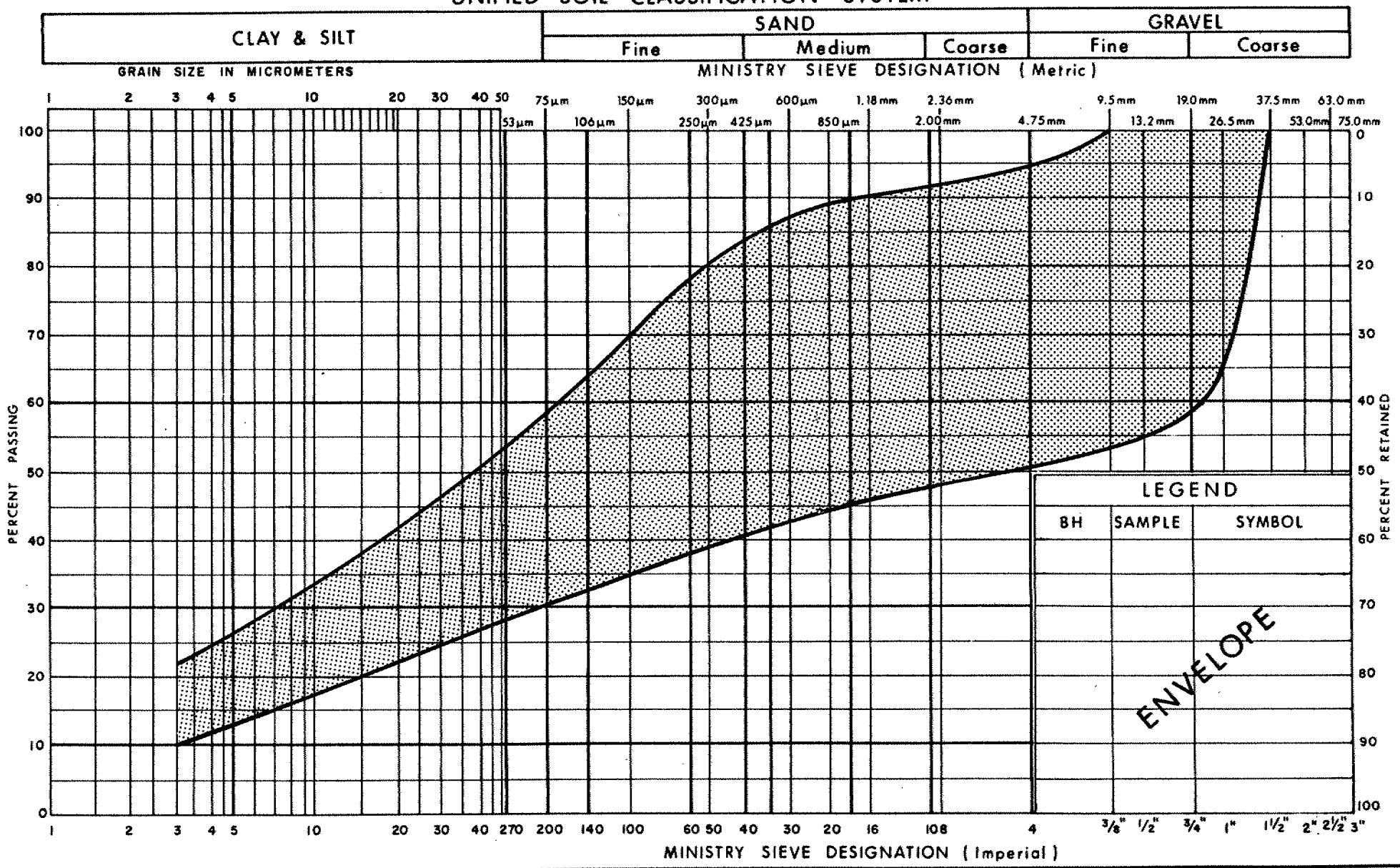
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 91-84-03

14

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4

W P 91-84-03

15

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 91 - 84 - 03 LOCATION CO - ORDS: N 4 737 837.0; E 410 404.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 05 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
206.0	Ground Surface					
0.0 / 205.2	Granular Fill					
0.8	SILTY CLAY, Some Sand, Trace of Gravel, Stiff to Very Stiff	1	SS	11		2 13 37 48
		2	SS	13		
		3	SS	12		
		4	SS	21		
		5	SS	22	▼	
199.4		6	SS	12		
6.6	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)	7	SS	55		
		8	SS	100	/28cm	28 37 25 10
		9	SS	100	/13cm	
193.8		10	SS	100	/10cm	49 22 21 8
12.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)	11	SS	100	/28cm	
		12	SS	100	/25cm	
		13	SS	105		7 33 42 18
		14	SS	100	/18cm	
181.7		15	SS	100	/25cm	
24.3	End of Borehole					

ELEVATION SCALE: 204, 202, 200, 198, 196, 194, 192, 190, 188, 186, 184, 182

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa — ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE — 20 40 60 80 100

120/25cm

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) — 20 40 60

UNIT WEIGHT γ kN/m^3

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 886.5; E 410 383.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 03 CHECKED BY T C K

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 kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.9	Ground surface										
0.0 / 199.4	CLAYEY SILT, Some Sand, Some Organics, Stiff (Fill)		1	SS	10	▼	200				
1.5	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		2	SS	100/18cm						
			3	SS	100/18cm			120/10cm			
			4	SS	100/20cm		198		o		15 41 36 8
			5	SS	100/8cm		196				
195.0			6	SS	100/28cm				o⊣		12 34 36 18
5.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	100/10cm		194		o⊣		6 38 42 14
			8	SS	105		192				
			9	SS	70		190				
			10	SS	107		188				
			11	SS	100/23cm						
			12	SS	102/20cm		186				
182.5			13	SS	100/8cm		184				
18.4	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2A 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 893.0; E 410 397.2 ORIGINATED BY D K
DIST 2 HWY 4 BOREHOLE TYPE CONE TEST COMPILED BY D K
DATUM GEODETIC DATE 94 05 03 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
201.6	Ground Surface										
0.0	Probable Fill						200				
199.0											
2.6	End of Borehole	*						120/ 17cm			
	* Cone Refusal on Probable Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 901.0; E 410 377.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 04 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE)	WATER CONTENT (%) PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.8	Ground Surface							20 40 60 80 100	20 40 60		
0.0 / 199.8	CLAYEY SILT, With Organics, Firm (Fill)		1	SS	7	▼	200				
1.2	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		2	SS	100/5cm			120/	28cm o		
			3	SS	100/20cm						6 42 42 10
			4	SS	100/20cm		198				
			5	SS	103		196				
			6	SS	100/25cm		194				
192.9									o⊢		
7.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	106		192				14 31 34 21
			8	SS	100/18cm						
			9	SS	83		190				
188.4			10	SS	100/25cm						
12.4	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 934.0; E 410 365.6 ORIGINATED BY D K
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY D K
DATUM GEODETIC DATE 94 05 05 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Ground Surface										
0.0 / 204.2	Granular FIII										
0.8	SILTY CLAY, Some Sand, Trace of Gravel, Occasional Organics, Firm to Stiff (FIII)		1	SS	6		204				
			2	SS	7						
			3	SS	13		202				6 19 37 38
			4	SS	15						
199.5			5	SS	7		200				
5.5	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		6	SS	100/18cm	▼			o		3 43 48 6
			7	SS	100/8cm		198				
			8	SS	100/15cm		196				
			9	SS	102						
			10	SS	100/23cm		194		o		6 38 50 6
191.2			11	SS	100/10cm		192				
13.8	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 101 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 919.4; E 410 381.9 ORIGINATED BY M V&T H

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 20 & 21 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.3	Hwy. 4 Shoulder							20 40 60 80 100	20 40 60		
0.0	Clayey Silt		1	SS	7		204				
	SILTY SAND TO SANDY SILT, Occasional Organics, Loose (Fill)		2	SS	7		202				
201.3											
4.0	GRAVELLY SAND, Some Silt, Occasional Organics, Compact		3	SS	10	▼	200				
198.8			4	SS	62						
6.5			5	SS	90	/15cm	198				
			6	SS	135		196				
	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		7	SS	65		194				
			8	SS	84	/15cm	192				
			9	SS	120	/20cm					
			10	SS	104	/10cm	190				
189.2											
16.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		11	SS	90	/15cm	188		o		
186.6			12	SS	150				o		
18.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 102 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 893.7; E 410 405.1 ORIGINATED BY M V
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 95 03 20 CHECKED BY T C K

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
202.0	Ground Surface										
0.0 / 200.6	Organics / SILT, Tr. of Sand, Tr. of Clay, Loose										
1.4 / 199.2	GRAVELLY SAND, Some Silt, Compact		1	SS	11	▼	200				
2.8	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		2	SS	104	/15cm	198				
			3	SS	86	/15cm					
			4	SS	104		196				
			5	SS	163		194				
192.2			6	SS	112	/13cm					
9.8	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	91		192				
			8	SS	124		190				
			9	SS	106	/15cm	188				
			10	SS	128		186				
			11	SS	126	/15cm					
183.4			12	SS	84	/15cm	184				
18.6	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 103 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 850.0; E 410 407.0 ORIGINATED BY M V&T H
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 95 03 21 & 22 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
206.0	Hwy. 4 Northbound Lane						
0.0	Asphalt						
204.8	SILTY SAND, Some Gravel, Compact (Fill)		1	SS	18		
1.2	Organics		2	SS	9		204
	SILTY CLAY, Some Sand, Trace of Gravel, Stiff		3	SS	8		
			4	SS	10		202
200.0			5	SS	108/13cm	▼	200
6.0	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		6	SS	111/20cm		198
			7	SS	100/15cm		196
195.5			8	SS	155		
10.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	100/10cm		194
			10	SS	100/15cm		192
			11	SS	159/23cm		190
							188
185.9			12	SS	90/13cm		186
20.1	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 104 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION See PLAN of Proposed Bailey Bridge ORIGINATED BY M V

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 21 CHECKED BY T C K

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 kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
202.5	Ground Surface										
0.0	Tr. Organics						202				
	SANDY SILT, Occasional sand Layers, Very Loose to Loose		1	SS	6						
			2	SS	2						
199.6			3	SS	4	▼	200				
2.9	GRAVELLY SAND, Some Silt, Occasional Organics, Loose		4	SS	8						
3.6			5	SS	78						
			6	SS	83		198				
			7	SS	93						
							196				
	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		8	SS	99						
			9	SS	92		194				
			10	SS	56		192				
189.9			11	SS	119		190				
12.6	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 105 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION See PLAN of Proposed Bailey Bridge ORIGINATED BY M V

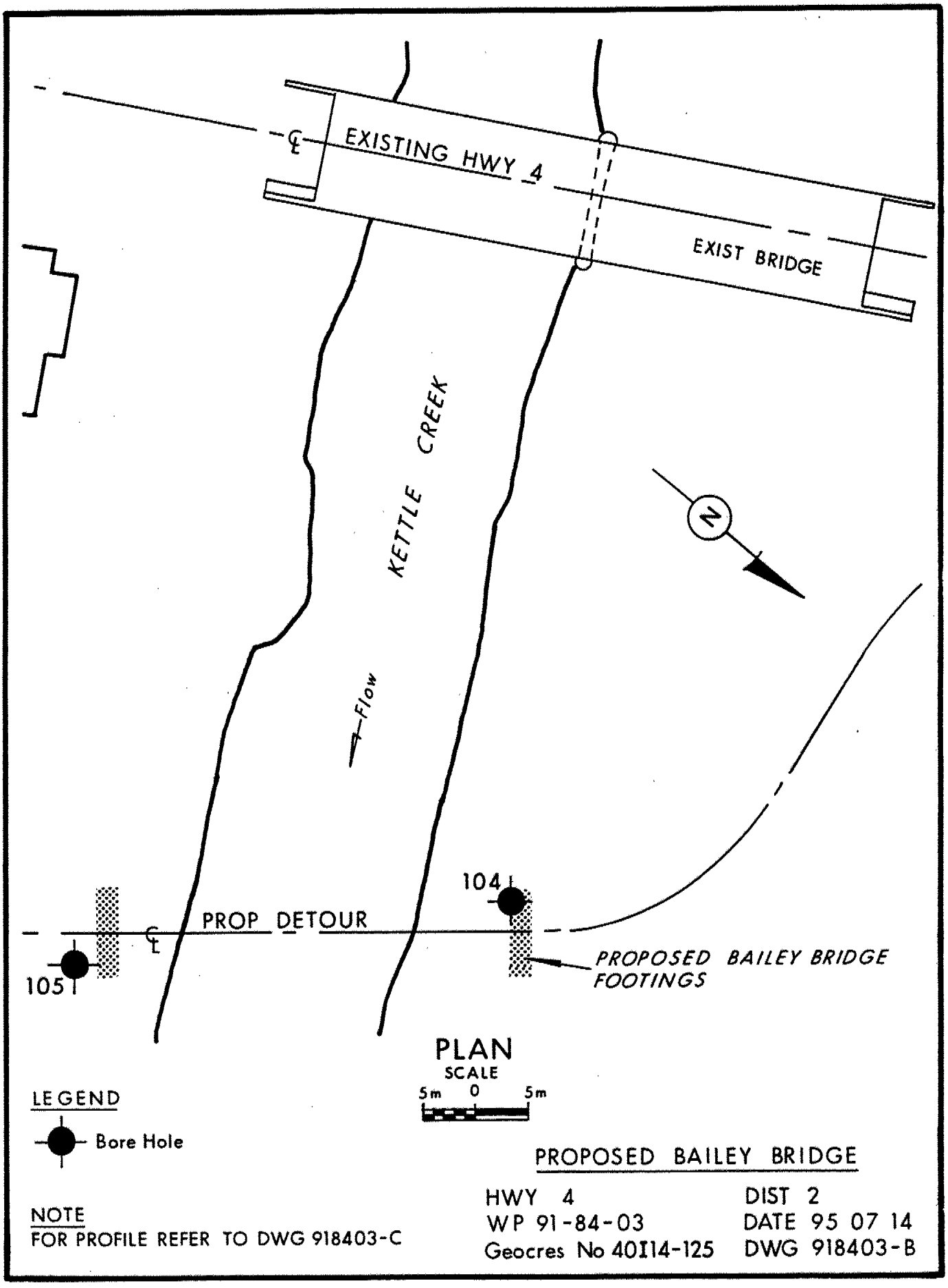
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 22 CHECKED BY T C K

