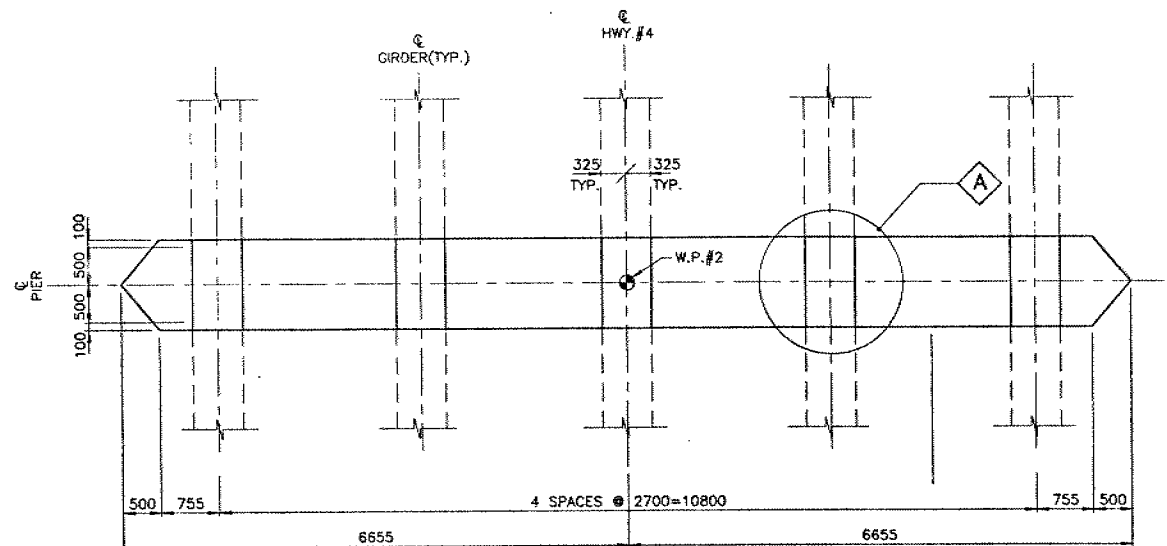


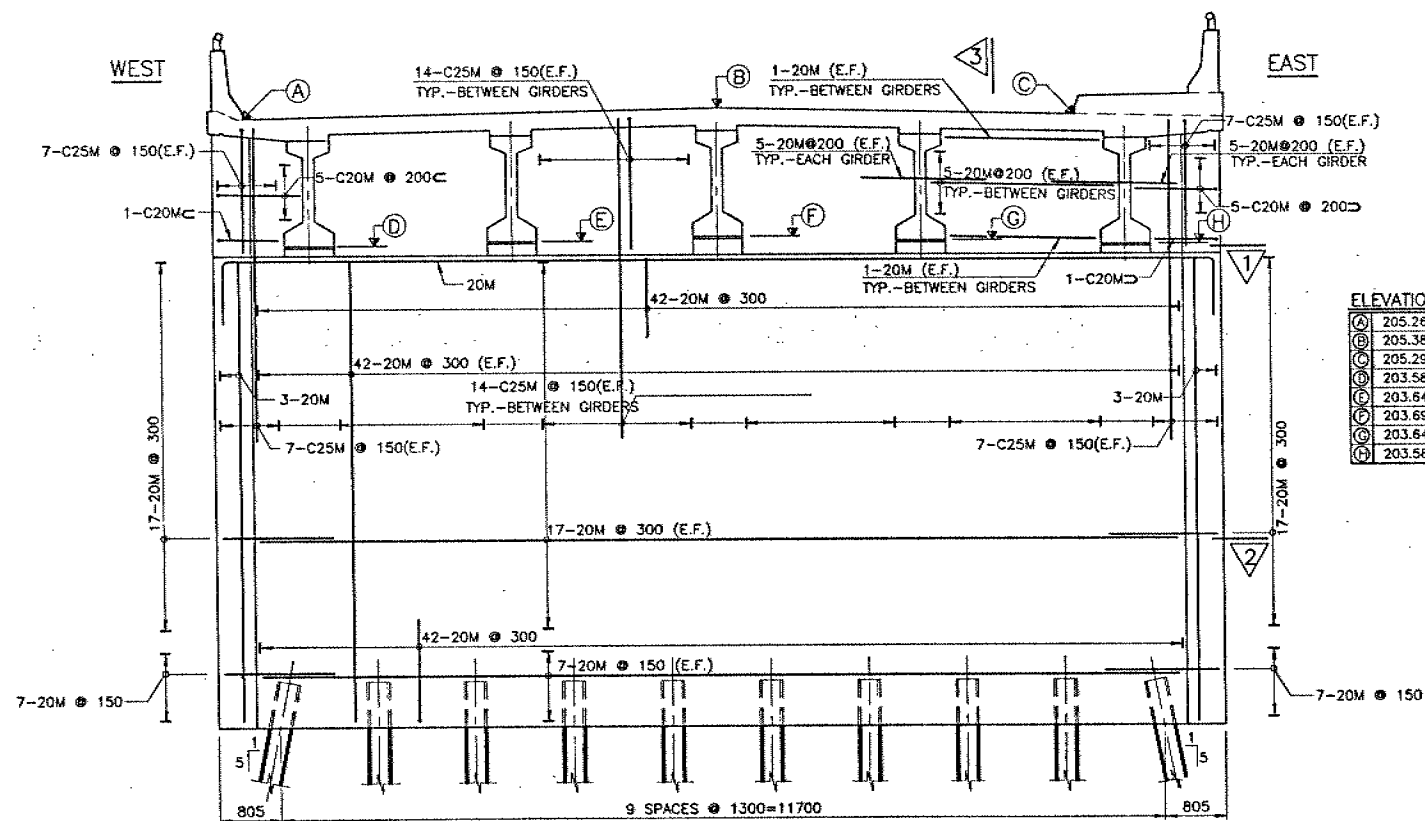
G.I.-30 SEPT. 1976

GEOCRES No. 40I14-126DIST. 2 REGION W.P. No. 91-84-04CONT. No. 97-12W. O. No. STR. SITE No. 5-66HWY. No. 4LOCATION Hwy 4 & Kettle Creek  
Bridge (South)No. of PAGES - OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

