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W. O. No.

STR. SITE No.

HWY. No. 407

LOCATION EMBANKMENT STABILITY
Hwy 407 / KIPLING AVE Intch.

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 88-78-02 DIST 6

HWY 407 STR SITE N/A

EMBANKMENT STABILITY

Highway 407/Kipling Avenue Interchange

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FOUNDATION INVESTIGATION REPORT
For
Embankment Stability
Highway 407/Kipling Avenue Interchange
W.P. 88-78-02, Vaughan Township
District 6, Toronto

INTRODUCTION

This report summarizes the results of a series of foundation investigations conducted for the deep cuts and fills proposed at the ramps to the Highway 407/Kipling Avenue Interchange. The following deep cut areas were investigated:

Ramp NE	Sta. 10+206 to Sta. 10+309
Ramp W-NS	Sta. 10+300 to Sta. 10+540
Ramp SW	Sta. 10+238 to Sta. 10+275
Ramp E-NS	Sta. 10+500 to Sta. 10+672
Martingrove Road Connection	Sta. 9+580 to Sta. 9+742
Highway 407	Sta. 13+925 to Sta. 14+075
Kipling Avenue Extension	Sta. 10+120

Boreholes were also advanced at the following fill sections:

Ramp SE	Sta. 10+324 to Sta. 10+537
Martingrove Road Connection	Sta. 9+840 to Sta. 10+000

The investigations were carried out, in part, by the Foundation Design Section and by Strata Engineering Corporation at the request of Central Region Geotechnical Section.

SITE DESCRIPTION

The proposed Highway 407 and Kipling Avenue Interchange and Martingrove Road Connection are situated in Vaughan Township, approximately 700 m north of the intersection of Kipling and Steeles Avenue. The site is located in an old river valley carved by a branch of the Humber River. At present, the valley consists of a meandering Rainbow Creek and adjacent flood plains. In the vicinity of the Highway 407 and Kipling Avenue Interchange, the valley floor ranges in width from 110 m to 200 m. Rainbow Creek varies

in width from 1.0 m to 8.0 m. During the investigation, the creek was approximately 0.3 m deep, but rose to a depth exceeding 0.5 m following a heavy rainstorm. Rainbow Creek flows south easterly through the site, and is redirected to flow in an easterly direction as it approaches the CNR embankment. Rainbow Creek eventually flows into the Humber River further east of the site.

The slopes of the valley vary from as steep as 0.5H:1V to as flat as 6H:1V and rise to heights of 22 m on the southwest side and 19 m on the north-east side. The valley floor is densely covered by trees and brush with occasional open spaces covered by tall grasses and shrubs. The creek bed is composed largely of gravel and sand, but also contains cobbles and occasional boulders.

The site lies within the physiographic region known as the South Slope (after Chapman and Putnam, 1984) and it consists largely of glacial deposits.

INVESTIGATION PROCEDURES

i) Field

The field investigation for the SE Ramp was carried out by the Foundation Design Section between the period 89 09 12 and 89 09 13. The fieldwork conducted by Strata Engineering Corporation was carried out from 89 10 02 to 89 10 27 for the remaining cut and fill sections.

In total, 46 boreholes were advanced for analysis of the cut and fill areas exceeding heights of 4.5 m. Dynamic cone penetration tests were carried out at 14 of the borehole locations. The boreholes were advanced using track-mounted auger machines equipped with 83 mm I.D. hollow stem augers and solid stem augers.

Samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the ground according to the specifications of the Standard Penetration Test (ASTM D 1586-8).

The elevations and locations were provided either by MTO Central Region Surveys and Plans Office or interpolated from plans and profiles of the site.

ii) Laboratory

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden including:

- Natural Moisture Content
- Atterberg Limits
- Grain Size Distribution
- Bulk Unit Weight

The results of the laboratory testing are plotted on the Record of Borehole sheets.

SUBSURFACE CONDITIONS

In general, the subsurface conditions in the immediate vicinity of Rainbow Creek are composed of a variety of water-laid deposits underlain by cohesive clayey silt to silt layers that were frequently found to confine water-bearing silty sand strata. The valley floor away from the creek contains surficial organic deposits of peat and organic silt in the order of 3.2 m thick or less.

The slopes of the valley are composed largely of a clayey silt to silt glacial till deposit that is interbedded and/or underlain by non-cohesive silty sand material.

Detailed subsurface conditions may be found in the soil investigation report issued by Strata Engineering Corporation following their field work conducted for the proposed Highway 407/Kipling Avenue Interchange ramps and Martingrove Road Connection. The consultant was retained by the Central Region Geotechnical Section. The details of the soils investigation and

subsurface conditions are contained in a report under W.P. 88-78-02 entitled Hwy. 407/Kipling Avenue Interchange Cuts, From Martingrove Road E'ly to Humber River.

The boundaries of the different strata, together with the field and laboratory test results, appear on the Record of Borehole sheets appended to this Report. Refer to these sheets for the locations and elevations of the boreholes (BH's 1 through 18, 20 through 34, 41 through 54).

GROUNDWATER CONDITIONS

The groundwater conditions vary across the site. In the vicinity of the valley floor, the groundwater conditions are highly unpredictable. Artesian conditions were encountered in some areas and not in others. Where artesian conditions were not present, the groundwater table is close to the ground surface and is perched above the clayey silt to silt and silty sand deposits.

Boreholes advanced at higher elevations revealed a variable groundwater level as a result of a perched water table at many locations. Artesian conditions were not encountered atop the valley slopes.

Refer to the individual borehole log sheets for the groundwater conditions.

The elevation of the creek, at the time of the soils investigation conducted by the Foundation Design Section, was approximately 136.5 m. The creek level experienced a fluctuation in the order of 0.5 m following a period of heavy rainfall.

DISCUSSION

The extent of the proposed deep cut and fill sections for the Highway 407/
Kipling Avenue Interchange are as follows:

<u>Location</u>	<u>Maximum Depth of Cut/Fill</u>
Martingrove Road Connection, Sta. 9+560 - Sta. 9+840	11.0 m Cut
Martingrove Road Connection, Sta. 9+840 - Sta. 10+000	6.5 m Fill
Ramp E - NS	13.5 m Cut
Ramp S - W	13.0 m
Ramp N - E	13.0 m
Ramp W - NS	12.0 m Cut
Ramp S - E	8.1 m Fill
Highway 407, Sta. 13+900 - Sta. 14+300	7.5 m Cut
Kipling Avenue Extension, Sta. 10+120	12.5 m Cut

RECOMMENDATIONS

Recommendations consisting of slope stability, slope geometry and slope treatment are provided for the deep cut and high fills proposed at the Highway 407/Kipling Avenue Interchange.

Slope Stability for Cut Sections

Slope stability calculations were performed using Effective Stress Analysis for each of the deep cut locations. The results of the analyses are sketched in Figures 1 and 2. No stability problems are anticipated provided that 2H:1V slopes are maintained. Where the depth of cut is equal to or greater than 6.0 m, a bench should be incorporated in the slope. The width of the bench varies with the depth of the cut, as shown in Figure 3. The benches may be run out as quickly as is feasible in the area beyond which they are required for stability. There should be a slight grade in the berm towards the slope to prevent ponding of water on the bench.

For cuts greater than 4.5 m, the lower half of the slopes should be treated with a 600 mm thick granular blanket. For cuts greater than or equal to 6.0 m, the 600 mm granular blanket should protect the lower slope of the cut embankment. The geometry and recommended slope treatment are sketched in Figure 4, appended to this report.

The granular blanket should consist of Granular 'A'.

Toe drains should be placed at the base of the lower slopes to facilitate drainage of surface runoff. Provision should be made to connect the toe drains to an appropriate permanent drainage system, taking into consideration the effects of erosion and freezing.