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 kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
202.5	Ground Surface										
0.0	Organics						202				
	SANDY SILT, Occasional Sand Layers, Loose		1	SS	7						
			2	SS	5						
199.9			3	SS	5	▼	200				
2.6	GRAVELLY SAND, Some Silt, Compact		4	SS	16						
198.8											
3.7			5	SS	105						
			6	SS	102	/10cm	198				
	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		7	SS	107		196				
			8	SS	77						
193.0			9	SS	79		194				
9.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		10	SS	126		192		o⊢		
190.0			11	SS	119	/15cm					
12.5	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10



PLAN

SCALE

5m 0 5m

LEGEND

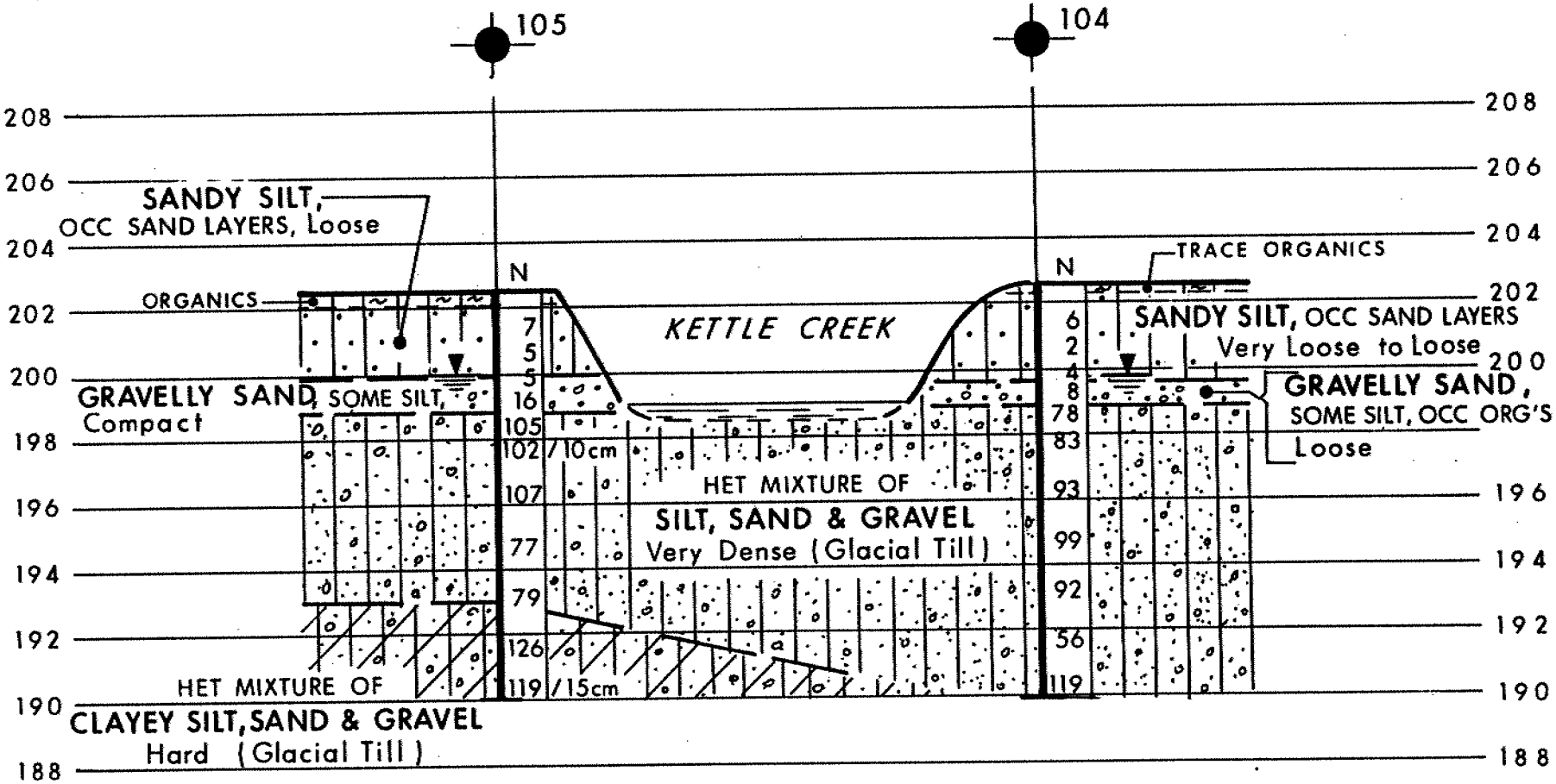
Bore Hole

NOTE

FOR PROFILE REFER TO DWG 918403-C

PROPOSED BAILEY BRIDGE

HWY 4	DIST 2
WP 91-84-03	DATE 95 07 14
Geocres No 40I14-125	DWG 918403-B



℄ PROFILE PROPOSED DETOUR

SCALES

5m 0 5m HOR

2m 0 2m VERT

LEGEND

Bore Hole

WL at time of investigation 95 03

NOTE

FOR PLAN REFER TO DWG 918403-B.

PROPOSED BAILEY BRIDGE

HWY 4 DIST 2

WP 91-84-03 DATE 95 07 14

Geocres No 40I14-125 DWG 918403-C

FOUNDATION INVESTIGATION REPORT

For

Kettle Creek Replacement Bridge (South)

W.P. 91-84-04; Site 5-66

Highway 4, District 31, London

INTRODUCTION

This report contains the results of a foundation investigation carried out at the south crossing of Kettle Creek and Highway 4. The fieldwork for the first phase of this investigation was carried out between 1994 05 06 and 1994 05 11. Upon finalization of the type of structure, the fieldwork for the second phase was carried out between 1995 03 22 and 1995 03 24. The fieldwork comprised of eight sampled boreholes and Dynamic Cone Penetration Test adjacent to three of these holes. In addition, Dynamic Cone Penetration Test was carried out at two locations.

Boreholes were advanced to a maximum depth of 15.7 m (El. 187.3) below the existing road level using a 82 mm I.D. continuous flight hollow stem auger.

SITE DESCRIPTION

The site under investigation is located on Highway 4, approximately 6.5 km south of Highway 3 at the boundary of City of St. Thomas and Township of Yarmouth in the County of Elgin.

A succession of ridges and valleys lies in the County of Elgin. The ridges are moraines of calcareous clay or silty clay while in the valley, it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

The soil stratigraphy within the upper 2.7 m to 7.9 m varies from location to location. The subsoil at this site consists of 3.8 m to 4.3 m firm to very stiff clayey silt fill underlain by 4.7 m to 7.5 m firm to very stiff clayey silt with varying proportions of sand and gravel sized particles which overlies 4.7 m to 6.9 m hard heterogeneous mixture of clayey silt, sand and gravel (glacial till). In some boreholes, 2.7 m to 3.9 m very loose to compact silty sand with occasional gravelly sand layer was encountered immediately below the topsoil or fill. For classification purposes, the soils encountered at this site can be divided into four different zones.

a) Clayey Silt, Some Sand, Trace of Gravel (Fill)

b) Clayey Silt, Trace of Sand, Trace of Gravel

c) Silty Sand, Some Gravel

d) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

A stratigraphical profile section is shown on Drawing No. 918404-A.* This drawing also shows the location and elevation of the borings. Description of the strata encountered at this site are given below.

Clayey Silt, Some Sand, Trace of Gravel (Fill)

The fill which was placed to raise the grade of Highway 4 consists of clayey silt with varying proportions of sand and gravel sized particles. The thickness of this fill varies from 3.8 m to 4.3 m and extends to elevations 201.2 to 200.7. The Standard Penetration Test results were observed to vary over a wide range (4 blows/0.3 m to 21 blows/0.3 m). The consistency may be classified as firm to very stiff.

Clayey Silt, Trace of Sand, Trace of Gravel

This clayey silt deposit was encountered in all the boreholes with the exception of boreholes 2, 5 and 103, immediately below the silty sand or topsoil. In boreholes 2, 5 & 103, it was encountered immediately below the fill. The thickness of this deposit varies from a minimum of 1.6 m to a maximum of 7.5 m and extends to elevations 196.0 to 193.1. The natural moisture content varies

* Dwg. No. 2, Sheet 81, of the Contract Drawings.

from 14% to 23.5% with an average value of 20.4%. The Atterberg Limits determined for the representative soil samples of this deposit are shown on Figure 1. The Standard Penetration Test results were observed to vary over a wide range (4 blows/0.3 m to 25 blows/0.3m). Based on these values, the consistency may be classified as firm to very stiff.

Silty Sand, Some Gravel

This silty sand deposit was encountered only in three boreholes (1, 4, & 102) immediately below the topsoil or fill. Occasional gravelly sand layer varying in thickness from 0.4 m to a maximum of 1.3 m was also intercepted in this deposit. The thickness of the silty sand deposit varies from 2.7 m to 3.9 m and extends to elevations 198.1 to 197.1. The Standard Penetration Test values vary from 2 blows/0.3 m to 26 blows/0.3 m indicating very loose to compact state of denseness.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

The upper boundary of this cohesive glacial till deposit was encountered between elevations 196.0 to 193.1. The natural moisture content was observed to vary from 6% to 12% with an average value of 8.5%. The Atterberg Limits determined for the representative soil samples are shown on Figure 2. The results of the Gradation Test are shown on Figure 3 in an envelope form. The results indicate 5% to 26% gravel, 26% to 43% sand and 42% to 69% clayey silt. The Standard Penetration Test values vary from 33 blows/0.3 m to over 100 blows/0.3 m indicating hard consistency. The full extent of this deposit was proven only in boreholes 3 & 102. The thickness of this deposit varies from 4.7 m to a maximum of 6.9 m and extends to elevation 188.4 to 187.9.

The glacial till deposit is underlain by gravelly sand to sand layer and the full extent of this layer was not explored due to the presence of artesian conditions below elevations 188.4 to 187.9.