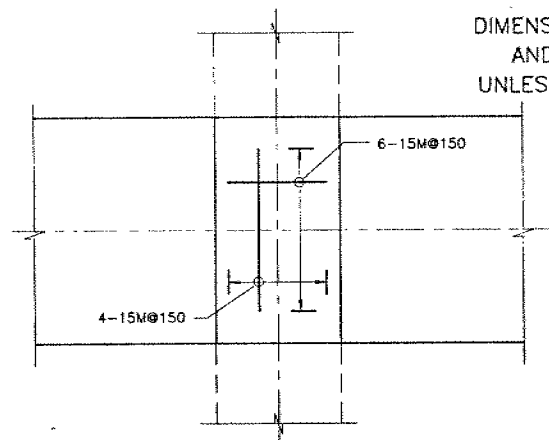
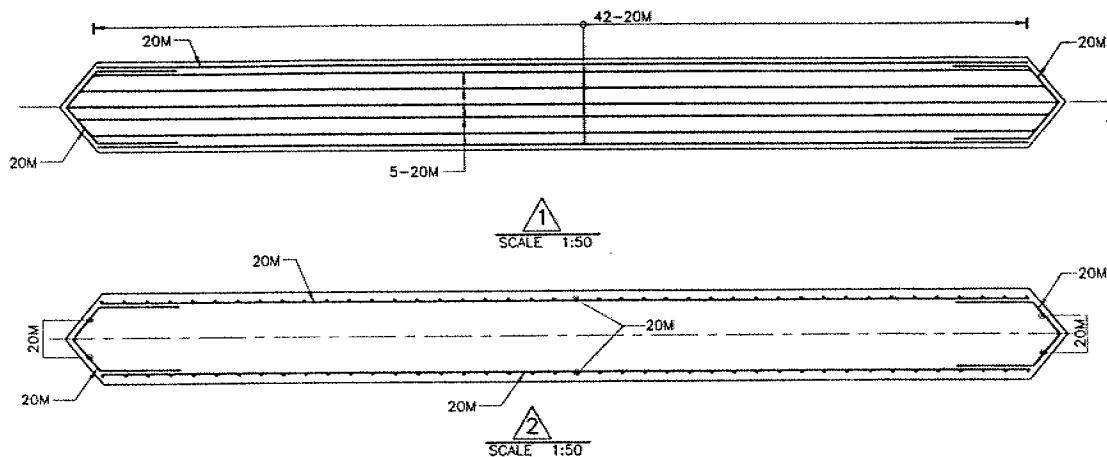
AutoCAD Drawing: /users/pieczonk/temp/wp918404/kettier.DWG updated: DEC 12/1996 07:42 AM



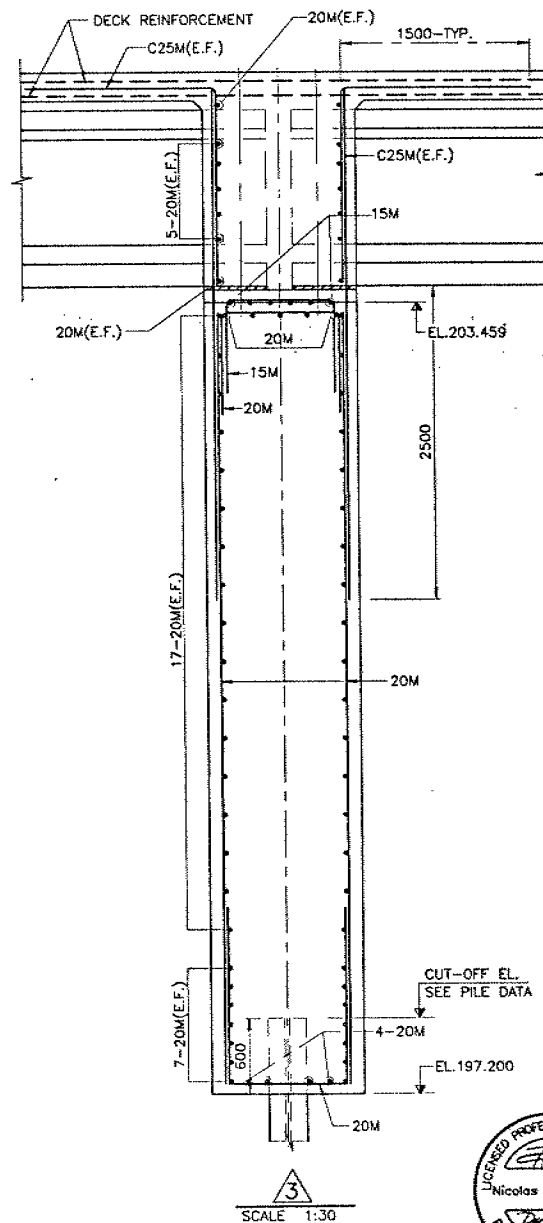
PLAN  
SCALE 1:50



ELEVATION  
SCALE 1:50



DETAIL "A"  
SCALE 1:20

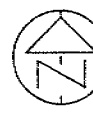


SCALE 1:30

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

DIST  
CONT No  
WP No 91-84-04

KETTLE CREEK BRIDGE  
(SOUTH)  
PIER



SHEET  
84

PILE NOTES:

- ALL PILES TO BE HP310x110 STEEL "H" PILES.
- 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.
- PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS103-10 OR SS103-11 USING AN ULTIMATE CAPACITY OF 3450KN/PILE FOR THE SOUTH ABUTMENT AND PIER AND AN ULTIMATE CAPACITY OF 3000KN/PILE FOR THE NORTH ABUTMENT.
- ABUTMENT PILES TO BE LOWERED INTO 600mm DIA.x3000mm LONG PRE-AUGERED HOLES AND THEN DRIVEN. THE ANNULAR SPACE SHALL BE FILLED WITH FINE TO MEDIUM GRAINED UNIFORMLY GRADED LOOSE SAND.
- NO ATTEMPT SHALL BE MADE TO DRIVE PILES BELOW EL.190.00.
- PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTHS BELOW CUT-OFF ELEVATION.
- ALL PILES TO HAVE DRIVING SHOES.
- 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.200.400	7550
	5	VERT.		7400
PIER	2	1:5	EL.197.800	5920
	8	VERT.		5800
NORTH ABUT.	2	1:5	EL.202.100	11320
	5	VERT.		11100

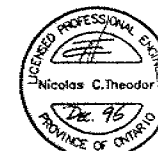
PILE DESIGN DATA		
LOCATION	FACTORED LOAD @ SLS(kN)	FACTORED LOAD @ ULS(kN)
SOUTH ABUT.	1150	1600
PIER	1150	1600
NORTH ABUT.	1000	1400

NOTE:

THIS DRAWING TO BE READ IN CONJUNCTION WITH DWG.3 & 4.