Interceptor ditches should be placed at the top of the slopes. In addition, topsoil and slope vegetation should be established as soon as possible after completion of the cut to control surficial erosion.

Slope Stability for Fill Sections

Prior to the placement of the fill, all surficial organic and/or soft cohesive material should be removed under the plan limits of the embankments and sub-excavated for an additional width beyond the embankment equal to the depth of sub-excavation. Refer to Figure 5 for a typical section. The

sub-excavated material should be replaced with suitable compacted granular backfill. Temporary excavations should be inclined at 1.5H:1V.

Sub-excavation will be required at the proposed fill section locations to the approximate elevations provided below:

Martingrove Road Connection, Sta. 9+840 - Sta. 10+000	E1. 138 m±
Ramp S-E, Sta. 10+324 to Sta. 10+537	E1. 136 m±

The exposed sub-excavated base should be proof-rolled and any soft pockets should be removed.

Because the subsurface conditions at this site are similar to those encountered during the investigation for the Kipling Avenue Overpass, the results of the Total Stress Analysis performed at the latter site were applied at the two high fill sections. No stability problems are anticipated provided that 2H:1V slopes are maintained and a berm is incorporated in fills that are greater than or equal to 6.0 m in height. The berm widths increase with the height of fill and are charted in Figure 6. The berms may be run out as quickly as is feasible in the area beyond which they are required for stability. The berm should grade slightly towards the slope to prevent ponding of water.

To protect the slopes from erosion, the granular blanket treatment, as described for the cut sections, should be applied to the fill sections to the anticipated high water level. A granular blanket is not required if the embankment fill is composed of granular material. No toe drains are required for the fill sections.

As in the case of the cut sections, slope vegetation should be established as soon as possible after placement of the fill in order to control surficial erosion.

Settlement

It is anticipated that minor settlements will take place within the high

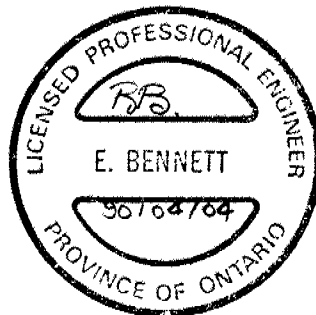
fill embankments. It is expected that much of the anticipated settlement will take place during construction. To minimize post-construction settlements the fill area may be pre-loaded for a minimum three month duration. A height of 6.0 m above original ground is recommended for the pre-load embankment.

MISCELLANEOUS

The fieldwork for the investigation conducted by the Foundation Design Section was carried out by B. Sedgwick, University of New Brunswick Engineering Student, D. Colquhoun, Engineer on a Jamaican Exchange Program and B. Bennett, Foundation Engineer. The equipment was owned and operated by Master Soil Investigations Limited of Toronto, and Marathon Drilling Company Limited of Ottawa.

Drilling equipment for the investigation conducted by Strata Engineering Corporation was owned and operated by Eastern Soil Investigation Limited of Ajax, Ontario.

The report was prepared by Ms. B. Bennett under the general supervision of Mr. D. Dundas, Senior Foundation Engineer. The report was reviewed by Mr. D. Dundas and approved by Mr. M. Devata, Chief Foundation Engineer.



B. Bennett
B. Bennett, P.Eng.
Foundation Engineer

M. Devata
M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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

STRESS AND STRAIN

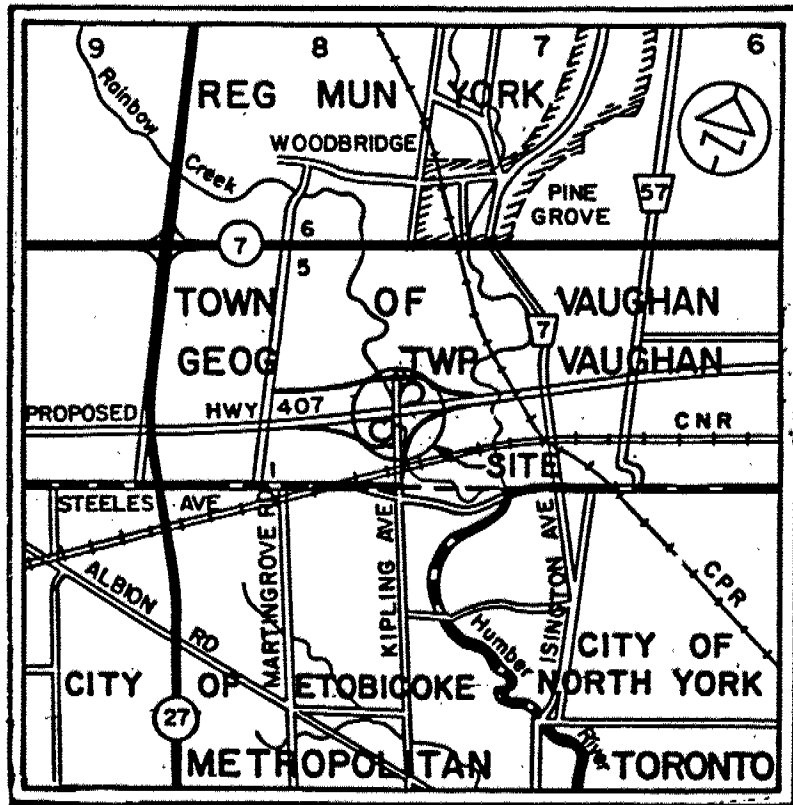
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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