Groundwater Conditions

The groundwater level measurements were taken in open boreholes during the investigation and was observed between elevation 200.0 to 198.4.. Artesian condition was encountered in boreholes No. 3 and 102 at about elevations 187.9 and 188.4, respectively. Seasonal fluctuation of the groundwater level may be expected due to the influence of the creek. The groundwater level at each borehole location is as follows:

Borehole No.	Elevation	Remarks
1	198.8	
2	198.5	
3	-	Artesian at El. 201.7
4	199.3	
5	198.4	
101	200.0	
102	-	Artesian at El. 200.4
103	198.5	

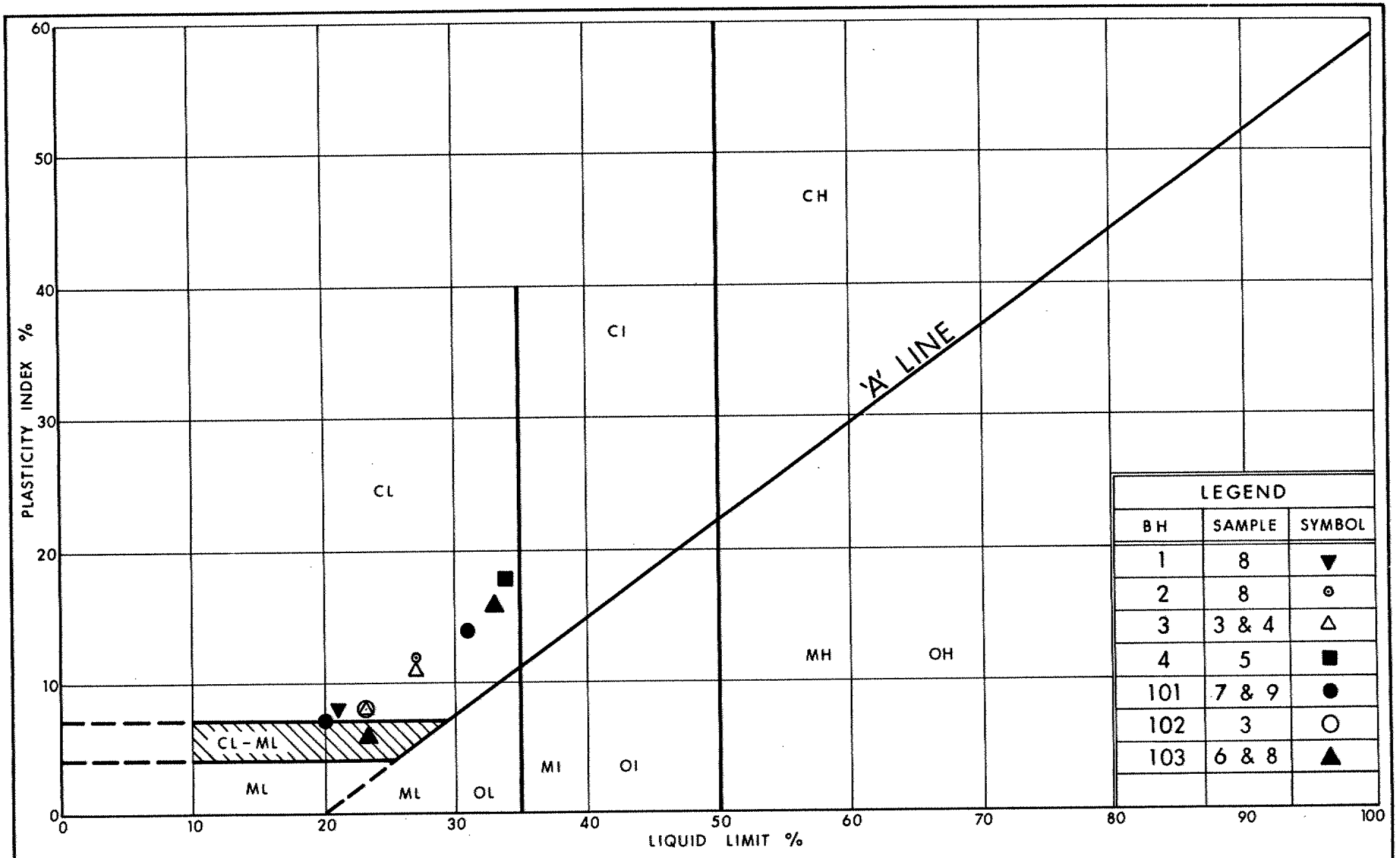
MISCELLANEOUS

The first phase of the fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer. The equipment used was owned and operated by Dominion Soil Investigation Inc.

The second phase of the fieldwork was carried out under the supervision of Tom Hickey and M. Vasavithasan. The equipment used was owned and operated by London Soil Test Ltd. This report was prepared by M. Vasavithasan, Foundation Engineer and reviewed by T.C. Kim, Senior Foundation Engineer.

T.C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX



LEGEND		
BH	SAMPLE	SYMBOL
1	8	▼
2	8	⊙
3	3 & 4	△
4	5	■
101	7 & 9	●
102	3	○
103	6 & 8	▲

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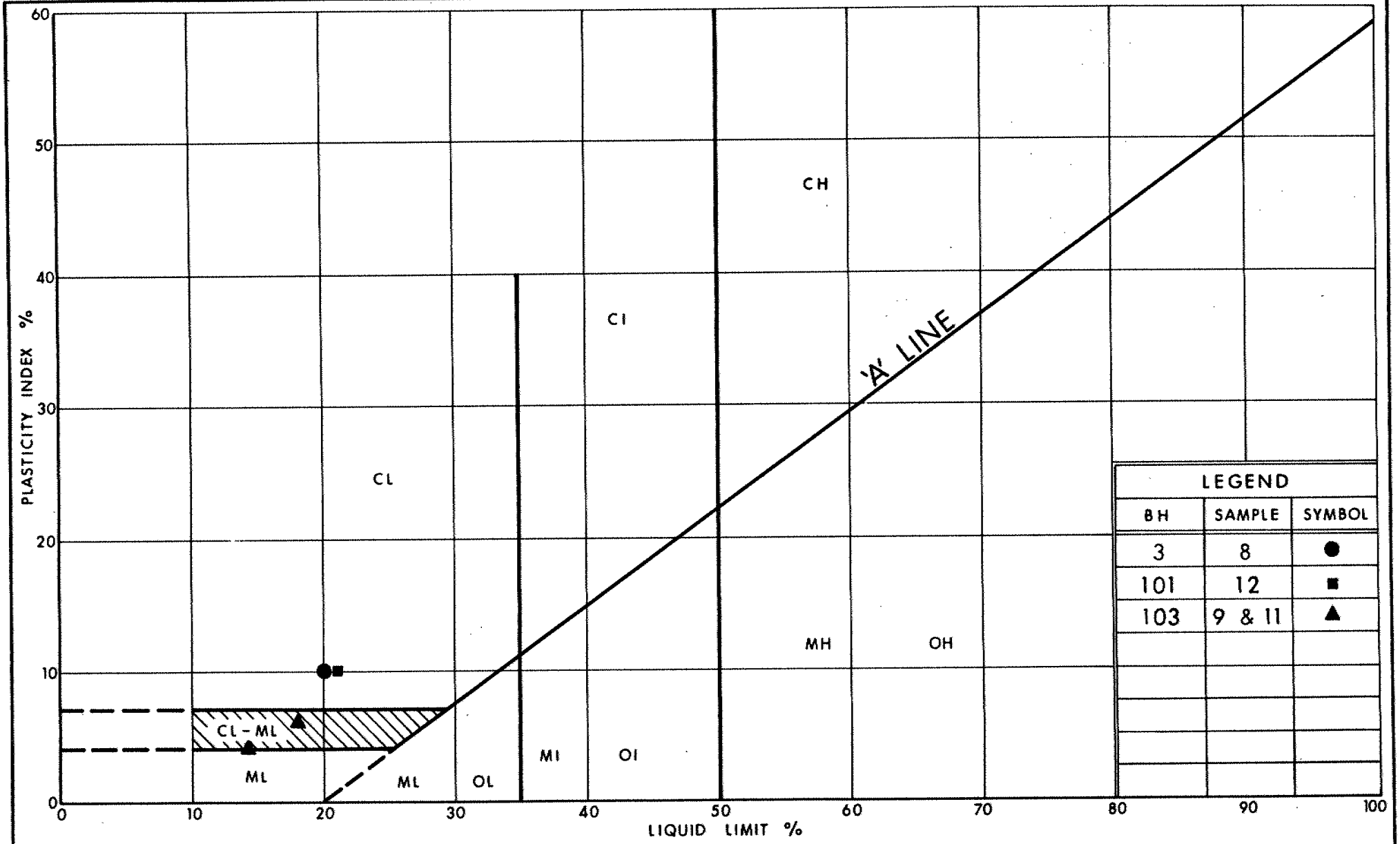
Ontario

PLASTICITY CHART
CLAYEY SILT
TRACE OF SAND, TRACE OF GRAVEL

FIG No 1
W P 91-84-04



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PLASTICITY CHART

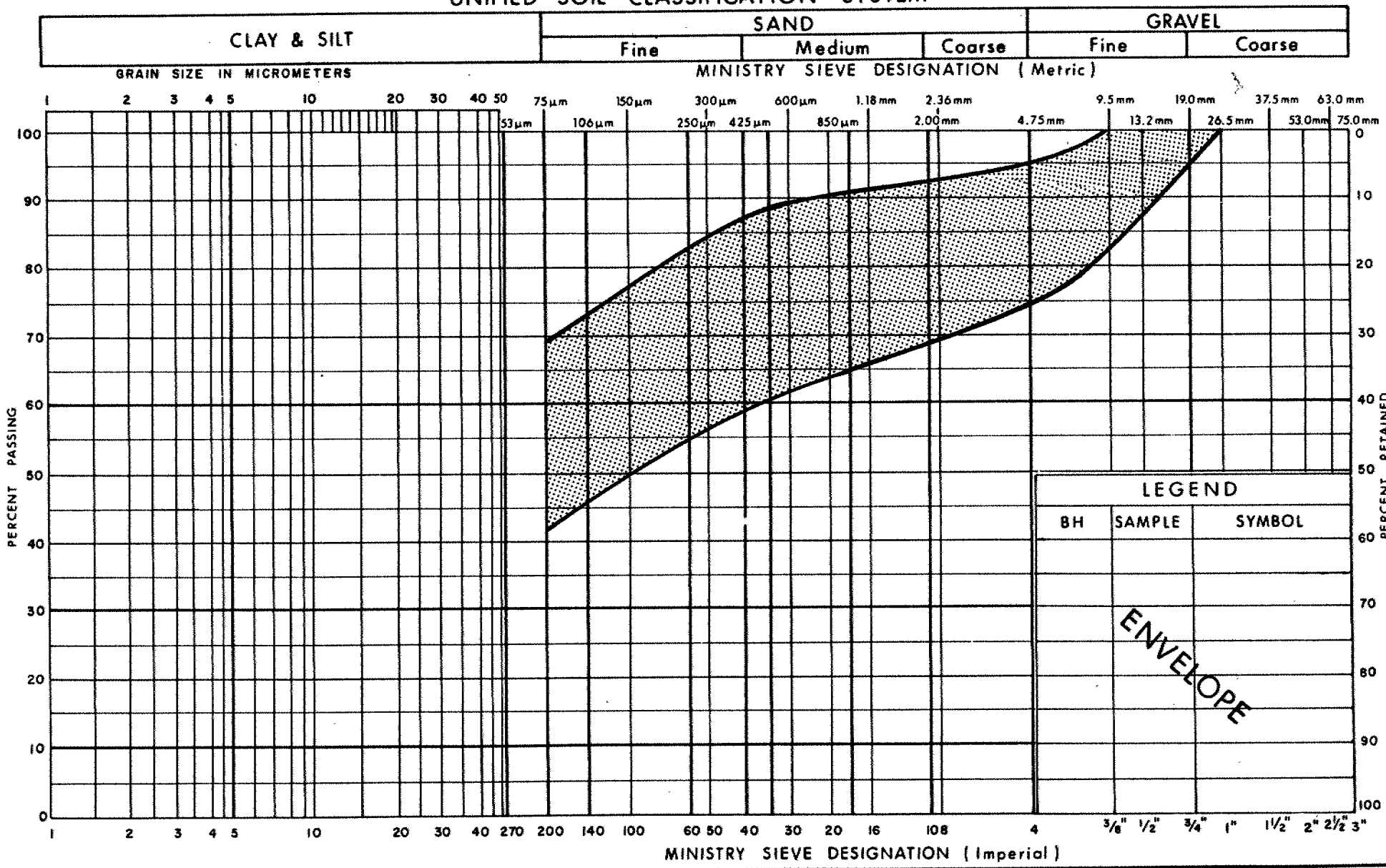
HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 91-84-04

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 91-84-04

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 552.2; E 410 540.2 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY D K

DATUM GEODETIC DATE 94 05 11 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.2	Ground Surface							20 40 60 80 100	20 40 60		
0.0	SILTY CLAY, Some Sand, Trace of Gravel, Some Organics, Occasional Silty Sand Layers, Firm to Very Stiff (Fill)		1	SS	5		204				
			2	SS	8						
			3	SS	19				o		2 14 40 44
201.2			4	SS	21		202				
4.0	SILTY SAND, Some Gravel Compact		5	SS	14		200				
			6	SS	14	▼			o		12 65 18 5
197.3	Gravelly Sand		7	SS	9		198				
7.9	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff										
195.7			8	SS	20		196				1 6 70 23
9.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	100/20cm						
194.3											
10.9	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 565.6; E 410 533.6 ORIGINATED BY D K
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY D K
DATUM GEODETIC DATE 94 05 11 CHECKED BY T C K