APPLICABLE STANDARD DRAWINGS:

OPSD-3301.00 SPLICE AND DRIVING SHOE DETAILS FOR STEEL "H"-PILES.  
OPSD-3701.00 POSITIVE MOMENT CONNECTION.

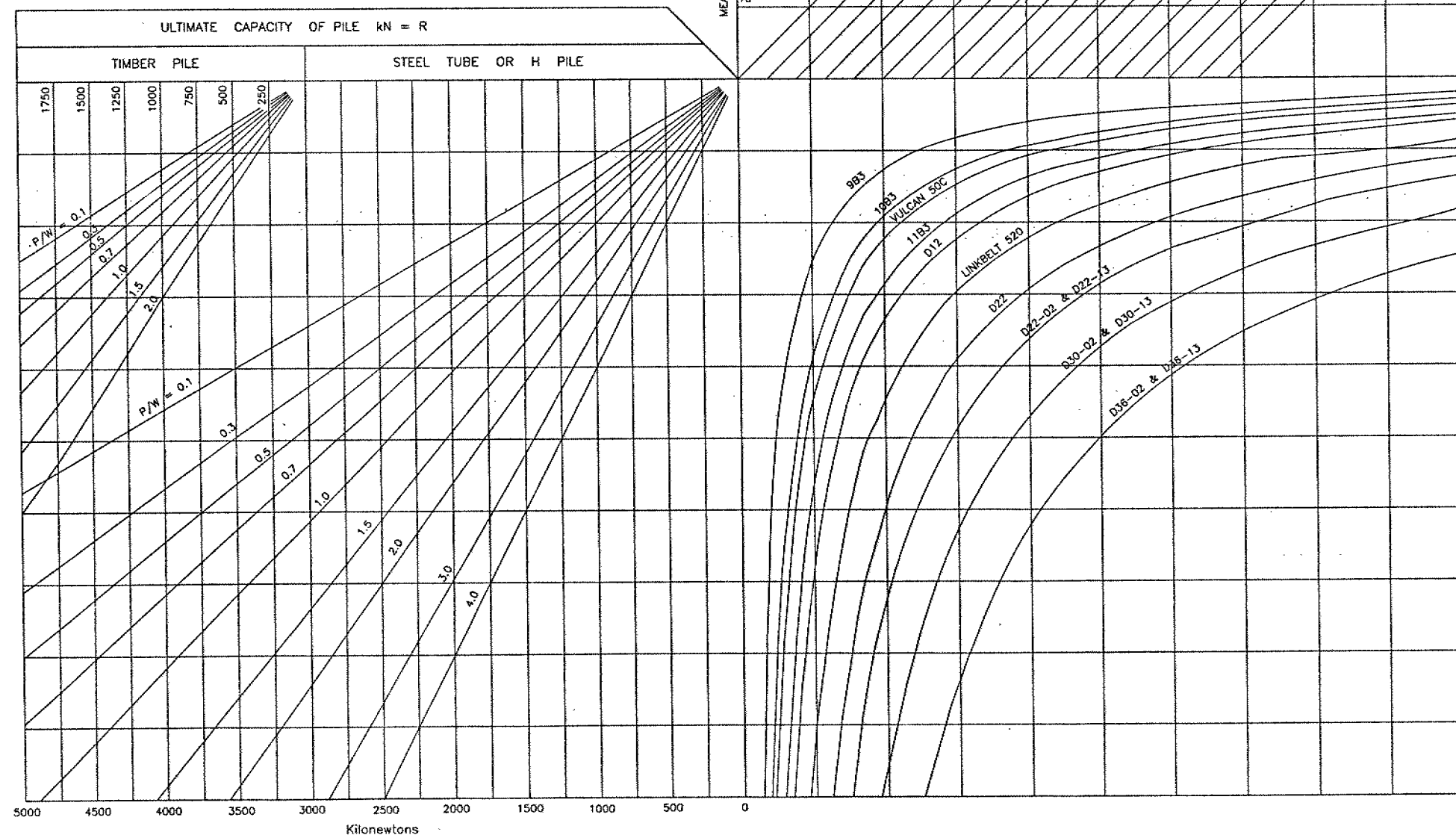
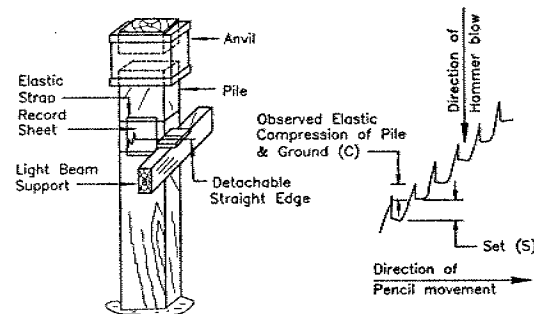


DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS		DESCRIPTION
DESIGN	N.C.T.	CHK N.J.P. CODE OH80C'91
DRAWN	J.O.	CHK SITE 5-66 ISTRUCT 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 91-84-04

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

SHEET  
92

#### METHOD OF APPLYING THE HILEY FORMULA

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

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 =  $\frac{W + P_e^2}{W + P}$

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  $P = 994.6 + 600 = 1594.6 \text{ kg}$

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

Observed measured rebound  $C = 10 \text{ mm}$

Observed measured penetration  $S = 5 \text{ mm}$

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

$$\text{read ultimate capacity } R = 1512 \text{ kN } L = \frac{1512}{3} = 504 \text{ kN}$$