KEY PLAN



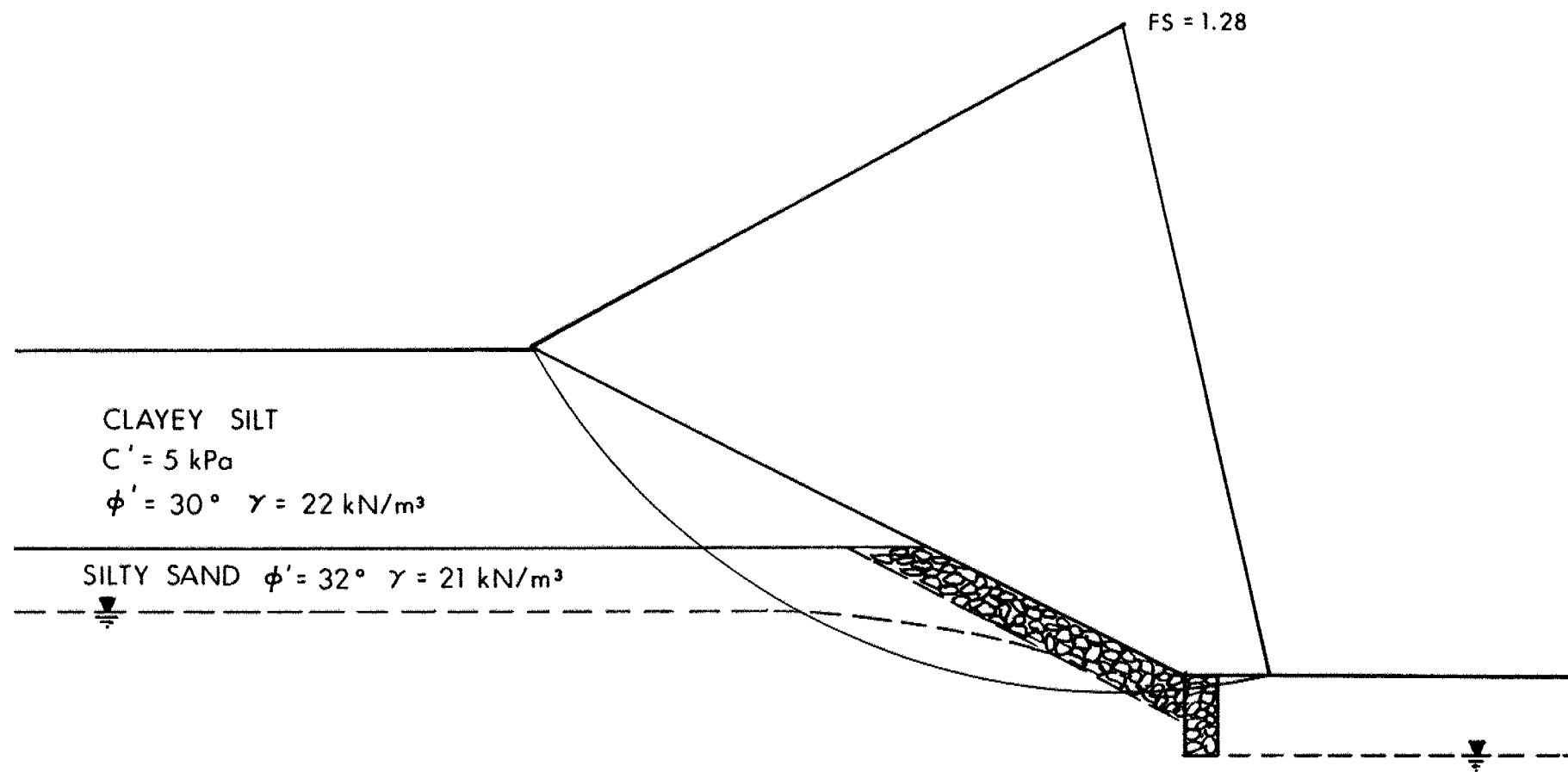


FIG 1 - EFFECTIVE STRESS ANALYSIS FOR 5.0 m DEEP CUT SECTION

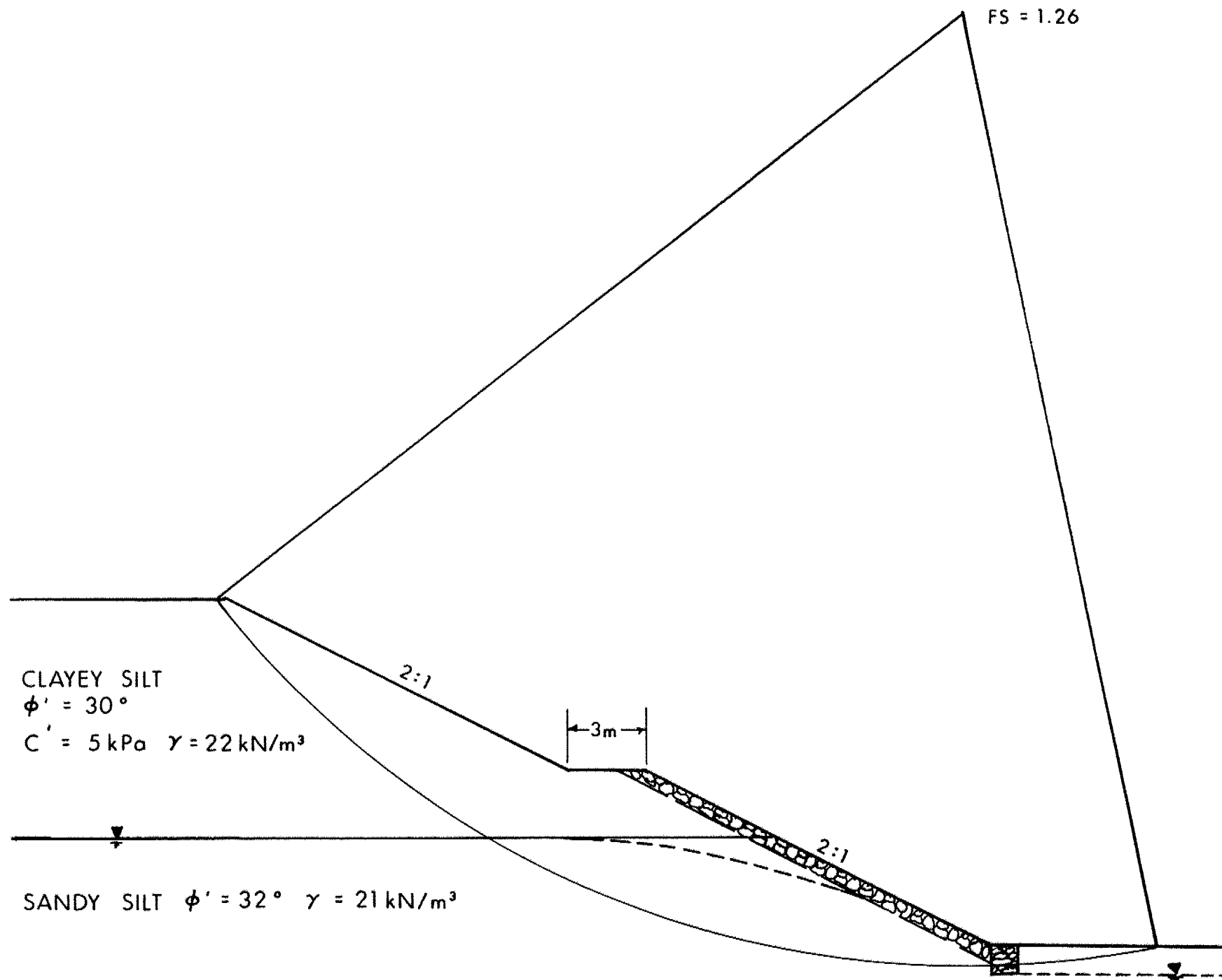


FIG 2 - EFFECTIVE STRESS ANALYSIS FOR 13.0 m CUT SECTION