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 kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Ground Surface										
0.0	CLAYEY SILT, Some Sand, Trace of Gravel, Some Organics, Stiff to Very Stiff Occasional Sandy Silt Layers, (Fill)		1	SS	16		204				
			2	SS	8						
			3	SS	16		202				
201.0			4	SS	10						
4.0	Silty Sand, Trace of Clay		5	SS	19		200				
			6	SS	14	▼			o		1 61 28 10
	Boulders						198				
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		7	SS	20						
195.5			8	SS	34		196				0 2 60 38
9.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	100/20cm		194				
			10	SS	100/15cm						
191.1			11	SS	100/18cm		192		oH		6 43 37 14
13.9	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 602.6; E 410 511.4 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY D K

DATUM GEODETIC DATE 94 05 09 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
199.5	Ground Surface										
0.0	Topsoil										
			1	SS	12		198				
			2	SS	4						
	Trace of Sand, Some Organics										
	CLAYEY SILT, Some Sand, Trace of Gravel,		3	CS	PH		196				7 16 50 27
			4	SS	9						1 11 58 30
194.8	Firm to Stiff										
4.7			5	SS	54						
			6	SS	100/23cm		194	120/15cm			
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	100/20cm		192				
			8	SS	100/23cm		190				5 28 43 28
187.9			9	SS	100/18cm						
11.6							188				
187.3	GRAVELLY SAND										
12.2	End of Borehole										

* Artesian pressure encountered at elevation 187.3m, and water level stablized at 2.24m (elevation 201.7m) above ground surface

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3A 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 611.0; E 410 526.8 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONE TEST COMPILED BY D K

DATUM GEODETIC DATE 94 05 10 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	WATER CONTENT (%)		GR SA SI CL
199.8	Ground Surface							20 40 60 80 100	20 40 60		
0.0	Probable CLAYEY SILT, Trace of Sand, Trace of Gravel						198 196 194				
193.1											
6.7	End of Cone Test							120/28cm			

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 621.4; E 410 520.4 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY D K

DATUM GEODETIC DATE 94 05 10 CHECKED BY T C K

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 kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.8	Ground Surface										
0.0	Topsoil										
	SILTY SAND, With Organics, Very Loose to Compact		1	SS	6	▼	200				
			2	SS	2				o		8 43 41 8
198.1			3	SS	15						
2.7			4	SS	15		198				
	CLAYEY SILT, Some Sand, Trace of Gravel, Stiff		5	SS	10		196				1 15 47 37
193.8			6	SS	9						
7.0							194				
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	33				o		6 32 55 7
			8	SS	100/18cm		192	120/25cm			
189.9			9	SS	100/25cm		190				
10.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4A 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 612.4; E 410 506.6 ORIGINATED BY D K
DIST 2 HWY 4 BOREHOLE TYPE CONE TEST COMPILED BY D K
DATUM GEODETIC DATE 94 05 06 CHECKED BY T C K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
200.0	Ground Surface										
0.0	Probable SANDY SILT						198				
195.7							196				
4.3	Probable CLAYEY SILT, Trace of Sand, Trace of Gravel										
194.3											
5.7	End of Cone Test							120/25cm			

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO - ORDS: N 4 737 652.0; E 410 487.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY D K

DATUM GEODETIC DATE 94 05 10 CHECKED BY T C K

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 kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Ground Surface										
0.0	Granular Fill										
	CLAYEY SILT, Trace of Gravel, Trace of Organics, Firm to Stiff (Fill)		1	SS	7		204				
			2	SS	14						
			3	SS	14		202				
			4	SS	16						
200.9			5	SS	12						
4.1			6	SS	20		200				0 4 50 46
	SILTY CLAY, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		7	SS	18	▼	198				
			8	SS	25						
			9	SS	15		196				
			10	SS	25		194				
193.4											
11.6	Heterogeneous Mixture of SILT, SAND and GRAVEL, Dense (Glacial Till)		11	SS	37				o		6 35 55 4
192.4											
12.6	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 101 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO-ORDS: N 4 737 829.2, E 410 504.8 ORIGINATED BY M V&T H

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 23 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Hwy. 4 Southbound Lane							20 40 60 80 100	20 40 60		
0.0	Asphalt										
	Silt, Trace of Sand		1	SS	14		204				
	CLAYEY SILT to SILTY CLAY, Trace of Sand, Trace of Gravel, Stiff (Fill)		2	SS	10				o		
201.2			3	SS	10		202				
			4	SS	12						
3.8	SILT, Trace of Sand, Trace of Gravel, Occasional Organics, Loose		5	SS	8	▼	200				
	Gravelly Sand		6	SS	8						
198.2							198				
6.8	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		7	SS	11						
			8	SS	23		196				
193.6			9	SS	21		194				
11.4	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		10	SS	50						26 32 (42)
			11	SS	90	/13cm	192				
189.3			12	SS	170	/28cm	190		o		7 27 (66)
15.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 102 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO-ORDS: N 4 737 610.0, E 410 536.7 ORIGINATED BY M V
DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 95 03 22 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.2	Ground Surface										
0.0	SILTY SAND, Trace of Clay Occasional sand layers, Compact		1	SS	26		200				
197.1	Gravelly Sand		2	SS	5		198				
3.1	CLAYEY SILT, Trace of Sand, Trace of Gravel, Firm to Very Stiff		3	SS	8		196				
193.1			4	SS	19		194				
7.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		5	SS	72 /15cm		192				11 41 (48)
			6	SS	81 /15cm		190				
188.4			7	SS	106 /10cm	▽	188				
11.8 187.3	SAND, Trace of Silt										
12.9	End of Borehole										

* Note:
Artesian Pressure Encountered at El. 188.4 and Water Level Stabilized at El. 200.4

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \frac{20}{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 103 1 OF 1 METRIC

W.P. 91 - 84 - 04 LOCATION CO-RDS: N 4 737 572.2, E 410 544.8 ORIGINATED BY M V&T H

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 23 & 24 CHECKED BY T C K

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 kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Hwy. 4 Shoulder										
0.0	Silty Sand										
	CLAYEY SILT, Trace of Sand, Firm to Very Stiff (Fill)		1	SS	4		204				
			2	SS	5						
			3	SS	6		202				
			4	SS	9						
200.7			5	SS	12						
4.3	CLAYEY SILT, Trace of Sand, Trace of Gravel, Occasional Organics, Firm to Stiff		6	SS	11		200		H		
			7	SS	4	▼					
			8	SS	14		198		H		
198.0											
9.0	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	33		196		oH		
			10	SS	162						
			11	SS	100 /15cm		194		oH		
			12	SS	133 /15cm		192				
189.5			13	SS	95 /15cm		190				
15.5	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

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Ministry
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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 91-84-03 DIST 31
HWY 4 STR SITE 5-65

CONT 97-12

Kettle Creek Replacement Bridge (North)

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GEOCRES 40I14-125 DATE AUG 15 1995

FOUNDATION INVESTIGATION REPORT

For

Kettle Creek Replacement Bridge (North)

W.P. 91-84-03; Site 5-65

Highway 4, District 31, London

INTRODUCTION

This report contains the results of a foundation investigation carried out at the north crossing of Kettle Creek and Highway 4. The fieldwork for the first phase of this investigation was carried out between 1994 05 03 and 1994 05 05. Upon finalization of the type of structure and the location of the bailey bridge, the fieldwork for the second phase was carried out between 1995 03 20 and 1995 03 22. The fieldwork comprised of nine sampled boreholes and Dynamic Cone Penetration Test adjacent to four of these holes. In addition, Dynamic Cone Penetration Test was carried out at one location.

Boreholes were advanced to a maximum depth of 24.3 m (El. 181.7) below the existing road level using a 82 mm I.D. continuous flight hollow stem auger.

SITE DESCRIPTION

The site under investigation is located on Highway 4, approximately 6 km south of Highway 3 at the boundary of City of St. Thomas and Township of Yarmouth in the County of Elgin.

The river valley is relatively flat on the north side, however, the south bank is about 7.5 m deep at this point. The width of the creek along the centreline of Highway 4 is approximately 26 m and during peak flood, the depth of the water is expected to be about 3.5 m at the deepest location.

A succession of ridges and valleys lies in the County of Elgin. The ridges are moraines of calcareous clay or silty clay while in the valley it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

The subsurface conditions at the bailey bridge location, with the exception of upper 2.6 m to 2.9 m, is similar to that was encountered at the structure site. The subsoil conditions are discussed separately to differentiate one from the other. The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report.

Replacement Bridge

The soil stratigraphy within upper 1.2 m to 6.6 m varies from location to location. The underlying subsoil consists of 1.2 m to 4.7 m firm to stiff clayey silt fill with varying proportions of sand and gravel overlying 4.4 m to 9.6 m very dense heterogeneous mixture of silt, sand and gravel (glacial till). However, the boreholes located on the south side of the creek indicated presence of 4.8 m to 5.8 m stiff to very stiff silty clay immediately below the fill. The boreholes located on the north side of the creek revealed presence of 1.4 m to 2.5 m compact gravelly sand immediately below the fill and topsoil. The silty clay and gravelly sand deposits are underlain by 4.5 m to 9.6 m very dense heterogeneous mixture of silt, sand and gravel (glacial till). The non cohesive glacial till layer is underlain by hard heterogeneous mixture of clayey silt, sand and gravel (glacial till) which extends to the full depth probed. For classification purposes, the soils encountered at this site can be divided into five different zones.

a) Clayey Silt/Silty Sand (Fill)
b) Silty Clay, Some Sand, Trace of Gravel
c) Gravelly Sand, Some Silt
d) Heterogeneous Mixture of Silt, Sand and Gravel (Non Cohesive Glacial Till)
e) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Cohesive Glacial Till)

A stratigraphical profile section is shown on Drawing No. 918403-A. This drawing also shows the location and elevation of the borings. Description of the strata encountered at this site are given below.

Clayey Silt/Silty Sand (Fill)

The composition of the fill which was placed to raise the finished grade of Highway 4 varies from location to location. The boreholes located near the abutments indicated presence of silty sand to sandy silt with varying proportions of gravel content. The thickness of this granular fill varies from 0.8 m to 4.0 m. The Standard Penetration Test results in this fill varies from 7 blows/0.3 m to 18 blows/0.3 m indicating loose to compact state of denseness.

However, the borehole located away from the abutments indicated the presence of clayey silt to silty clay fill with varying proportions of sand and gravel sized particles. The thickness of this clayey fill varies from 1.2 m to 4.7 m. The Standard Penetration Test values were observed to vary from 7 blows/0.3 m to 15 blows/0.3 m. The consistency may be classified as firm to stiff.

Silty Clay, Some Sand, Trace of Gravel

This silty clay deposit was encountered immediately below the fill in boreholes located on the south side of the creek. The thickness of this deposit varies from 4.8 m to 5.8 m and extends to elevations 200.0 to 199.4. The natural moisture content was observed to vary from 21% to 33% with an average value of 26.2%. The Atterberg Limits determined for the representative soil samples of this deposit are shown on Figure 1. Based on Standard Penetration Test results (N-values 8 blows/0.3 m to 22 blows/0.3 m), the consistency may be classified as stiff to very stiff.

Gravelly Sand, Some Silt

This gravelly sand deposit was encountered only in boreholes located north of the creek. The thickness of the deposit varies from 1.4 m to 2.5 m and extends to elevations 199.2 to 198.8. The Standard Penetration Test results in this deposit (10 blows/0.3 m to 11 blows/0.3 m) indicate compact state of denseness.

Heterogeneous Mixture of Silt, Sand and Gravel (Non Cohesive Glacial Till)

The gravelly sand and silty clay deposits are underlain by this heterogeneous mixture of silt, sand and gravel strata. The thickness of this glacial till strata varies from a minimum of 4.4 m to a maximum of 9.6 m and extends to elevations 195.5 to 189.2. The Gradation Test carried out on representative soil samples are shown on Figure 2 in an envelope form. The test results indicate 3% to 28% gravel, 37% to 43% sand and 35% to 56% silt and clay sized particles. The Standard Penetration Test results indicate very dense state of denseness (N values 55 blows/0.3 m to over 100 blows/0.3 m.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Cohesive Glacial Till)

The upper boundary of this cohesive glacial till deposit was encountered between elevations 195.5 and 189.2. The natural moisture content was observed to vary from 5% to 9% with an average value of 7.4%. The Atterberg Limits determined for the representative soil samples are shown on Figure 3. The results of the Gradation Test are shown on Figure 4 in an envelope form. The results indicate 7% to 49% gravel, 22% to 38% sand and 29% to 60% clayey silt. The Standard Penetration Test values vary from 70 blow/0.3 m to over 100 blow/0.3 m indicating hard consistency. The full extent of this deposit was not proven below elevation 181.7.