#### EXAMPLE 2:

HP 310x110, 50 m long plus anvil of mass 600 kg giving

$P = 5500 + 600 = 6100 \text{ kg}$ . The hammer is Delmag D22-13

$$W = 2200 \text{ kg, } n = \frac{W + P_e^2}{W + P} = \frac{2200 + (6100 \times 0.32 \times 0.32)}{2200 + 6100} = \frac{2824}{8300} = 0.34$$

Energy of hammer ( $Wgh$ ) = 67000 J/blow

Observed measured rebound  $C = 10 \text{ mm}$

Observed measured penetration  $S = 5 \text{ mm}$

#### USING HILEY FORMULA:

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

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

#### 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  $C = 5 \text{ mm}$  and  $S = 2 \text{ mm}$  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 Birmingham 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	QHBDC'91/LOAD CL-A [DATE]
DRAWN J.O.	CHK	SITE 5-66	STRUCT [SCHEME] DWG 13



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

DIST 2  
CONT No  
WP No 91-84-04



KETTLE CREEK BRIDGE  
(SOUTH)  
GENERAL ARRANGEMENT

SHEET  
80

#### GENERAL NOTES:

##### CLASS OF CONCRETE:

PRECAST GIRDERS ..... 40MPa  
REMAINDER ..... 30MPa  
UNLESS OTHERWISE NOTED.....

##### 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:

1. GENERAL ARRANGEMENT
2. BORE HOLE LOCATION & SOIL STRATA
3. SOUTH ABUTMENT AND WINGWALLS
4. NORTH ABUTMENT AND WINGWALLS
5. PIER
6. PRESTRESSED GIRDERS AND BEARINGS
7. DECK DETAILS
8. DECK REINFORCEMENT
9. BARRIER WALL W/RAILING-WEST
10. BARRIER WALL WITH S/W & RAILING-EAST
11. RAILING FOR BARRIER WALL-E&W.
12. 6000mm APPROACH SLAB
13. PILE DRIVING-STEAM & DIESEL HAMMERS
14. STANDARD DETAILS
15. QUANTITIES-STRUCTURE I

W.P.'s	CO-ORDINATES	
	NORTH	EAST
1	4737578.139	410536.793
2	4737602.207	410521.945
3	4737623.930	410509.572

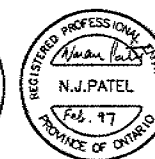
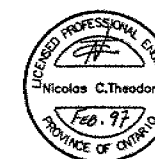
PLAN  
1:200

ELEVATION  
1:200

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

207  
206  
205  
204  
203  
202  
201  
200  
199  
198  
197  
196  
195  
194  
193  
192  
191  
190

BM 205.346  
CC ON NW COR. OF CSW N END  
CONC BRIDGE OVER KETTLE CREEK  
4.8 RT 21+700.5



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS		DESCRIPTION	
DESIGN	N.C.T. CHK	CODE OHBDC'91	LOAD CL-A
DRAWN	J.O. CHK	SITE 5-66	STRUCT SCHEME
		DATE	MAY 1998
		DWG	1



Ministry of  
Transportation and  
Communications

---

## FOUNDATION DESIGN SECTION

**foundation  
investigation and  
design report**

**ENGINEERING MATERIALS OFFICE**  
**FOUNDATION DESIGN SECTION**

WP 91-84-04 DIST 31  
HWY 4 STR SITE 5-66

*CONT 97-12*

Kettle Creek Replacement Bridge (South)

**DISTRIBUTION**

A. Ho (2)  
E. Magni  
A.E. Irving  
P. Bryar (2)  
M. Holowka  
J. Robinson  
E.A. Joseph  
G. Laithwaite (Cover Only)  
F. Bacchus (Cover Only)  
File

# 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



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:

<u>Borehole No.</u>	<u>Elevation</u>	<u>Remarks</u>
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	

## 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 September, 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 September, 1994.

The proposed replacement bridge will be a two span concrete structure with integral abutments placed at elevation 200.0. 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 205.5.

In order to facilitate the replacement of the Kettle Creek south structure, a local detour west of Highway 4 will be utilized enabling the closure of Highway 4 for the duration of the construction.

The existing bridge is a two span concrete arch structure, with centre to centre of each span is about 24.0 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 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 196.7. The footing of the pier is about 2.6 m wide, whereas the footing of the abutments is approximately 2.3 m.

### Structure Foundations

Considering the subsoil conditions encountered at pier and abutment locations, the recommendations for the design of foundations are given separately.

### North Abutment

It is recommended that the piles for this abutment be driven to elevation 191 and designed assuming the following axial capacity values for 310 x 110 steel H-piles.

Factored Axial Capacity at U.L.S. = 1400 kN

Axial Capacity at S.L.S. = 1000 kN

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

<u>Elevation</u>	<u>Subgrade Reaction (kN/m<sup>3</sup>)</u>
200.0 - 193.5	21,600
193.5 - 191.0	97,000
Sand Backfill	1,000

### South Abutment

It is recommended that the 310 x 110 steel H-piles be driven to elevation 193.0 and designed assuming the following axial capacities.

Factored Axial Capacity at U.L.S.	= 1600 kN
Axial Capacity at S.L.S.	= 1150 kN

The following coefficient of horizontal subgrade reaction values are recommended for this location.

<u>Elevation</u>	<u>Subgrade Reaction (kN/m<sup>3</sup>)</u>
200.0 - 196.0	16,200
196.0 - 193.0	97,000
Sand Backfill	1,000

Driving of piles shall be carefully monitored and controlled employing the Hiley Dynamic Pile Driving Formula driven in accordance with MTO Standards SS103-10 or SS 103-11 assuming an ultimate capacity as follows:

<u>Location</u>	<u>Ultimate Capacity (kN)</u>
North Abutment	3000
South Abutment	3450

The piles for both abutments be lowered in pre-augered holes extending to the point of contraflexure and driven to tip elevations recommended above. The annular space be backfilled with fine to medium grained uniformly grade loose sand.

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.

In view of the presence of artesian conditions below elevation 188.0, no attempt should be made to drive the piles below elevation 190.0. This information should be included in the note on structural drawings.

### Pier

The centre pier for the structure is proposed to be supported on caissons. It is recommended that the caissons be founded at elevation 192.0. The caissons may be designed assuming the following bearing capacity values.