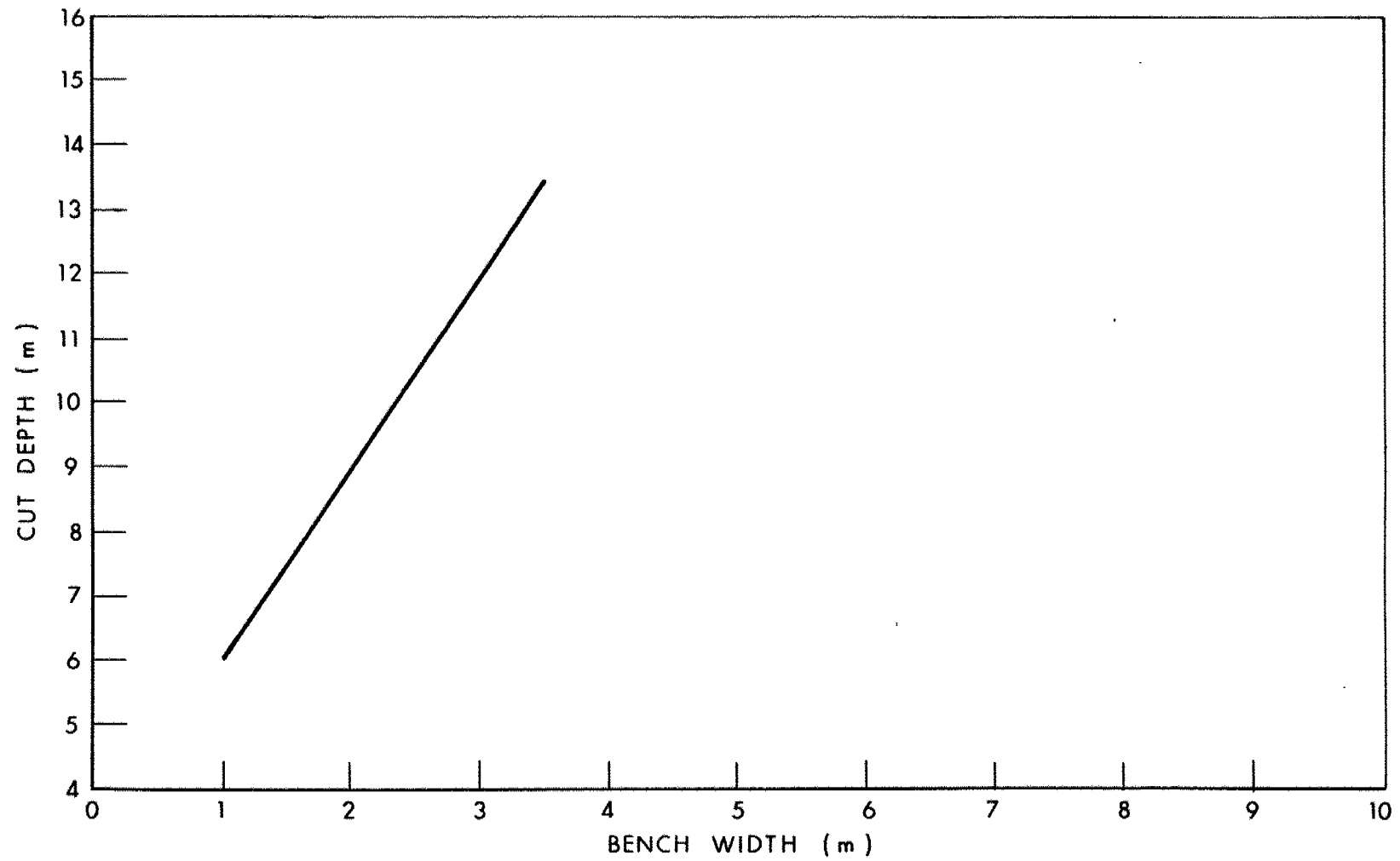


FIG 3- CUT DEPTH versus BENCH WIDTH

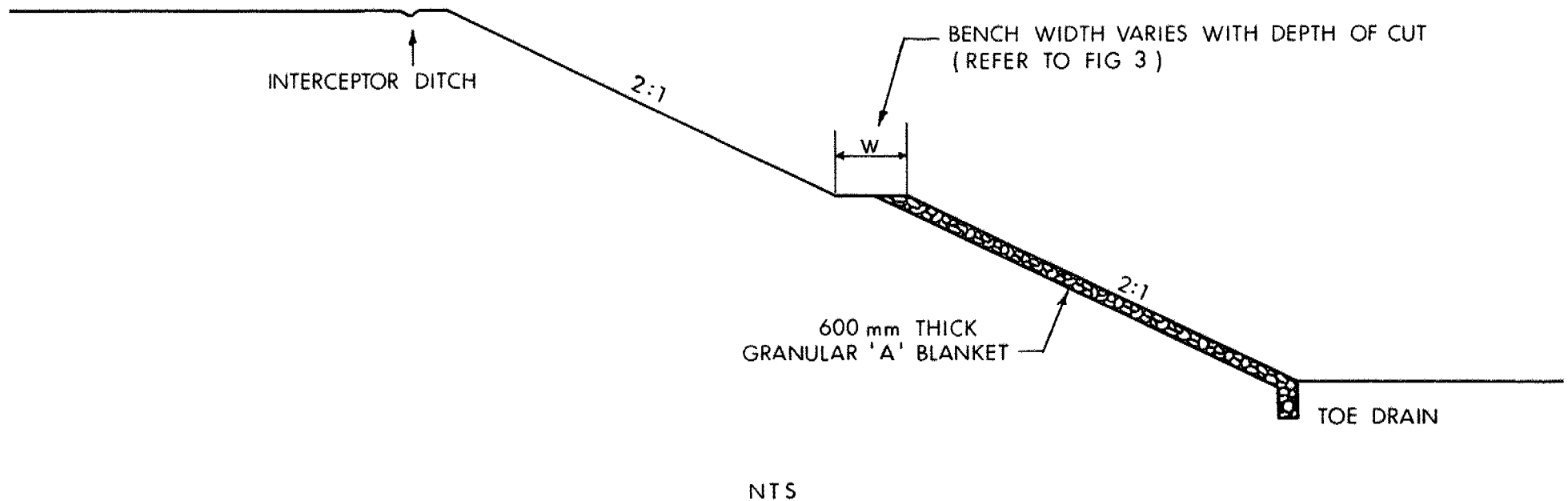
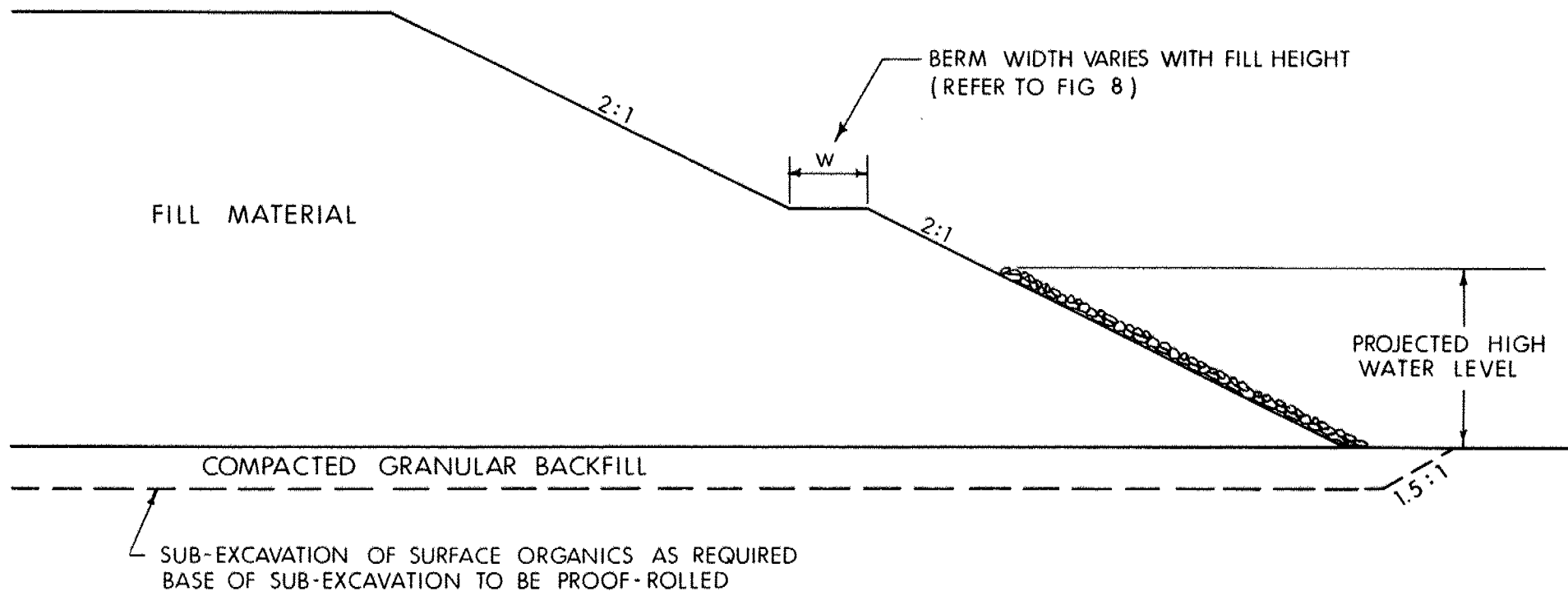