Groundwater Conditions

The groundwater level measurements were taken in open boreholes during the investigation and was observed between elevation 201.5 and 199.7. Seasonal fluctuation of the groundwater level may be expected due to the influence of the creek. The groundwater level at each borehole location is as follows:

Borehole No.	Elevation
1	201.5
2	199.9
3	200.2
4	199.0
101	199.9
102	200.3
103	199.7

Bailey Bridge

The underlying subsoil at this location consists of 2.6 m to 2.9 m very loose to loose sandy silt underlain by 0.7 m to 1.1 m loose to compact gravelly sand which overlies very dense heterogeneous mixture of silt, sand and gravel (glacial till). For classification purposes, the soils encountered at this location can be divided into three different zones.

a) Sandy Silt, Occasional Sand Layers
b) Gravelly Sand, Some Silt
c) Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till)

The location of the borings is shown on Drawing No. 918403-B. A stratigraphical section is shown on Drawing No. 918403-C. Description of the soils encountered at this location are given below.

Sandy Silt, Occasional Sand Layers

This sandy silt layer was encountered immediately below the topsoil. The thickness of this layer varies from 2.6 m to 2.9 m and extends to elevations 199.9 to 199.6. The Standard Penetration Test results indicate this sandy silt is in a very loose to loose state of denseness (N- values 2 blows/0.3 m to 7 blows/0.3 m).

Gravelly Sand, Some Silt

The sandy silt layer is underlain by this gravelly sand deposit. The thickness of this deposit varies from 0.7 m to 1.1 m and extends to elevations 198.9 to 198.8. The Standard Penetration Test results vary from 8 blows/0.3 m to 16 blows/0.3 m indicating loose to compact state of denseness.

Heterogeneous Mixture of Silt, Sand & Gravel (Non Cohesive Glacial Till)

The upper boundary of this non cohesive glacial till deposit was encountered between elevations 198.9 and 198.8. The Standard Penetration Test results of this deposit vary from 77 blows/0.3 m to over 100 blows/0.3 m indicating very dense state of denseness. The full extent of this strata was not proven at this location, however, in Borehole 105, this strata is underlain by a cohesive glacial till deposit.

Groundwater Conditions

The groundwater level mesurements were taken in open boreholes during investigation and was observed between elevations 200.0 and 199.7. Seasonal fluctuation of the groundwater level may be expected dùe to the influence of the creek. The groundwater level at each borehole location is as follows:

Borehole No.	Elevation
104	199.7
105	200.0

DISCUSSION AND RECOMMENDATIONS

General

Initially, it was planned to replace the existing bridge with a three span structure consisting of reinforced concrete deck slab supported on CPCI 1200 type girders. A foundation investigation was carried out in May, 1994 and the recommendation for the design of the foundation was given in the Foundation Investigation Report issued in August, 1994. However, on completion of hydrotechnical investigations, it was decided to build a two span integral abutments type of structure.

In view of the changes made to the proposed replacement bridge, additional foundation investigation was undertaken in March, 1995 to provide information for the design of the structure with integral abutments. This report supersedes the Foundation Investigation Report issued in August, 1994.

The proposed replacement bridge will be a two span concrete structure with integral abutments placed at elevation 201.5. The span on the south side will be 5.0 m longer than that on the north side and the spans are 30.0 m and 25.0 m, respectively. The finished grade will be set at about elevation 206.3.

In order to facilitate the replacement of the Kettle Creek north structure, a local detour west of Highway 4 will be utilized enabling the closure of Highway 4 for the duration of the construction. A private access road east of Highway 4 will be constructed to provide local access for both the landlocked property owner and the contractor. The detour at the crossing of Kettle Creek will be supported on a single bailey bridge.

The existing structure is a two span concrete arch bridge, with centre to centre of each span is about 26.7 m. The approach embankments appear in good condition, however, undercutting of the bank by the creek action or erosion is evident at the south abutment. The approach fill as well as the abutment is protected by gabion from further erosion. The reinforcement of the deck has

been exposed and corroded at several locations. In addition, voids have been created at the underside of the deck due to the spalling of concrete.

It appears from the structural drawings that the abutments as well as the pier of the existing bridge are supported on spread footing placed at about elevation 197.9. The footing of the pier is about 2.7 m wide, whereas the footing of the abutments is approximately 2.4 m.

Structure Foundations

Abutments

Considering the subsoil conditions encountered at this site, it is recommended that the piles for both north and south abutments be lowered in pre-augered holes extending to elevation 195.0 and driven to elevations 192.0 and 194.0, respectively. The annular space from El. 195 to the point of contraflexture be backfilled with concrete and the space above the point of contraflexture be backfilled with fine to medium grained uniformly graded loose sand. The following axial capacity values may be assumed for the design of the foundation using 310 x 110 steel H-piles.

Factored Axial Capacity at U.L.S. = 1600 kN

Axial Capacity at S.L.S. = 1150 kN

The point of contraflexture may be determined for 310 x 110 steel H-piles assuming the following coefficient of horizontal subgrade reaction values.

Elevation	Subgrade Reaction (kN/m^3)
198.5 - 196.0	45,000
196.0 - 194.0	125,000
194.0 - 192.0	196,000
Sand Backfill	1,000

Driving of piles shall carefully be monitored and controlled employing the Hiley Dynamic Pile Driving Formula driven in accordance with MTO Standards SS103-10 or SS103-11 assuming an ultimate capacity of 3450 kN. The pile tips should be reinforced with driving shoes as per MTO Standard DD-3301. The centre to centre space between the piles should be at least 1.0 m.

Pier

The centre pier for the structure is proposed to be supported on caissons. It is recommended that the caissons be founded at elevation 188.0. The caissons may be designed assuming the following bearing capacity values.

Factored Bearing Capacity at U.L.S.	=	1450 kPa
Axial Capacity at S.L.S.	=	1200 kPa

The lateral resistance for a 1.0 m diameter caisson may be computed assuming the following coefficient of horizontal subgrade reaction values.

Elevation	Subgrade Reaction (kN/m^3)
199.0 - 196.0	16,500
196.0 - 192.5	52,000
192.5 - 188.0	40,000

Alternatively, the pier may be supported on steel H-piles driven to elevation 194.0. The subsoil at this location is very dense below elevation 199.0. In view of this, the piles will have to be lowered in pre-augered holes extending to elevation 195.0 and driven to elevation 194.0. The annual space from elevation 195.0 to the bottom of the pile cap may be filled with concrete. The axial capacities recommended for the abutment foundations may be used for the design of the 310 x 110 steel H-piles. The coefficient of horizontal subgrade reaction values for this location are as follows:

Elevation	Subgrade Reaction (kN/m^3)
199.5 - 197.0	44,500
197.0 - 194.0	142,000

Bailey Bridge Foundation

There is no detail available regarding the duration of the detour, however, if it is proposed to be temporary during the summer construction months, the foundation may be placed at about elevation 202.0 after removing all the spongy and soft area observed within the width of the footing. The following bearing capacity values are recommended for the design of the bailey bridge supported on conventional timber crib or equivalent abutments founded at El. 202.0.

Factored Bearing Capacity at U.L.S. = 100 kPa
Bearing Capacity at S.L.S. = 75 kPa

However, appropriate frost cover (1.2 m) shall be provided to the footings should the foundation exist in the winter months. If the foundation is placed below the frost penetration depth i.e. El. 201, the following bearing capacity values may be assumed for the design of footings.

Factored Bearing Capacity at U.L.S. = 250 kPa
Bearing Capacity at S.L.S. = 150 kPa

Lateral Earth Pressure

Earth pressure should be computed as per Section 6.7.4.5 of the O.H.B.D.C., and the coefficient of earth pressure at rest shall be used for rigid and unyielding walls. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	Granular 'A'	Granular 'B'
Angle of Internal Friction	$\phi = 35^0$	$\phi = 30^0$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

Approach Embankment

The proposed finished grade of the Highway 4 varies between El. 206.3 and El. 205.9. The maximum height of approach fill at the north abutment is expected to be about 5.0 m. No major stability problems are anticipated for the approach embankments constructed with 2H:1V side slope. The fill should consist of well compacted acceptable material. The topsoil as well as any spongy or soft area observed within the base width of the embankment should be removed before placing the fill. However, the approach on the south side will be formed in a cut. It is recommended that the cut slope be constructed with 2H:1V forward slope.

Other Considerations

The spread footings as well as pile caps should have a minimum of 1.2 m earth cover to protect against frost penetration.

As indicated before, the pier is proposed to be supported on caissons. The high water level at this site will impose greater difficulties for the construction of caissons. In view of this, slurry displacement method may be considered if there is no environmental restriction to use bentonite. The bents for this method of construction may be supported by a short lead-in tube or liner. Alternatively, liners may be used to prevent formation of cavities, inflow of soil and water. If the hole cannot be dewatered effectively, tremie concreting may be used to construct the caissons.

Steel H-piles were recommended as an alternate to support the pier. In this option, the pile caps will have to be constructed below the creek water level and for this purpose a dewatering scheme consisting of cofferdam will be required.

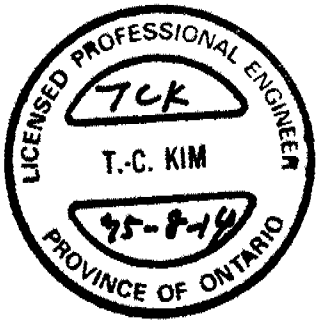
Undercutting of the bank by the creek action or erosion is evident on the south side of the creek. This may precipitate surface slides . In order to prevent erosion along the south bank, it should be protected by placing about 0.6 m thick rockfill consisting of 150 mm to 200 mm size to a height of 1.0 m above the high water level. The rockfill should extend to at least 10 m on both sides of the abutment.

Miscellaneous

The first phase of the fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer. The equipment used was owned and operated by Dominion Soil Investigation Inc.

The second phase of the fieldwork was carried out under the supervision of Tom Hickey and M. Vasavithasan. The equipment used was owned and operated by London Soil Test Ltd. This report was prepared by M. Vasavithasan, Foundation Engineer and reviewed by T.C. Kim, Senior Foundation Engineer.