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

<u>Elevation</u>	<u>Subgrade Reaction (kN/m<sup>3</sup>)</u>
199.0 - 194.0	6,700
194.0 - 192.0	40,000

Alternatively, the pier may be supported on steel H-piles driven to elevation 192.0. The axial capacities and driving criteria recommended for the south abutment foundation may be used for the design of piles at this location. The coefficient of horizontal subgrade reaction values for this location are as follows:

<u>Elevation</u>	<u>Subgrade Reaction (kN/m<sup>3</sup>)</u>
199.0 - 194.0	21,600
194.0 - 192.0	130,000

### 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.

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction	$\phi = 35^{\circ}$	$\phi = 30^{\circ}$
Unit Weight (kN/m <sup>3</sup> )	$\gamma = 22.8$	$\gamma = 21.2$

### Approach Embankment

The proposed finished grade of the Highway 4 varies between El. 205.6 and El. 205.3. The maximum height of approach fill at the north abutment is expected to be about 4.0 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 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.

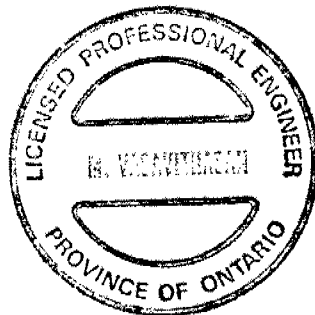
Steel H-piles were recommended as an alternate to support the pier. In this option, the pile caps will have to be constructed below the creek water level and for this purpose a dewatering scheme consisting of cofferdam will be required.

Undercutting of the bank by the creek action or erosion is evident on the south side of the bridge. 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.

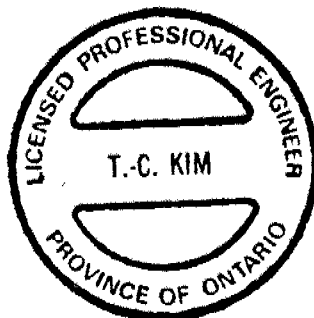
### MISCELLANEOUS

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.



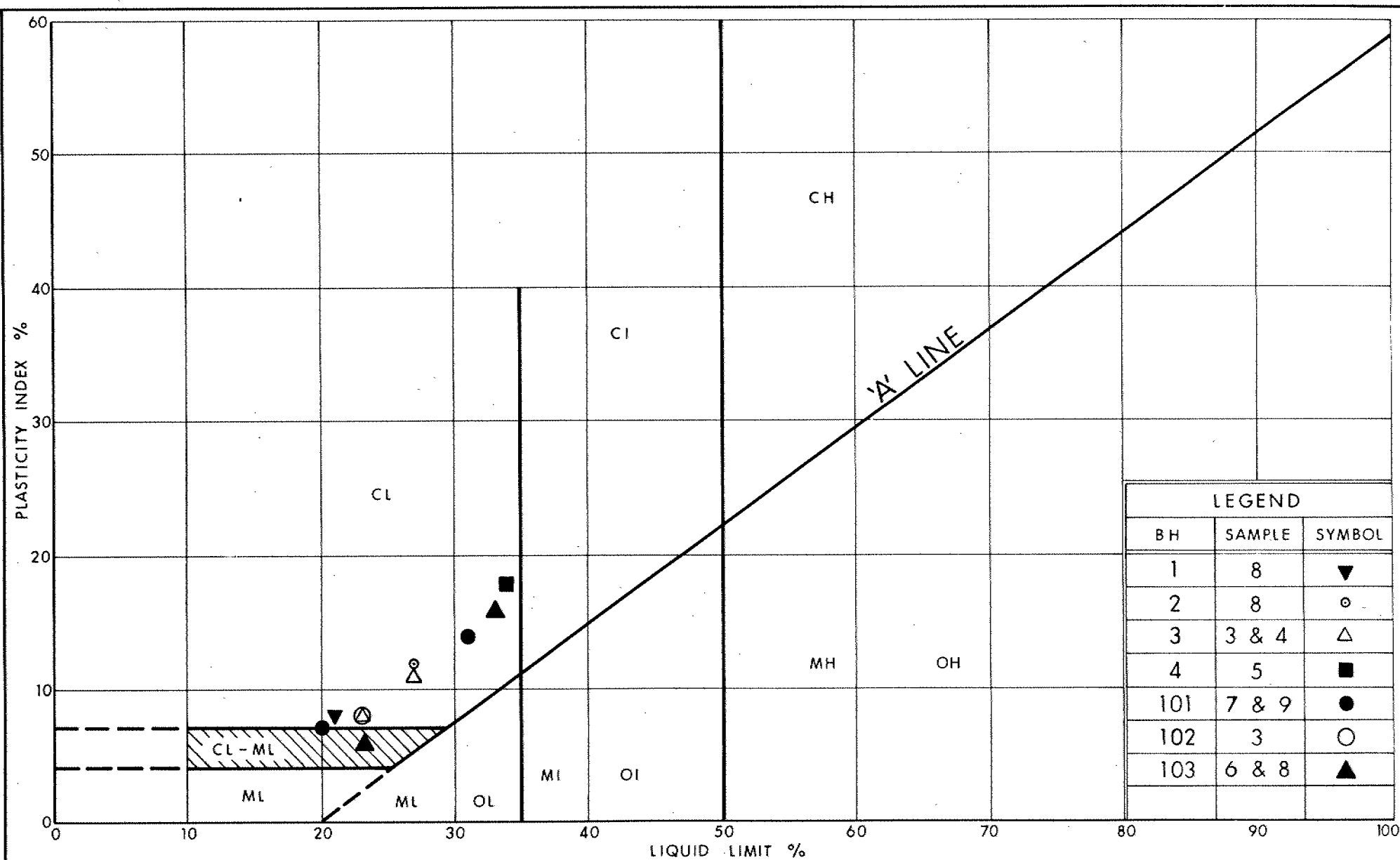
*M. Vasavithasan*  
M. Vasavithasan, P. Eng.  
Foundation Engineer