FIG 4 - TYPICAL SLOPE GEOMETRY AND TREATMENT FOR CUT SECTIONS



NTS

FIG 5 - TYPICAL SLOPE GEOMETRY AND TREATMENT FOR FILL SECTIONS

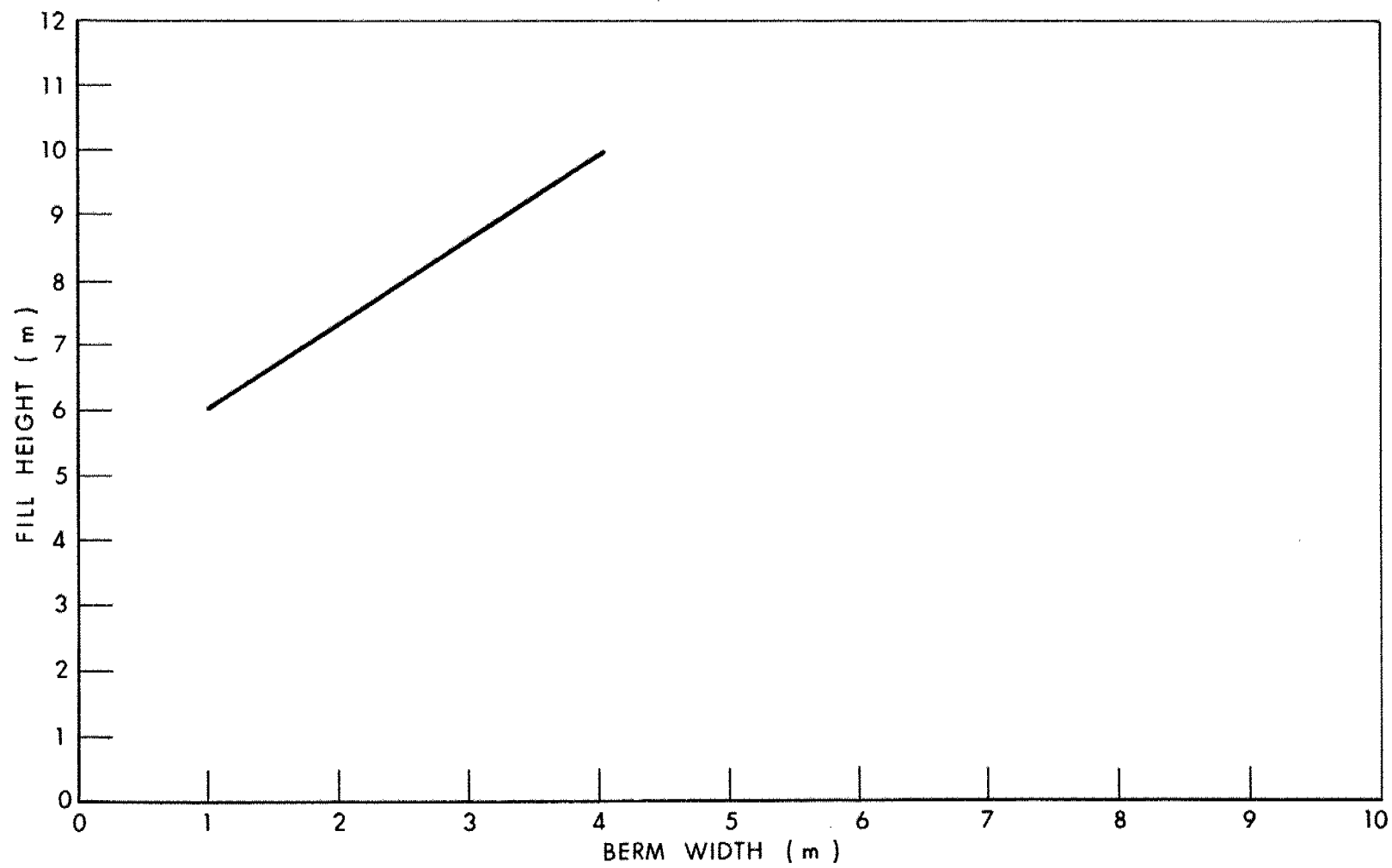


FIG 6 - FILL HEIGHT versus BERM WIDTH

RECORD OF BOREHOLE No 1

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA 9 + 580 C.L. ORIGINATED BY DM
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY SS
 DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
162.4	Ground Surface															
0.0	300 mm Topsoil		1	SS	70											
	Clayey Silt with some sand (Glacial Till) Grey-Brown		2	SS	102											
	occ. seams light brown silt and sand		3	SS	88											
	Hard		4	SS	91	/28cm										
			5	SS	60	/15cm										
155.1			6	SS	100	/10cm										
7.3	Silty Sand with gravel Brown		7	SS	80	/15cm										
	occ. gravelly zones V. dense															
152.0			8	SS	90											
10.4	Clayey Silt (Glacial Till) Grey Hard															
150.1	Sand & Gravel V. Dense		9	SS	75	/15cm										
12.3	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 640 C.L. ORIGINATED BY DM
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY SS
 DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
162.8	Ground Surface																
0.0	300 mm Topsoil		1	SS	33		162										
	Clayey Silt with some Sa occ. gravel (Glacial Till) Random seams of Lt. Br. Si and Sa V. stiff to Hard Grey-Brown		2	SS	43		160										
			3	SS	62		158										
157.3			4	SS	48		156										
5.9	Silty sand with gravel Tr. clay V. Dense occ. gravel lenses Brown		5	SS	59		154										
			6	SS	100		152										
			7	SS	112		150										
152.6			8	SS	75		148										
10.2	Clayey silt-silt some Sa, occ. grav. (Glacial Till) Grey Hard		9	SS	90												
150.6			10	SS	72												
12.2	Si sand & gravel Brown V. dense																
147.9																	
14.9	Sandy silt. Brown V. dense		11	SS	100												
147.3																	
15.5	End of Borehole																

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

RECORD OF BOREHOLE No 3

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA 9 + 700 C.L. ORIGINATED BY MJP
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
162.1	Ground Surface															
0.0	300 mm Topsoil					162										
	Clayey silt with some sand, occ. gravel (Glacial Till)		1	SS	60	160										
	Grey-Brown Hard		2	SS	70	158										
			3	SS	125	156										
	occ. seams of fine sand and silt		4	SS	72	154										
			5	SS	100	152										
	Sand with some gravel V. Dense		6	SS	82	150										
151.7			7	SS	100	148										
10.4	Si sand with gravel. Grey V. dense					146										
150.5																
11.6	Laminated silt to a clayey silt Grey. Hard		8	SS	137											
149.1			9	SS	68											
13.0	Silty sand to sandy silt Grey to Brown V. dense occ. gravel seams		10	SS	115											
145.1			11	SS	104											
17.0	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15 ÷ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 742 C.L. ORIGINATED BY MJP
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 17 CHECKED BY CM