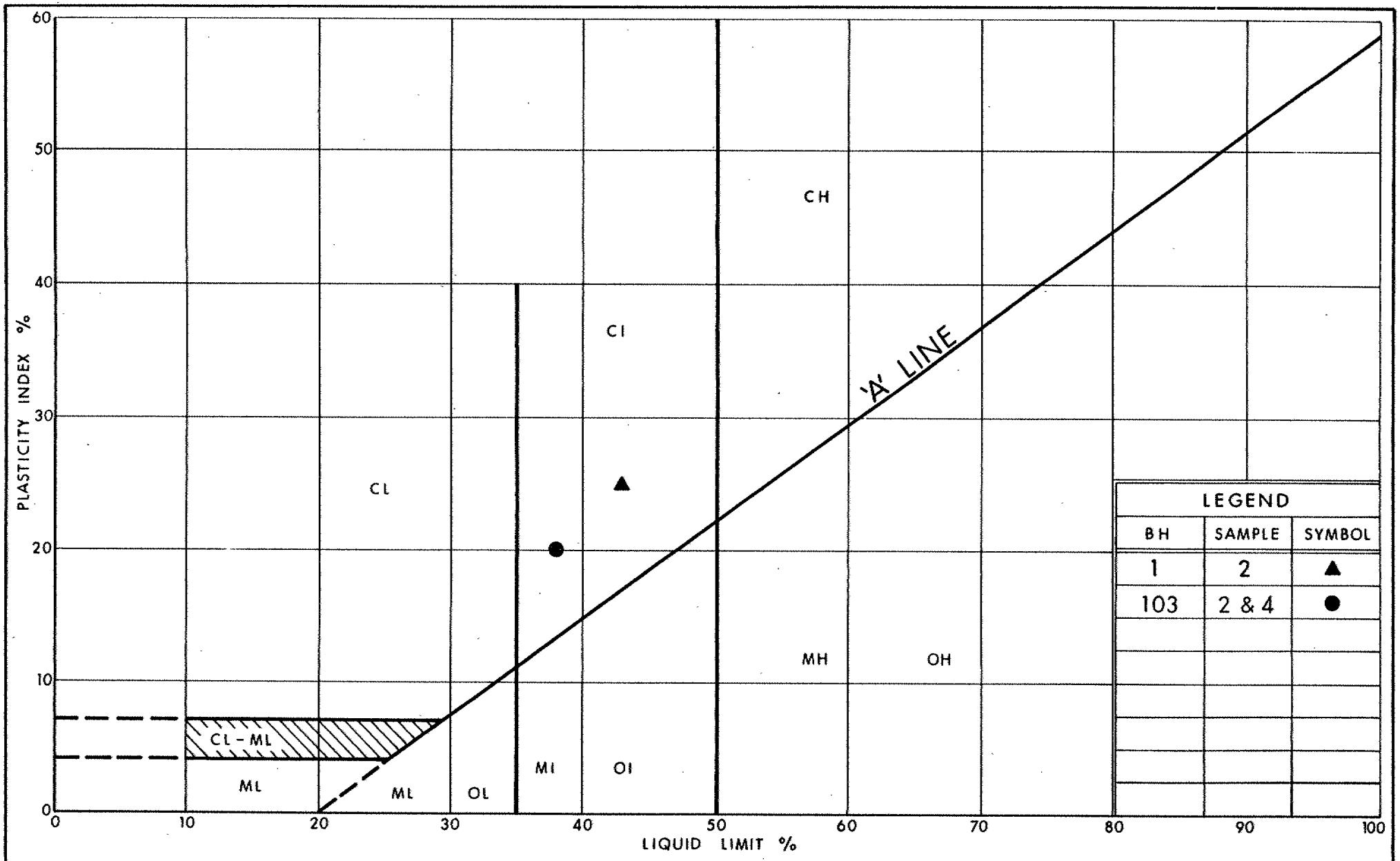
M. Vasavithasan, P. Eng.
Foundation Engineer



T.C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX

Oct 75, FF-S-21

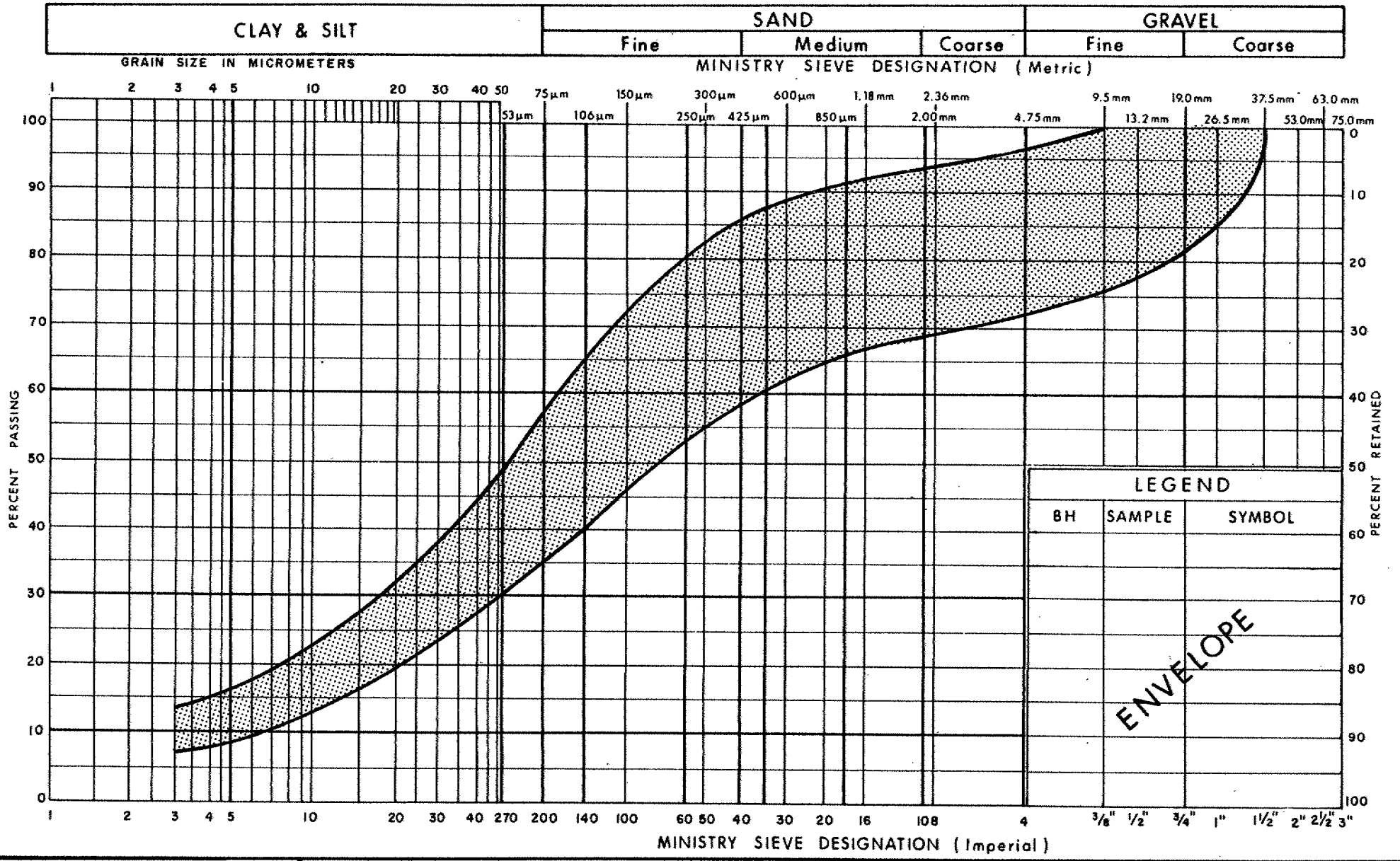


Ministry of Transportation
Ontario

PLASTICITY CHART
SILTY CLAY
SOME SAND, TRACE OF GRAVEL

FIG No 1
W P 91 - 84 - 03

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

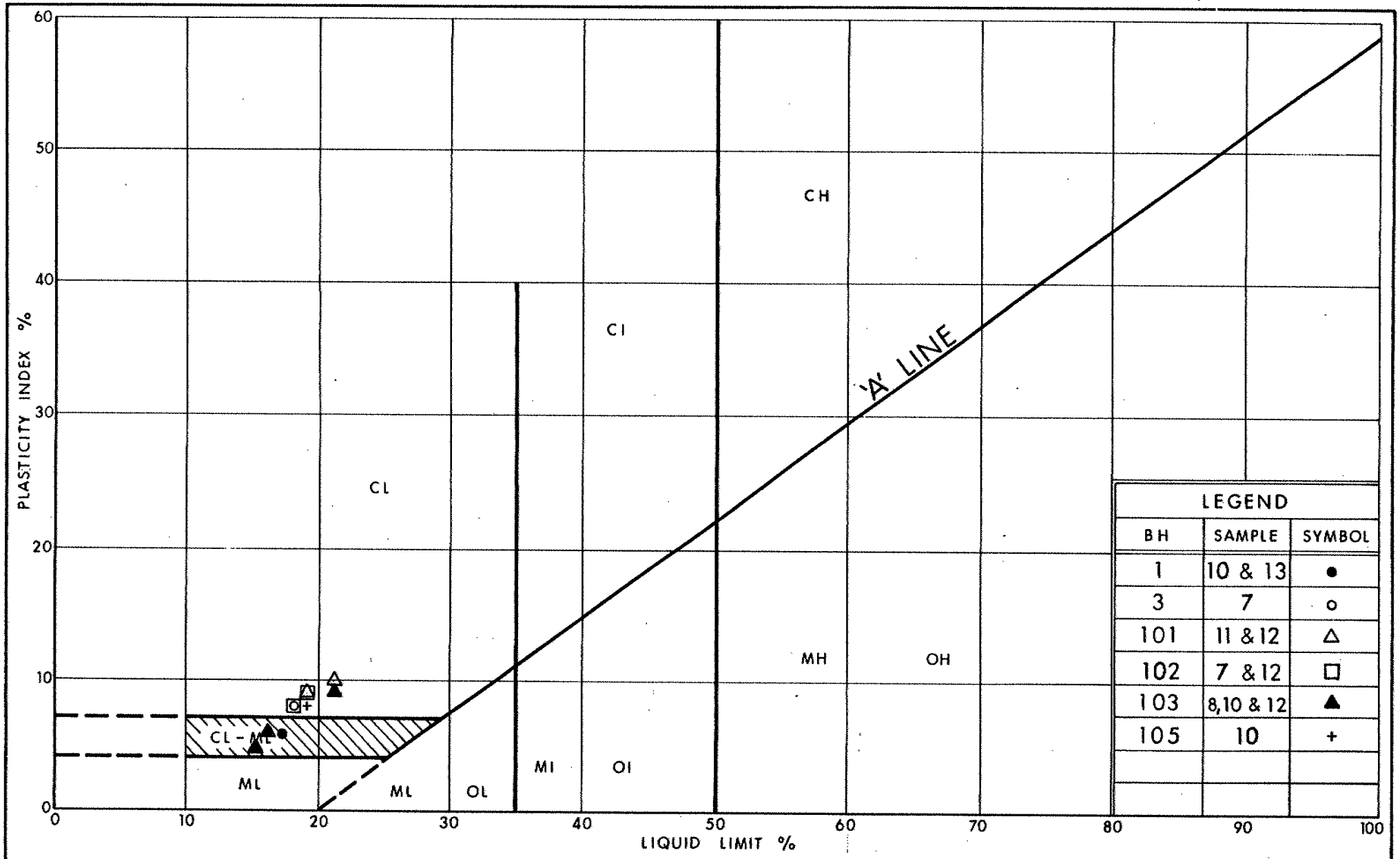
HETEROGENEOUS MIXTURE OF

SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 91-84-03

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
1	10 & 13	●
3	7	o
101	11 & 12	△
102	7 & 12	□
103	8,10 & 12	▲
105	10	+

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PLASTICITY CHART

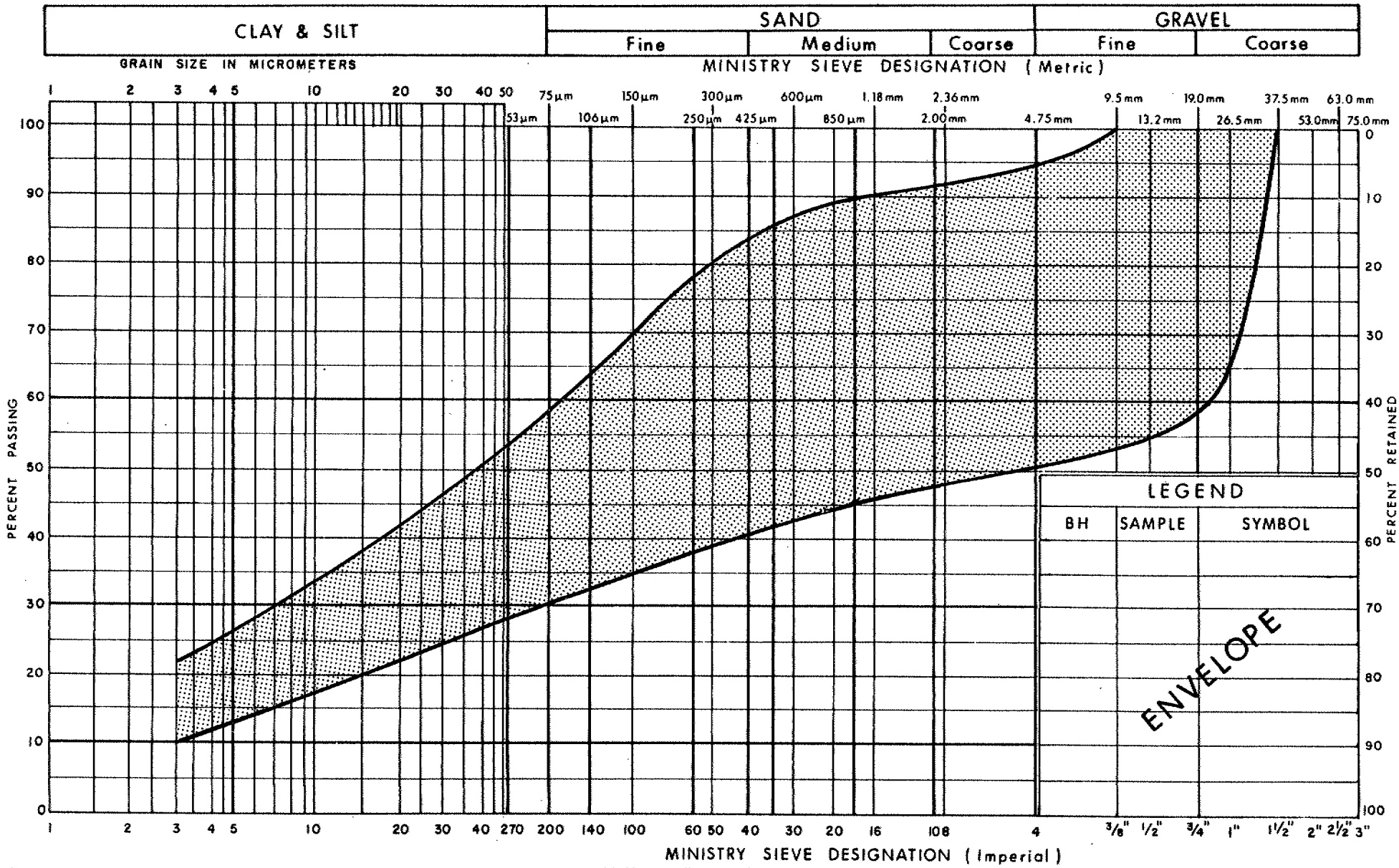
HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 91-84-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4