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



## **APPENDIX**



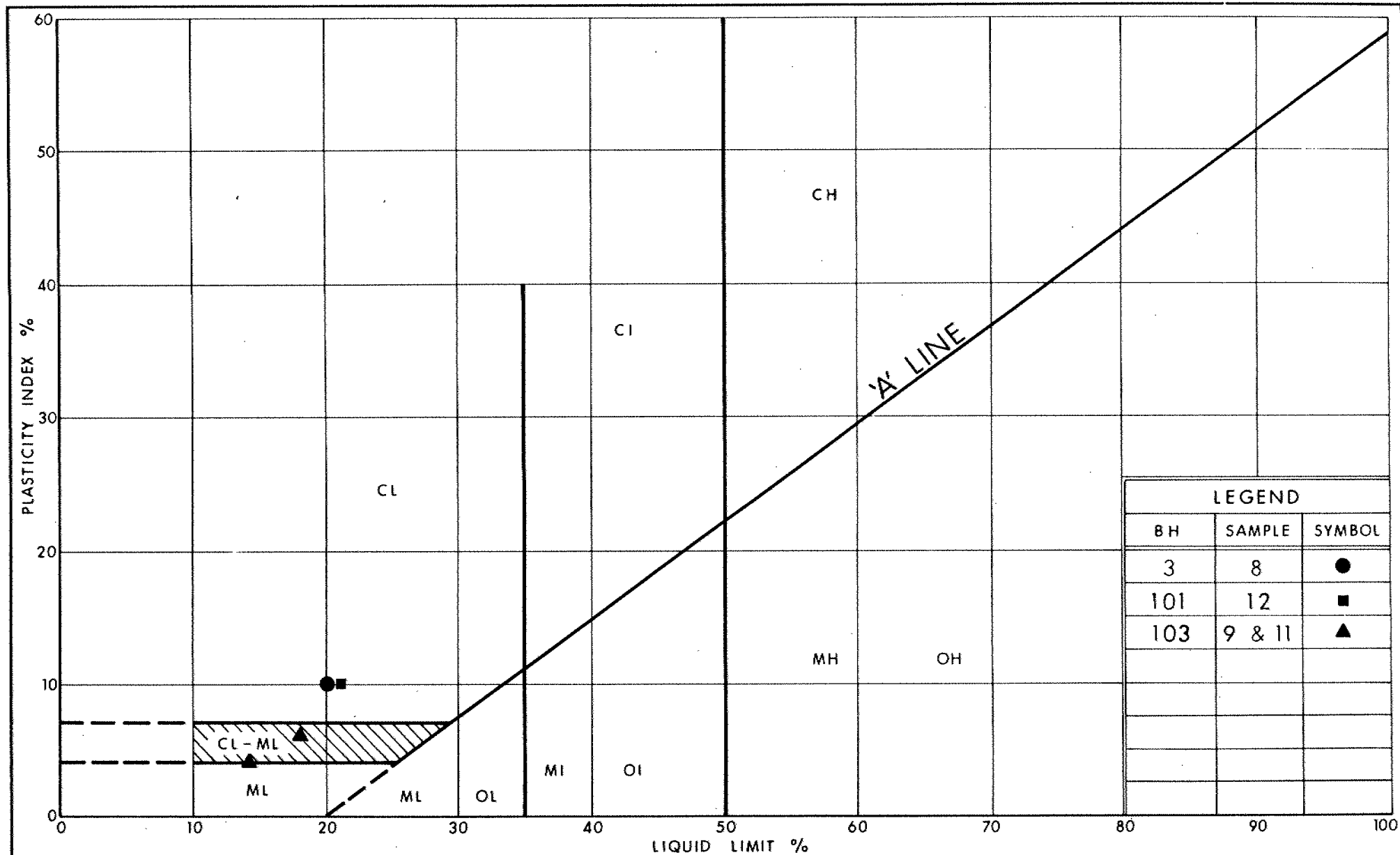
Ministry of  
Transportation

Ontario

# PLASTICITY CHART CLAYEY SILT TRACE OF SAND, TRACE OF GRAVEL

FIG No 1

W P 91-84-04



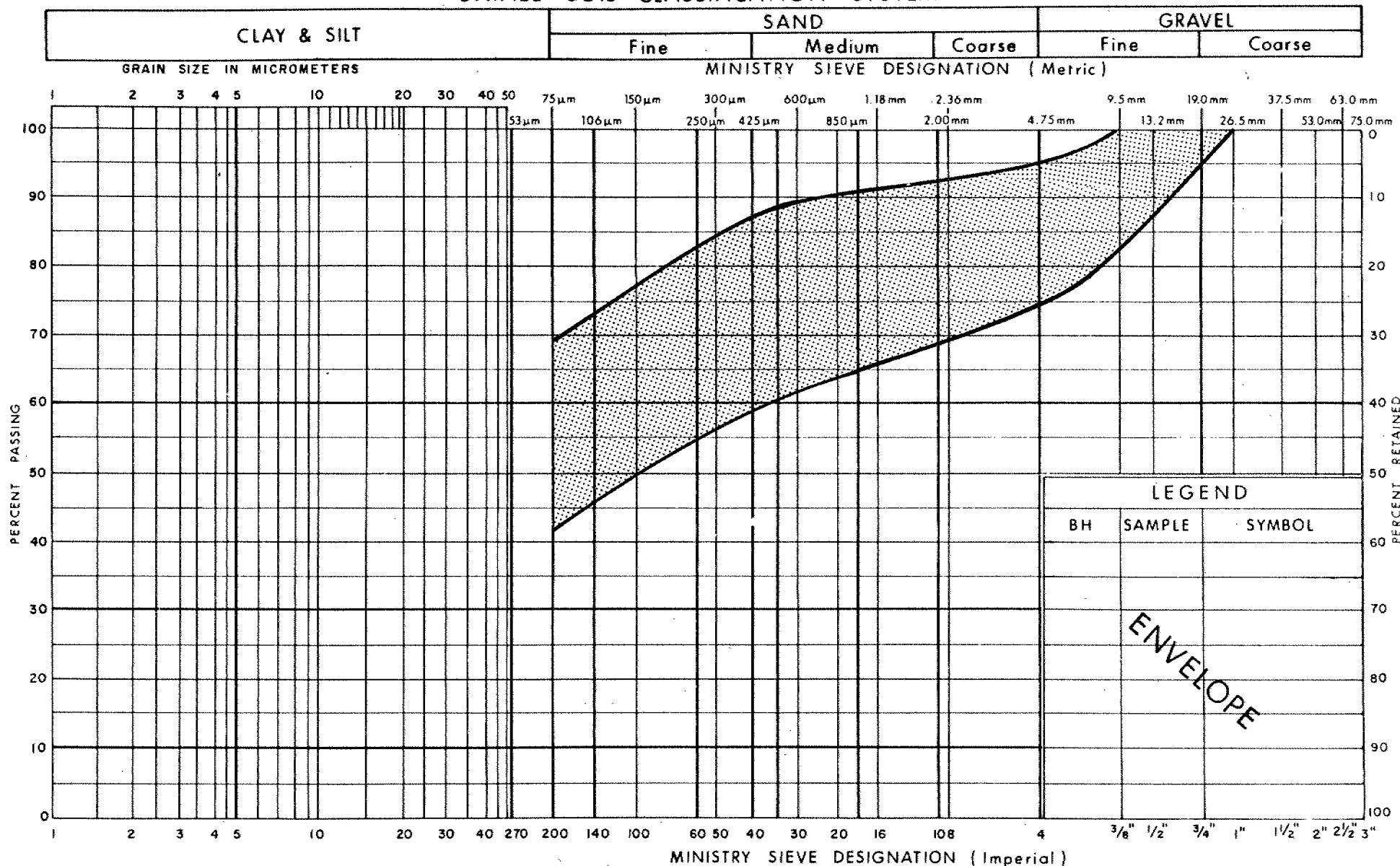
Ministry of  
Transportation  
Ontario

# PLASTICITY CHART HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 91-84-04

## UNIFIED SOIL CLASSIFICATION SYSTEM


 Ministry of  
Transportation

Ontario

## 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

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
205.2	Ground Surface															
0.0	SILTY CLAY, Some Sand, Trace of Gravel, Some Organics, Occasional Silty Sand Layers, Firm to Very Stiff ( Fill )		1	SS	5											2 14 40 44
			2	SS	8											
			3	SS	19											
			4	SS	21											
201.2	SILTY SAND, Some Gravel Compact  Gravelly Sand		5	SS	14											12 65 18 5
4.0			6	SS	14											
			7	SS	9											
197.3	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		8	SS	20											1 6 70 23
7.9			9	SS	100											
195.7	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard ( Glacial Till )															
9.5																
194.3	End of Borehole															
10.9																

# 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.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
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								
			2	SS	8								
			3	SS	16								
201.0			4	SS	10								
4.0			5	SS	19								
	Silty Sand, Trace of Clay		6	SS	14								1 61 28 10
	Boulders		7	SS	20								
195.5	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		8	SS	34								0 2 80 38
9.5			9	SS	100								
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard ( Glacial Till )		10	SS	100								
191.1			11	SS	100								5 43 37 14
13.9	End of Borehole				18cm								

# 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.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	w <sub>p</sub> w w <sub>L</sub>	WATER CONTENT (%)		
199.5	Ground Surface												
0.0	Topsoil		1	SS	12		198						
	Trace of Sand, Some Organics		2	SS	4								
	CLAYEY SILT, Some Sand, Trace of Gravel, Firm to Stiff		3	CS	PH		196						7 16 50 27
194.8			4	SS	9								1 11 58 30
4.7			5	SS	54		194						
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		6	SS	100 /23cm		192						
			7	SS	100 /20cm		190						
			8	SS	100 /23cm		188						5 26 43 26
187.9			9	SS	100 /18cm								
11.6													
187.3	GRAVELLY SAND												
12.2	End of Borehole												
	* Artesian pressure encountered at elevation 187.3m, and water level stabilized at 2.24m (elevation 201.7m) above ground surface												