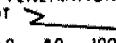
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
161.0	Ground surface																
0.0	300 mm Topsoil																
158.0	Clayey silt with some Sand, Tr. gravel (Glacial Till) Hard. Grey-Brown		1	SS	159		160										
3.0			2	SS	168	/25cm	158										
153.4	Sandy silt, to Silty sand Tr. clay V. dense Lt. Brown		3	SS	170		156										0 30 64 6
			4	SS	100	/15cm	154										
			5	SS	120	/5cm	152										
7.6	Silty sand with gravel Brown V. dense		6	SS	100	/10cm	150										W.L. on 1989 10 26 26 54 (20)
150.3			7	SS	100	/10cm	148										0 22 48 30
10.7	Silt Tr. clay Grey V. dense		8	SS	115	/15cm	146										0 2 86 12
148.6			9	SS	125	/10cm	144										
12.4	Sandy silt to silty sand with gravel Grey, V. dense		10	SS	130	/10cm											
145.8			11	SS	110	/10cm											
15.2	Clayey silt-silt with sand, some gravel (Glacial Till) Hard		12	SS	100	/8cm											
142.5																	
18.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 800 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
141.5	Ground surface																
0.0	Peat Fibrous, Black Soft		1	SS	4		140										W.L. on 1989 10 26
138.3	org.silt.occ.Peat V. Soft		2	SS	3												
1.2			3	SS	22												
3.4	Silty sand, some gravel grey V. dense occ. coarse sand and gravel seams		4	SS	121		138										
134.9			5	SS	133		136										
6.6	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 825, 0/s 15m Lt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
141.2	Ground surface																
0.0	Peat Fibrous Black V. Soft		1	CS	-												W.L. on 1989 10 27
0.6	org. silt		2	CS	-												
139.3	Dk. Brown-Grey Tr. shells, soft		3	SS	4												
1.9	Silty Sand some gravel Grey		4	SS	18												
	Compact to V. Dense occ. coarse sand and gravel seams		5	SS	128												
135.2	Silty Sand. Grey V. dense		6	SS	80	15cm											
6.0																	
6.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 825; 0/s 15m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			20	40	60	80	100					
141.2	Ground surface															
0.0	Peat, Fibrous Black-V. soft		1	SS	2											W.L. on 1989 10 26
139.4			2	SS	2											
1.8	org. silt Dk. Brown-Grey soft-firm		3	SS	7											
137.8			4	SS	41											
3.4	Silty sand some gravel Grey Dense occ. coarse sand and gravel seams		5	SS	45											
134.6			6	SS	10											possible sub-artesian condition
6.6	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 840 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.8	Ground surface																
0.0	Peat, Fibrous Black						140										W.L. on 1989 10 26
139.0	V. Soft		1	SS	1	/46cm											
1.8	org. silt v. soft		2	SS	13												
138.2	Grey		3	SS	110												
2.6	Silty sand some gravel		4	SS	135												
	Grey						138										
	V. dense																
	occ. coarse						136										
	sand and gravel																
134.5	seams		5	SS	90	/15cm											
6.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

**METRIC**

W P	88-78-02	LOCATION	Martin Grove Rd. Connection STA. 9 + 850; 0/s 15m Lt.	ORIGINATED BY	KSS
DIST	6 HWY 407	BOREHOLE TYPE	Solid Stem Auger	COMPILED BY	MJP
DATUM	Geodetic	DATE	1989 10 27	CHECKED BY	CM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 10

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 850; 0/s 15m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.5	Ground surface																
0.0	Peat, Fibrous Black V. Soft		1	SS	2		140										W.L. on 1989 10 25
138.7			2	SS	6												
1.8	Organic silt																
137.5	Grey soft-firm						138										
3.0	Silty sand some gravel grey		3	SS	24												
	compact-V. dense occ. coarse sand and gravel seams		4	SS	79		136										
134.3			5	SS	100	/10cm											
6.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 865; 0/s 18 m Lt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.2	Ground surface																
0.0	Peat, Fibrous Black Soft		1	TW	PM		140										
138.7			2	TW	PM												
138.1	org. silt Grey Firm		3	TW	PM												
2.1			4	SS	31		138										
	Silty sand some gravel Grey V. dense		5	SS	107												
			6	SS	87	/15cm	136										
133.8	occ. coarse sand and gravel seams		7	SS	116	/15cm	134										
6.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 12

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 865; 0/± 18 m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE
140.2	Ground surface																	
0.0	Peat, Fibrous Black V. Soft		1	TW	PM		140	1.8								W=215%	W.L. on 1989 10 25	
138.9			2	SS	2											W=299%		
138.3	org. silt, grey Firm		3	SS	7											W=49%		
1.9	Silty sand some gravel Grey Dense-V. Dense		4	SS	35		138											
			5	SS	119	/15cm	136											
	occ. coarse sand and gravel seams																	
133.8			6	SS	100	/13cm	134											
6.4	End of Borehole																	

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 875 C.L. ORIGINATED BY MJP
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 17 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.1	Ground surface																GR SA SI CL
0.0	Peat, Fibrous		1	SS	5		140										W.L. on 1989 10 17
138.4	Black-Dk. Brown V. soft - soft		2	SS	36												
1.7	org. silt Grey Firm		3	SS	42		138										
1.8	Silty sand some gravel Grey Dense-V. Dense		4	SS	69												
			5	SS	100	/11cm	136										
133.7	occ. coarse sand and gravel seams		6	SS	95	/15cm	134										
6.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to
Sensitivity

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

RECORD OF BOREHOLE No 14

METRIC

W P 88-78-02 LOCATION Ramp E-N,S STA 10 + 672 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 23 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
156.9	Ground surface																GR SA SI CL
0.0	300 mm Topsoil						156										
	Clayey Silt, some sand Tr. Gravel (Glacial Till) Grey-Brown Hard occ. si sa layers becoming grey with depth		1	SS	73	5cm	154										
			2	SS	70		152										
			3	SS	37		150										
150.2			4	SS	100		148										
6.7	Sandy silt to silty sand Tr. Clay Light Brown		5	SS	100	10cm	146										
			6	SS	114	15cm	144										
			7	SS	100	13cm	142										
	Grey V. Dense Tr. clay		8	SS	120	23cm	140										
			9	SS	80	8cm	138										
141.4	occ. to some gravel		10	SS	85	15cm											
15.5	Fine to Medium sand with silt Grey V. Dense		11	SS	95	15cm											
			12	SS	83	15cm											
136.9			13	SS	112	21cm											
20.0	End of Borehole																

W.L. on
1989 10 26

+3, x5: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15

METRIC

W P 88-78-02 LOCATION Ramp E-N, S STA 10 + 628 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 19 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
157.4	Ground surface															
0.0	300 mm Topsoil															
	Clayey silt with some sand (Glacial Till) Grey-Brown		1	SS	80	156										
			2	SS	53	154										
	occ. Red-Brown sand and gravel seams		3	SS	64	152										
	Grey		4	SS	67	150										
	Hard		5	SS	150	150										
148.3			6	SS	110	148										
9.1	Brown silty sand to sandy silt		7	SS	110	146										
	occ. gravel		8	SS	100	146										2 68 25 5
	Tr. clay		9	SS	120	144										6 39 51 4
	V. Dense		10	SS	100	142										0 60 34 6
140.6			11	SS	112	140										
16.8	Grey occ. seams of gravel		12	SS	135	138										W.L. on 1989 10 26
137.5			13	SS	110	138										
19.9	End of Borehole															

+³, x⁵: Numbers refer to Sensitivity
 20
 15
 10

20
 15
 10
 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16

METRIC

W P 88-78-02 LOCATION Ramp E-N,S STA 10 + 560 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
156.0	Ground surface																
0.0	300 mm Topsoil																
	Grey-Brown		1	SS	52		154										
152.8			2	SS	23		152										
3.2	Grey		3	SS	35		150										
	Clayey silt with some sand, occ. gravel (Glacial Till)		4	SS	71		148										
	V. Stiff-Hard		5	SS	73		146										
	occ. seams of sand and fine gravel		6	SS	50		144										
145.3			7	SS	110	/15cm	142										
10.7	Silty sand to sandy silt with some gravel Brown to Grey V. Dense		8	SS	100	/15cm	140										
			9	SS	100	/15cm											
			10	SS	100	/10cm											
			11	SS	170	/25cm											
138.9			12	SS	170	/18cm											
17.1	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 17