W P 91-84-03

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION CO - ORDS: N 4 737 837.0; E 410 404.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 05 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
206.0	Ground Surface										
0.0 / 205.2	Granular Fill										
0.8	SILTY CLAY, Some Sand, Trace of Gravel, Stiff to Very Stiff		1	SS	11						2 13 37 48
			2	SS	13						
			3	SS	12						
			4	SS	21						
			5	SS	22	▼					
199.4			6	SS	12			120/25cm			
6.6	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		7	SS	55						
			8	SS	100	/28cm			o		28 37 25 10
			9	SS	100	/13cm					
193.9			10	SS	100	/10cm			o H		49 22 21 8
12.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		11	SS	100	/28cm					
			12	SS	100	/25cm					
			13	SS	105				H		7 33 42 18
			14	SS	100	/18cm					
181.7			15	SS	100	/25cm					
24.3	End of Borehole										

ELEVATION SCALE: 204, 202, 200, 198, 196, 194, 192, 190, 188, 186, 184, 182

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 20 40 60

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 — 1 OF 1 — METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 886.5; E 410 383.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 03 CHECKED BY T C K

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 kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.9	Ground surface										
0.0 / 199.4	CLAYEY SILT, Some Sand, Some Organics, Stiff (Fill)		1	SS	10	▼	200				
1.5 / 195.0	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		2	SS	100/18cm						
			3	SS	100/18cm						
			4	SS	100/20cm		198		○		15 41 36 8
			5	SS	100/8cm		196				
5.9			6	SS	100/28cm				○H		12 34 36 18
			7	SS	100/10cm		194		○H		6 38 42 14
			8	SS	105		192				
			9	SS	70		190				
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		10	SS	107						
			11	SS	100/23cm		188				
			12	SS	102/20cm		186				
182.5			13	SS	100/8cm		184				
18.4	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 901.0; E 410 377.0 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST & WASHBORING COMPILED BY D K

DATUM GEODETIC DATE 94 05 04 CHECKED BY T C K

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.8	Ground Surface							20 40 60 80 100	20 40 60		
0.0 / 199.6	CLAYEY SILT, With Organics, Firm (Fill)		1	SS	7		200	120/28cm	o		
1.2	Heteorogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		2	SS	100/5cm						
			3	SS	100/20cm						
			4	SS	100/20cm		198				
			5	SS	103		196				6 42 42 10
			6	SS	100/25cm		194				
192.9											
7.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		7	SS	106		192		o		14 31 34 21
			8	SS	100/18cm						
			9	SS	83		190				
188.4			10	SS	100/25cm						
12.4	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 91-84-03 LOCATION CO - ORDS: N 4 737 934.0; E 410 365.6 ORIGINATED BY D K

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY D K

DATUM GEODETIC DATE 94 05 05 CHECKED BY T C K

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 kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.0	Ground Surface										
0.0 / 204.2	Granular Fill										
0.8	SILTY CLAY, Some Sand, Trace of Gravel, Occasional Organics, Firm to Stiff (Fill)		1	SS	6		204				
			2	SS	7						
			3	SS	13		202				6 19 37 38
			4	SS	15						
199.5			5	SS	7		200				
5.5	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		6	SS	100/18cm	▼			o		3 43 48 6
			7	SS	100/8cm		198				
			8	SS	100/15cm		196				
			9	SS	102		194				
			10	SS	100/23cm				o		6 38 50 6
191.2			11	SS	100/10cm		192				
13.8	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 101 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 919.4; E 410 381.9 ORIGINATED BY M V&T H

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY N V

DATUM GEODETIC DATE 95 03 20 & 21 CHECKED BY T C K

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.3	Hwy. 4 Shoulder										
0.0	Clayey Silt		1	SS	7		204				
	SILTY SAND TO SANDY SILT, Occasional Organics, Loose (Fill)		2	SS	7		202				
201.3											
4.0	GRAVELLY SAND, Some Silt, Occasional Organics, Compact		3	SS	10	▼	200				
198.8			4	SS	62						
6.5	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		5	SS	90	/15cm	198				
			6	SS	135		196				
			7	SS	65		194				
			8	SS	84	/15cm	192				
			9	SS	120	/20cm					
			10	SS	104	/10cm	190				
189.2											
16.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		11	SS	90	/15cm	188		o⊢		
186.6			12	SS	150				o⊢		
18.7	End of Borehole										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 102 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 893.7; E 410 405.1 ORIGINATED BY M V

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 95 03 20 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS
202.0	Ground Surface					
0.0	Organics					
200.6	SILT, Tr. of Sand, Tr. of Clay, Loose					
1.4	GRAVELLY SAND, Some Silt, Compact		1	SS	11	▼
199.2			2	SS	104	/15cm
2.8			3	SS	86	/15cm
	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		4	SS	104	
			5	SS	163	
192.2			6	SS	112	/13cm
9.8			7	SS	91	
			8	SS	124	
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	106	/15cm
			10	SS	128	
			11	SS	126	/15cm
183.4			12	SS	84	/15cm
18.6	End of Borehole					

ELEVATION SCALE: 200, 198, 196, 194, 192, 190, 188, 186, 184

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 103 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION Co-ords: N 4 737 850.0; E 410 407.0 ORIGINATED BY M V&T H

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 21 & 22 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS
206.0	Hwy. 4 Northbound Lane				
0.0	Asphalt				
204.8	SILTY SAND, Some Gravel, Compact (Fill)	1	SS	18	
1.2	Organics	2	SS	9	
	SILTY CLAY, Some Sand, Trace of Gravel, Stiff	3	SS	8	
		4	SS	10	
200.0		5	SS	106/13cm	▼
6.0	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)	6	SS	111	/20cm
		7	SS	100	/15cm
195.5					
10.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)	8	SS	155	
		9	SS	100	/10cm
		10	SS	100	/15cm
		11	SS	159	/23cm
185.9		12	SS	90	/13cm
20.1	End of Borehole				

ELEVATION SCALE: 204, 202, 200, 198, 196, 194, 192, 190, 188, 186

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 104 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION See PLAN of Proposed Bailey Bridge ORIGINATED BY M V

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 21 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
202.5	Ground Surface							20 40 60 80 100	20 40 60		
0.0	Tr. Organics						202				
	SANDY SILT, Occasional sand Layers, Very Loose to Loose		1	SS	6						
			2	SS	2						
199.6			3	SS	4	▼	200				
2.9	GRAVELLY SAND, Some Silt, Occasional Organics, Loose		4	SS	8						
3.6			5	SS	78						
			6	SS	83		198				
			7	SS	93		196				
	Heterogeneous Mixture of SILT, SAND, and GRAVEL, Very Dense (Glacial Till)		8	SS	99						
			9	SS	92		194				
			10	SS	56		192				
189.9			11	SS	119		190				
12.6	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 105 1 OF 1 METRIC

W.P. 91 - 84 - 03 LOCATION See PLAN of Proposed Bailey Bridge ORIGINATED BY M V

DIST 2 HWY 4 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 95 03 22 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
202.5	Ground Surface						
0.0	Organics						202
	SANDY SILT, Occasional Sand Layers, Loose		1	SS	7		
			2	SS	5		
199.9			3	SS	5	▼	200
2.6	GRAVELLY SAND, Some Silt,		4	SS	16		
198.8	Compact		5	SS	105		
3.7			6	SS	102	/10cm	198
	Heterogeneous Mixture of SILT, SAND and GRAVEL, Very Dense (Glacial Till)		7	SS	107		196
			8	SS	77		
193.0			9	SS	79		194
9.5	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		10	SS	126		192
190.0			11	SS	119	/15cm	
12.5	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$; Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