# 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 <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
199.8	Ground Surface											
0.0												
	Probable CLAYEY SILT, Trace of Sand, Trace of Gravel											
193.1												
6.7	End of Cone Test											



# 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

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub> W W <sub>L</sub>	WATER CONTENT (%)		
200.8	Ground Surface											
0.0	Topsoil											
	SILTY SAND, With Organics, Very Loose to Compact		1	SS	6							8 43 41 8
198.1			2	SS	2							
			3	SS	15							
2.7			4	SS	15							
	CLAYEY SILT, Some Sand, Trace of Gravel, Stiff		5	SS	10							1 15 47 37
193.8			6	SS	9							
7.0			7	SS	33							
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard ( Glacial Till )		8	SS	100							6 32 55 7
189.9			9	SS	100							
10.9	End of Borehole											

## METRIC

[illegible]

\* 3, x 5: Numbers refer to Sensitivity

# 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		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W		
205.0	Ground Surface															
0.0	Granular Fill		1	SS	7											
	CLAYEY SILT, Trace of Gravel, Trace of Organics, Firm to Stiff ( Fill )		2	SS	14											
			3	SS	14											
			4	SS	16											
200.9			5	SS	12											
4.1			6	SS	20											
	SILTY CLAY, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		7	SS	18											
			8	SS	25											
			9	SS	15											
193.4			10	SS	25											
11.6		Heterogeneous Mixture of SILT, SAND and GRAVEL, Dense ( Glacial Till )		11	SS	37										
192.4																
12.6	End of Borehole															

# RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 91 - 84 - 04 LOCATION CO-ORDS: N 4 737 629.2, 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

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
205.0	Hwy. 4 Southbound Lane																
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												
			3	SS	10												
201.2			4	SS	12		202										
3.8	SILT, Trace of Sand, Trace of Gravel, Occasional Organics, Loose		5	SS	8		200										
198.2	Gravelly Sand		6	SS	8												
6.8			7	SS	11		198										
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		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		192										25 32 (42)
			11	SS	90	/13cm	190										
189.3			12	SS	170	/28cm											7 27 (66)
15.7	End of Borehole																

# 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.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>		
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	6		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										
188.4			6	SS	81	/15cm	190										
11.8			7	SS	106	/10cm	188										
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																