METRIC

W P 88-78-02 LOCATION Ramp E-N,5 STA 10 + 500 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY HJP
 DATUM Geodetic DATE 1989 10 18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
154.7	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt with some sand Tr. gravel (Glacial Till)		1	SS	85.		154										
	Grey Brown		2	SS	42		152										
	Hard with Laminated silt and Clayey silt seams		3	SS	46		150										
	and		4	SS	52		148										
	occ. seams of sand and gravel		5	SS	61		146										
144.7			6	SS	61		144										
10.0	Grey		7	SS	72		142										
			8	SS	41		140										
141.0			9	SS	135/25												
13.7	Silty sand to sandy silt, occ. gravel																
139.2	V. Dense Grey		10	SS	90/15												
15.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

← Borehole
caved

W.L. on
1989 10 26

RECORD OF BOREHOLE No 18

METRIC

W P 88-78-02 LOCATION Ramp S-W; STA 10 + 238 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 24 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
155.8	Ground Surface															GR SA SI CL
0.0	300 mm Topsoil															
	Clayey silt with some sand occ. gravel (Glacial Till)		1	SS	75	154										
	Grey Brown to Grey		2	SS	76	152										
	Hard occ. seams of red Br. sand		3	SS	78	150										
			4	SS	115	150										
148.2			5	SS	140	148										
7.6	Silty sand to sandy silt V. Dense		6	SS	120	146										
	gravelly zone		7	SS	120	144										
	Light Brown to Grey		8	SS	92	142										
			9	SS	100	140										
			10	SS	100											
138.6			11	SS	180											W.L. on 1989 10 26
17.2	End of Borehole															

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

RECORD OF BOREHOLE No 20

METRIC

W P 88-78-02 LOCATION Ramp N-E; STA 10 + 206 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 06 CHECKED BY CH

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
159.6	Ground surface															
0.0	300 mm Topsoil															
	Clayey Silt with some sand occ. gravel (Glacial Till)		1	SS	68											
	Grey-Brown		2	SS	41											
	Hard		3	SS	88											
	Sand and gravel Brown V. Dense		4	SS	77	/5cm										
	Grey		5	SS	53											
150.8	Hard		6	SS	100	/10cm										
8.8	Sandy silt Tr. gravel Brown occ. f. sand or silt lamination		7	SS	100	/10cm										
			8	SS	100	/15cm										
146.6			9	SS	100	/13cm										
13.0	Grey		10	SS	100	/15cm										
			11	SS	110	/15cm										
142.7																
16.9	End of Borehole															

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

RECORD OF BOREHOLE No 21

METRIC

W P 88-78-02 LOCATION Ramp N-E; STA 10 + 259 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 10 to 11 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
158.4	Ground surface																
0.0	300 mm Topsoil						158										
	Clayey silt some sand, Tr. gravel (Glacial Till)		1	SS	110		156										
	Grey Brown Hard		2	SS	106		154										
			3	SS	53	/15cm	152										
152.0			4	SS	45		150										
6.4	Grey		5	SS	103	/23cm	148										
			6	SS	100	/8cm	146										
149.2			7	SS	100	/13cm	144										
9.2	Silty sand to sandy silt Tr. clay V. dense Grey		8	SS	100	/15cm	142										
			9	SS	75	/8cm	140										
			10	SS	100	/13cm											
			11	SS	130	/13cm											
	occ. coarse sand and gravel seams		12	SS	59												
139.6																	
18.8	End of Borehole																

W.L. on
1989 10 27

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (% STRAIN AT FAILURE

RECORD OF BOREHOLE No 22

METRIC

W P 88-78-02

LOCATION Ramp N-E; STA 10 + 309 C.L.

ORIGINATED BY KSS

DIST 6 HWY 407

BOREHOLE TYPE Solid Stem Auger

COMPILED BY IM

DATUM Geodetic

DATE 1989 10 13

CHECKED BY MJJ

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			'N' VALUES	20 40 60 80 100	Wp W WL	10 20 30			
157.6	Ground surface												
0.0	300 mm Topsoil												
	Clayey Silt with some sand, occ. gravel (Glacial Till)		1	SS	92								
	Grey-Brown		2	SS	65								
	Hard		3	SS	58								
152.1													
5.5	Grey		4	SS	81								
149.7			5	SS	126	20cm							
7.9	Sandy Silt to silty sand Tr. clay		6	SS	88	15cm							
	Brown		7	SS	84	15cm							
	V. Dense		8	SS	95	15cm							
144.5			9	SS	100	15cm							
13.1			10	SS	100	10cm							
	Grey		11	SS	100	13cm							
			12	SS	100	10cm							
	Sand and gravel V. dense												
139.1			13	SS	107								
18.5	Sand, some gravel Grey V. Dense												
137.5			14	SS	80	15cm							
20.1	End of Borehole												

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

RECORD OF BOREHOLE No 23

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 540 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 12 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	Wl	10 20 30		
158.3	Ground surface												
0.0	300 mm Topsoil												
	Clayey silt some sand Tr. gravel (Glacial Till)	1	SS	91									
	Hard	2	SS	100	/15cm								
	Grey-Brown to Grey	3	SS	61									
		4	SS	45									
		5	SS	73									
149.2		6	SS	100	/8cm								
9.1	Sand and gravel Tr. silt, clay V. dense	7	SS	100	/5cm								
147.6													
10.7	Sandy silt to silty sand Brown to Grey Brown V. dense	8	SS	100	/15cm								
		9	SS	75	/10cm								
		10	SS	98	/15cm								
		11	SS	100	/8cm								
139.9		12	SS	130	/15cm								
18.4	End of Borehole												

← Borehole
Caved
No water
above
cave level

RECORD OF BOREHOLE No 24

METRIC

W P 88-78-02 LOCATION Ramp W-N₂S; STA 10 + 510 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 16 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					
158.9	Ground surface												
0.0	300 mm Topsoil												
	Clayey silt, some sand Tr. gravel (Glacial Till) Grey Brown-Grey Hard						158						Borehole augered without sampling to 11.9 m
							156						
							154						
							152						
150.4							150						
8.5	Sand and gravel						148						
148.8	Brown V. dense						146						
10.1	Silty sand clayey silt (Glacial Till) Grey Brown to sandy silt Brown-grey brown V. dense		1	SS	100	/8cm							Borehole dry upon completion
			2	SS	100	/10cm							
			3	SS	120	/15cm							
144.4			4	SS	117	/13cm							
14.5	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
3 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 25

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 480 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 11 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
159.1	Ground surface																GR SA SI CL
0.0	300 mm Topsoil																
	Clayey silt with some Sa, Tr. gravel (Glacial Till)		1	SS	94		158										
	Grey-Brown		2	SS	45		156										
	Hard		3	SS	120		154										4 14 54 28
			3A	CS	-												
			4	SS	85		152										
			5	SS	100	/13cm	150										
	seams of fine sand		6	SS	160	/23cm	148										
148.7			7	SS	100	/10cm	146										
10.4	Silty sand to sandy silt Tr. clay		8	SS	100	/15cm	144										0 13 83 4
	Light Brown to grey		8A	CS	-												2 38 46 14
	V. dense occ. seams of reddish brown sand		9	SS	120	/14cm	142										
144.3			10	SS	100	/5cm											5 40 45 10
14.8	Clayey silt-silt with some sand occ. gravel (Glacial Till)		11	SS	130	/15cm											Borehole caved
	Grey, hard																No water above level of caving
*	sand and gravel V. dense		12	SS	100	/10cm											
140.6																	
18.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 27

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 420 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY IAM
 DATUM Geodetic DATE 1989 10 05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)				
160.0	Ground surface													
0.0	300 mm Topsoil													
	Clayey silt some sand occ. gravel (Glacial Till)		1	SS	61		158							
			2	SS	40		156							
	Grey-brown to Grey		3	SS	60	5cm	154							
			4	SS	60		152							
	Hard		5	SS	55		150							
	occ. seams of sand and gravel		6	SS	99		148							
150.0			7	SS	80	10cm	146							
10.0	Sandy silt to silty sand Tr. clay		8	SS	75	5cm	144							
	Grey		9	SS	70	8cm	142							
	V. dense		10	SS	80	8cm	140							
			11	SS	90	10cm	138							
143.1														
16.9	End of Borehole													

← Borehole
caved.
No water
above cave
level.