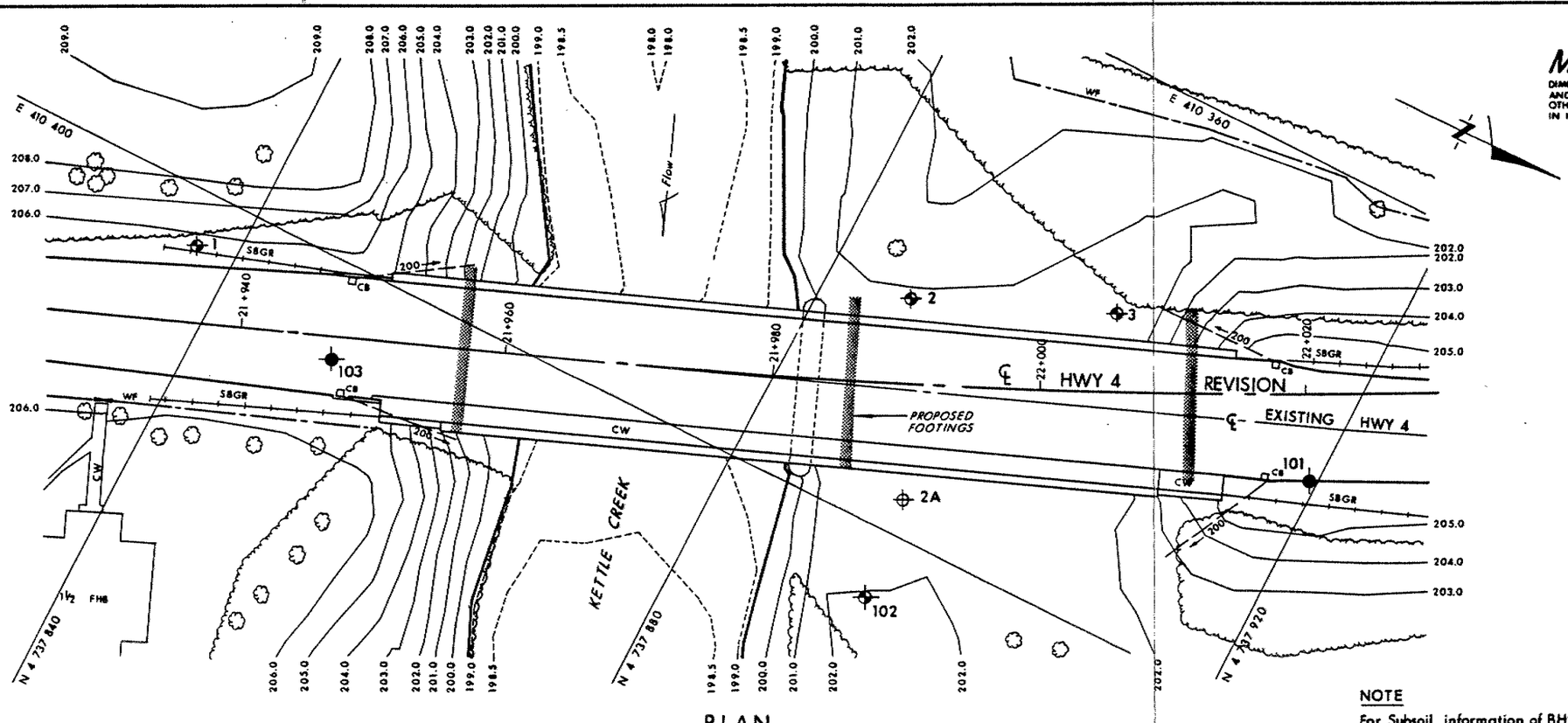
PHYSICAL PROPERTIES OF SOIL

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

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

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

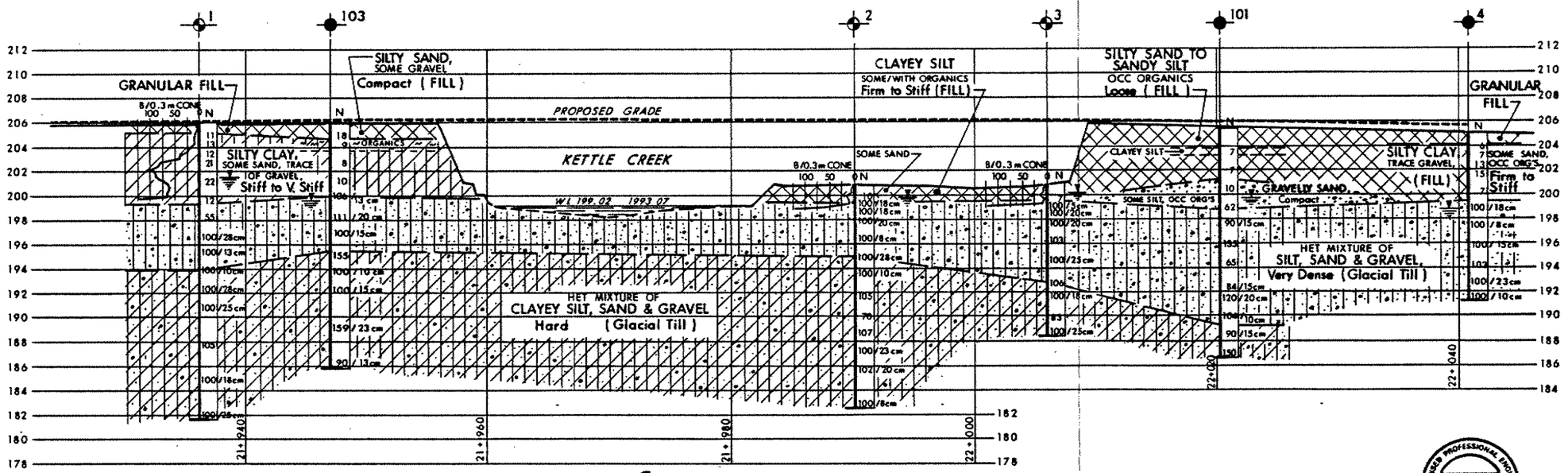
MINISTRY OF TRANSPORTATION, ONTARIO PH-0-267 88 10



PLAN

SCALE

4m 2 0 4m



℄ PROFILE HWY 4 REVISION

SCALE

4m 2 0 4m

REF No E-120-4-1, 1994 03

METRIC

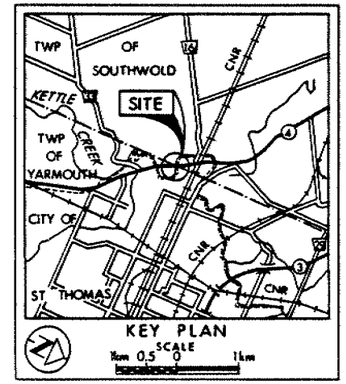
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 91-84-03

KETTLE CREEK (North)

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1994 05 and 1995 03

NOTE

For Subsoil information of BH's 2A & 102 refer to Record of Borehole Sheets.

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	206.0	4 737 837.0	410 404.0
2	200.9	4 737 886.5	410 383.0
2A	201.6	4 737 893.0	410 397.2
3	200.8	4 737 901.0	410 377.0
4	205.0	4 737 934.0	410 365.6
101	205.3	4 737 919.4	410 381.9
102	202.0	4 737 893.7	410 405.1
103	206.0	4 737 850.0	410 407.0

NOTE

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

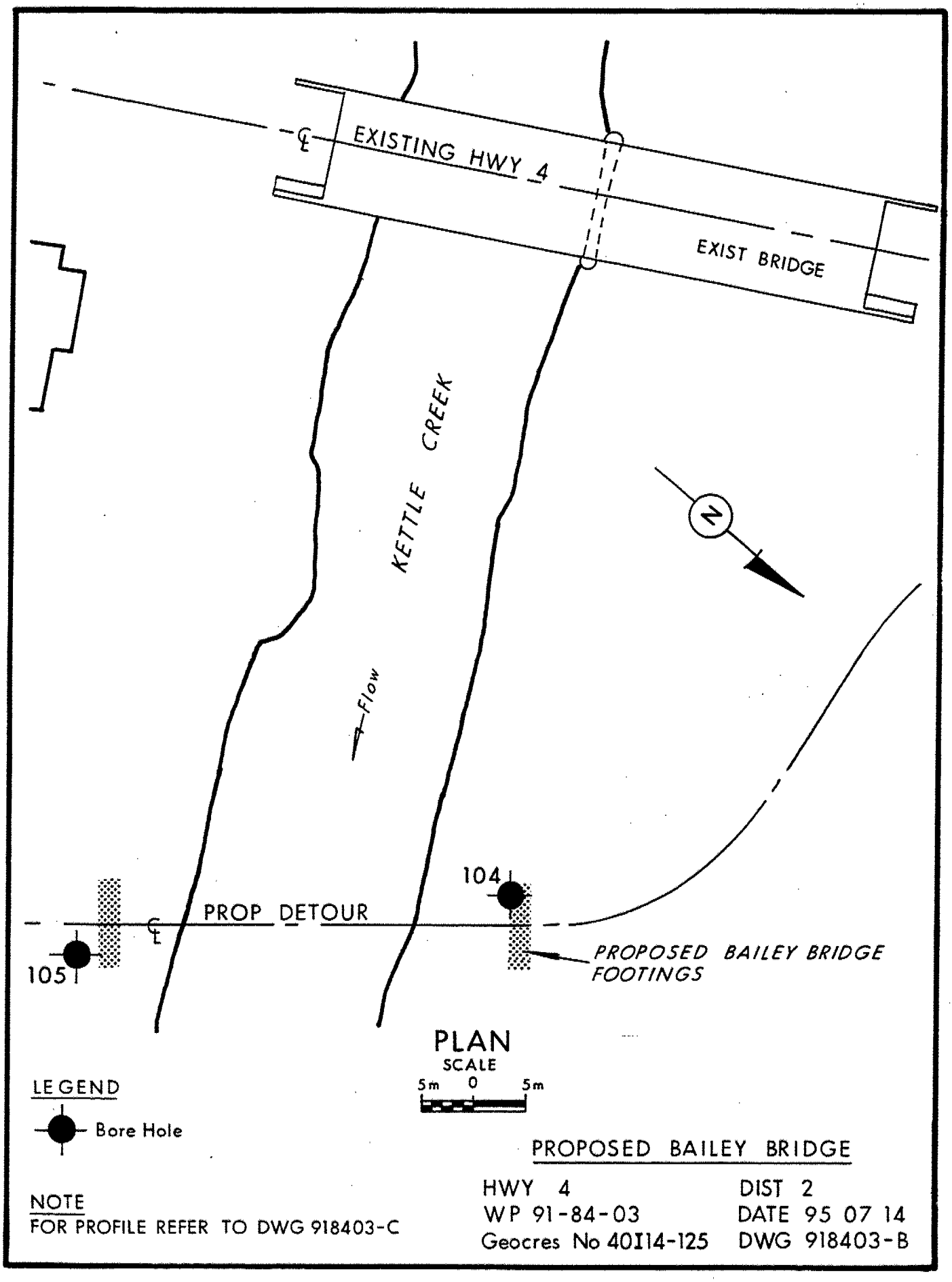
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen Cond.

REV.	DATE	BY	DESCRIPTION
	95 07 11	RS	BH's 101, 102 & 103 ADDED, PLAN & PROFILE REVISED

Geocres No 40I14-125

HWY No 4			DIST 2
SUBM'D MV	CHECKED AJT	DATE Jul 18, 1994	SITE 5-065
DRAWN VPS	CHECKED CF	APPROVED	DWG 918403-A

LICENCED PROFESSIONAL ENGINEER H. THANTHIRIGE PROVINCE OF ONTARIO



PLAN

SCALE

5m 0 5m

LEGEND

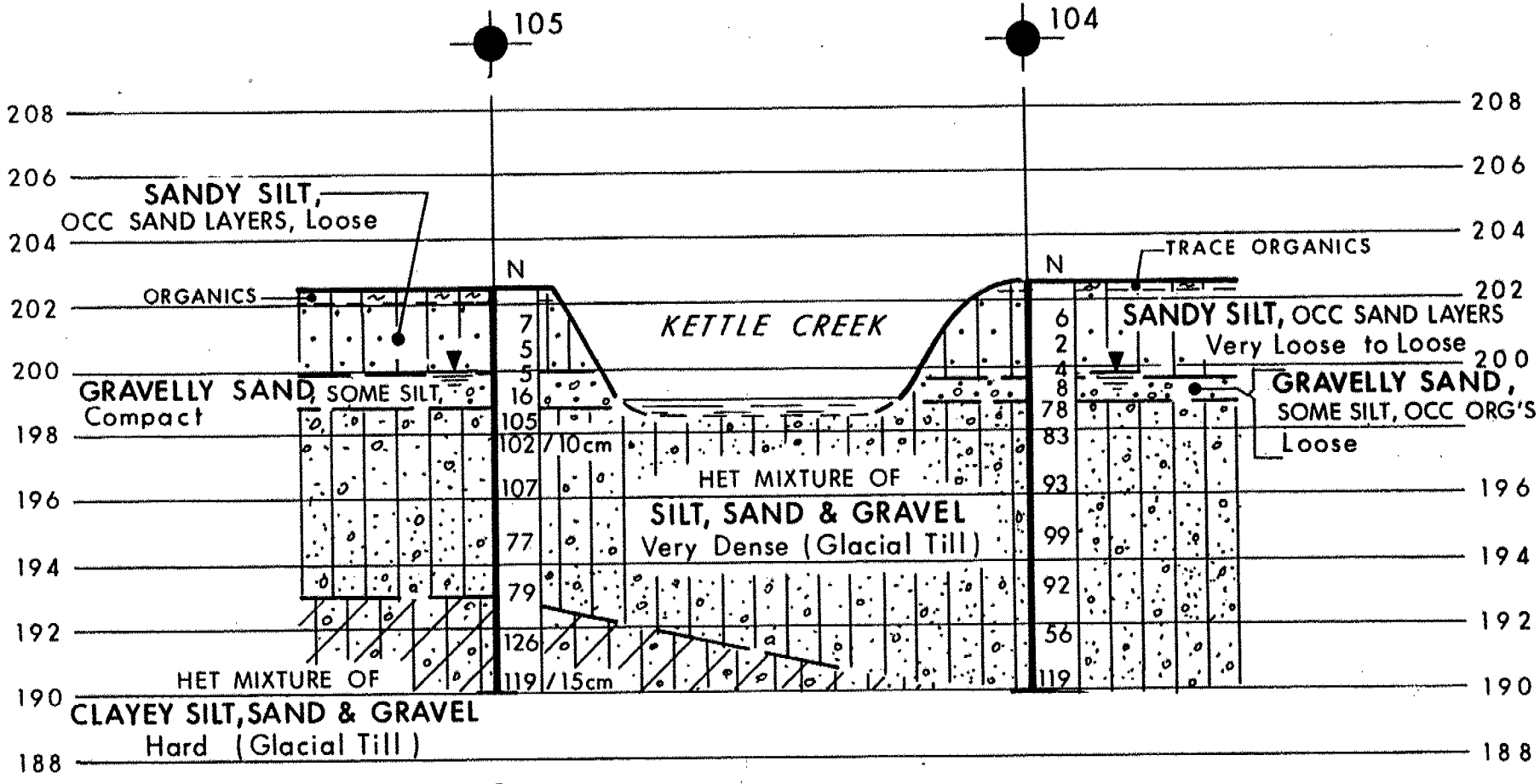
Bore Hole

NOTE

FOR PROFILE REFER TO DWG 918403-C

PROPOSED BAILEY BRIDGE

HWY 4	DIST 2
WP 91-84-03	DATE 95 07 14
Geocres No 40I14-125	DWG 918403-B



℄ PROFILE PROPOSED DETOUR

SCALES

5 m 0 5 m HOR

2 m 0 2 m VERT

LEGEND

Bore Hole

WL at time of investigation 95 03

NOTE

FOR PLAN REFER TO DWG 918403-B.

PROPOSED BAILEY BRIDGE

HWY 4 DIST 2

W.P 91-84-03 DATE 95 07 14

Geocres No 40I14-125 DWG 918403-C