# 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

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
205.0	Hwy. 4 Shoulder															
0.0	Silty Sand		1	SS	4											
	CLAYEY SILT, Trace of Sand, Firm to Very Stiff ( Fill )		2	SS	5											
			3	SS	6											
			4	SS	8											
200.7			5	SS	12											
4.3			6	SS	11											
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Occasional Organics, Firm to Stiff		7	SS	4											
			8	SS	14											
196.0			9	SS	33											
9.0			10	SS	162											
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard ( Glacial Till )		11	SS	100 /15cm											
			12	SS	133 /15cm											
189.5			13	SS	95 /15cm											
15.5	End of Borehole															

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{VO}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

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

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT- DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

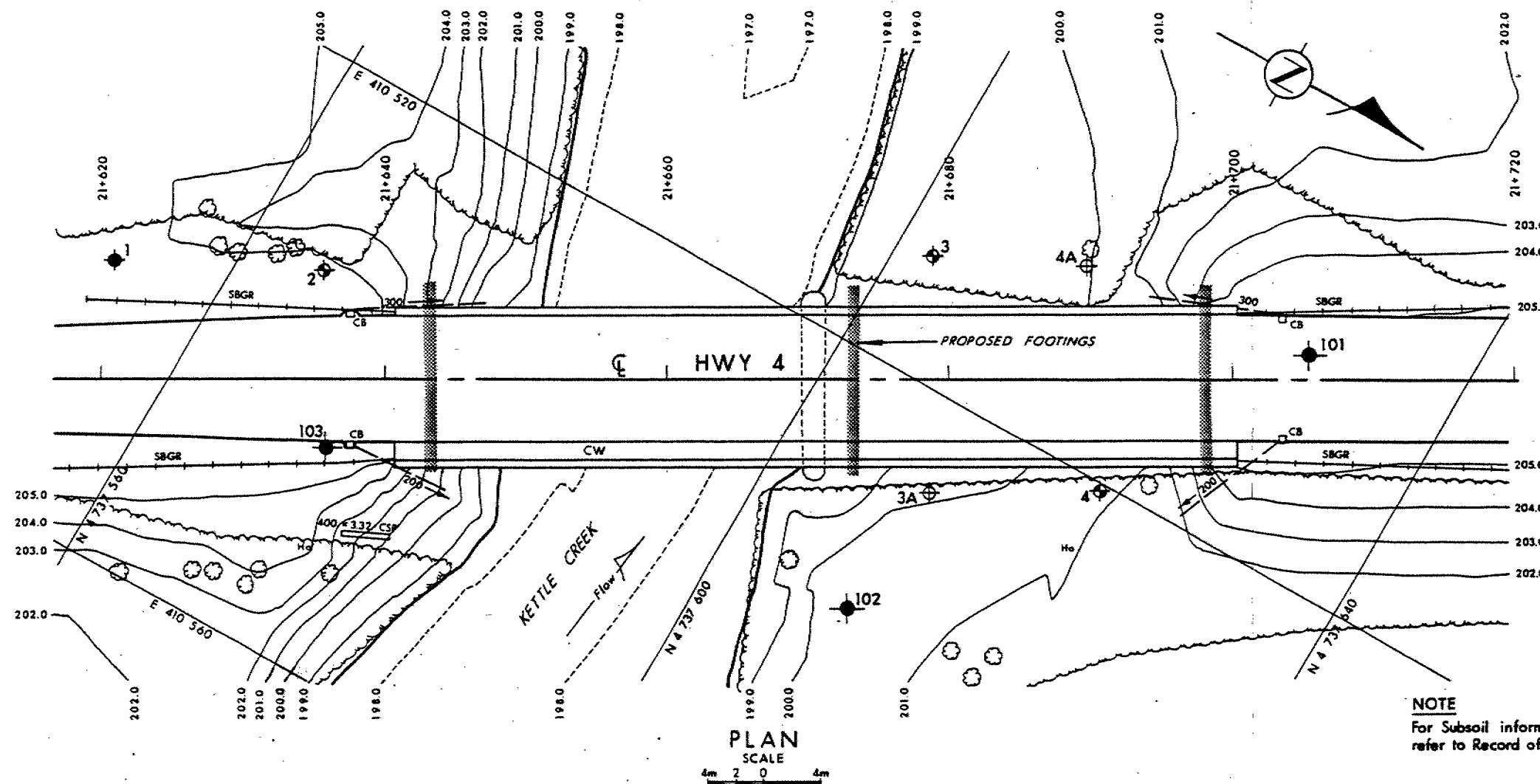
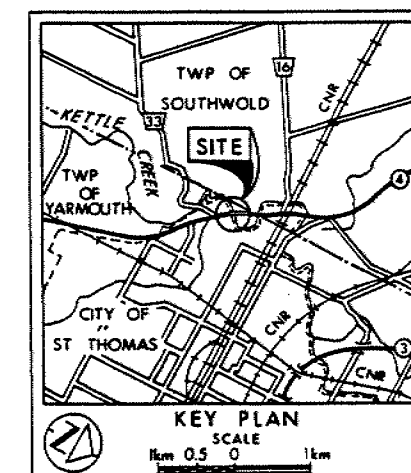
**METRIC**DIMENSIONS ARE IN METRES  
AND / OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.CONT No  
WP No 91-84-04

KETTLE CREEK (South)

BORE HOLE LOCATIONS &amp; SOIL STRATA



SHEET

**NOTE**For Subsoil information of BH's 2, 3A & 4A  
refer to Record of Borehole Sheets.**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
- Head
- ARTESIAN WATER Encountered

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	205.2	4 737 552.2	410 540.2
2	205.0	4 737 565.6	410 533.6
3	199.5	4 737 602.6	410 511.4
3A	199.8	4 737 611.0	410 526.8
4	200.8	4 737 621.4	410 520.4
4A	200.0	4 737 612.4	410 506.6
5	205.0	4 737 652.0	410 487.0
101	205.0	4 737 629.2	410 504.8
102	200.2	4 737 610.0	410 536.7
103	205.0	4 737 572.2	410 544.8

**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.

950725 RS	8.H.s 101, 102 & 103 ADDED, PROFILE REVISED
DATE	BY
DESCRIPTION	

Geocres No 40114-126

HWY No 4	DIST 2
SUBMD MV [CHECKED]	DATE Jul 18, 1994
DRAWN [CHECKED]	SITE 5-066
	DWG 918404-A

REF E-120-4-2, 1994 03

**PROFILE HWY 4**SCALE  
4m 2 0 4m