RECORD OF BOREHOLE No 28

METRIC

W P 88-78-02 LOCATION Ramp W-N.S; STA 10 + 360 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJJ
 DATUM Geodetic DATE 1989 10 05 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W _p	W	W _L		
								SHEAR STRENGTH kPa									
160.8	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand occ. gravel (Glacial Till) Hard. Grey-Brown		1	SS	72		160										
			2	SS	67	/15cm	158										
	occ. seams of grey silt and sand Dense		3	SS	46		156										
155.3			4	SS	80	/8cm	154										
5.5	Sand and gravel Brown. V. dense Tr. clay, silt		5	SS	110	/18cm	152										
152.9	Medium-coarse sand		6	SS	110	/23cm	150										
7.9	Red-Brown. V. dense		7	SS	78		148										
152.1			8	SS	93	/15cm	146										
8.7	Laminated silt and clayey silt with occ. fine sand seams Grey, Hard or V. dense		9	SS	100	/3cm											
147.5			10	SS	90	/10cm											
13.3	Sand and gravel																
146.5	grey. V. dense																
14.3	F. sand. Grey																
145.3	V. dense																
15.5	End of Borehole																

← Borehole
caved.
No water
above caved
level.

RECORD OF BOREHOLE No 29

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 300 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
160.8	Ground surface												
0.0	300mm Topsoil												
	Clayey silt some sand, occ. gravel (Glacial Till) Grey Brown Hard		1	SS	43	160							
	occ. seams of grey silt and sand V. dense		2	SS	46	158							
			3	SS	90	156							
155.0			3A	CS	-								
5.8	Sand and gravel Brown V. dense		4	SS	100	154							
152.3	Tr. clay, silt		5	SS	83	152							
8.5	Laminated silt and clayey-silt		6	SS	74	150							
	Grey		7	SS	59	148							
	Hard		8	SS	77								
	Sand and gravel		9	SS	82								
146.6													
14.2	End of Borehole												

+3, x5: Numbers refer to Sensitivity
 20
 15
 10

20
 15
 10

RECORD OF BOREHOLE No 30

METRIC

W P 88-78-02 LOCATION Hwy. 407, STA 13 + 925 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
160.9	Ground surface															GR SA SI CL
0.0	300 mm Topsoil															
	Clayey silt, some sand, occ. gravel (Glacial Till)		1	SS	88											
	Grey-Brown		2	SS	62											
	Hard		3	SS	96											
155.9																
5.0	Silty sand V. dense		4	SS	76	/15cm										
	Sand and gravel V. dense Brown		5	SS	100	/8cm										
	Silty sand V. dense		6	SS	105											
152.5			7	SS	44											
8.4	Laminated silt-clayey silt Grey Tr. sand		8	SS	47											
150.2			9	SS	138											
10.7	Sand and gravel Grey. Dense															
	Laminated silt and clayey silt. Hard		10	SS	74											
148.2																
12.7	End of Borehole															

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 31

METRIC

W P 88-78-02 LOCATION Hwy. 407, STA 13 + 975 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa		Wp W WL					
							O UNCONFINED + FIELD VANE X QUICK TRIAXIAL X LAB VANE		WATER CONTENT (%) 10 20 30						
161.3	Ground surface														
0.0	300 mm Topsoil														
	Clayey Silt some sand Tr. gravel (Glacial Till)	1	SS	72		160									
	Grey-brown	2	SS	126		158									0 18 45 37
	Hard	2A	CS	-											
		3	SS	75											
155.8						156									
5.5	Sandy silt- silty sand V. dense	4	SS	103											35 35 24 6
	Silty sand with gravel, Tr. clay V. dense	4A	CS	-		154									
	Several silt and sand seams Grey	5	SS	100	/13cm										W.L. on 1989 10 27
		6	SS	117		152									
150.6	Hard or V. dense	7	SS	93	/15cm										
10.7	Sand and Gravel Tr. silt, clay V. dense, Grey					150									
	Laminated silt and clayey silt Dark grey to Grey	8	SS	92		148									
	Hard	9	SS	97											
145.9	F. Sa seam	10	SS	73	/15cm	146									
15.4	End of Borehole														

+ 3, x 5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 33

METRIC

W P 88-78-02 LOCATION Hwy. 407: STA 14 + 075 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 03 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
159.5	Ground surface																
0.0	300 mm Topsoil																
157.1	Clayey silt, some sand Tr. gravel (Glacial Till) Stiff. Grey Brown		1	SS	29		158										0 20 77 3
2.4	Sandy silt to Silty sand with		2	SS	65		156										
			3	SS	83		154										
	Sand and gravel lenses throughout		4	SS	105		152										0 10 50 40 W.L. on 1989 11 16 and on 1989 10 03
	Clayey silt Hard		5	SS	47		150										
	Grey		6	SS	51		148										
	V. dense		7	SS	77		146										
	Grey heavily laminated		8	SS	119	/15cm											
145.7			9	SS	150	/10cm											
13.8	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 34

METRIC

W P 88-78-02 LOCATION Kipling Avenue; STA. 10 + 120 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 12 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT LIMIT CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							W _p W W _L		
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
158.0	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand, occ. gravel (Glacial Till)		1	SS	53		156										
	Grey Brown with red mottling		2	SS	64		154										
	Hard		3	SS	100	/15cm	152										
	occ. sand seams		4	SS	72		150										
149.5			5	SS	82		148										
8.5	Sandy silt to silty sand occ. gravel and sand seams		6	SS	110	/15cm	146										
	Yellow-Brown to Grey		7	SS	100	/13cm	144										
	V. dense		8	SS	110	/15cm	142										
			9	SS	110	/15cm											
			10	SS	130	/13cm											
			11	SS	110	/13cm											
			12	SS	130	/15cm											
141.0			13	SS	160	/20cm											
17.0	End of Borehole																

*3, *5: Numbers refer to Sensitivity
 20
 15
 10

20
 15
 10
 (% STRAIN AT FAILURE)

RECORD OF BOREHOLE No 41

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E; Co-ords N 4 846 956; E 297 378 ORIGINATED BY BB
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER % CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
139.6	Ground Surface													
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Black Very Soft to Stiff		1	SS	11									0 19 52 29
137.8			2	SS	2		138							0 28 48 24
1.8			3	SS	2		137							21 41 31 7
	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Very Soft to Hard		4	SS	46									
			5	SS	54									
			6	SS	56									
134.0			7	SS	54									
5.6	Gravelly Sand, Some Silt Trace Clay, Very Dense		8	SS	60									
133.0														
6.6	End of Borehole													
	• Artesian Condition Encountered at Elevation 136.5m Borehole Backfilled with Bentonite/Cement Slurry													

RECORD OF BOREHOLE No 42

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 907; E 297 369 ORIGINATED BY BB
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
138.2	Ground Surface												
0.0	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds Very Loose		1	SS	1	/36cm	137						0 68 24 8
138.1			2	SS	1	/30cm	136						0 21 73 6
2.1	Gravelly Sand Some Silt Trace Clay Compact to Very Dense		3	SS	21		135						
			4	SS	36		134						
			5	SS	58		133						
			6	SS	90		132						
132.5			7	SS	102	/26cm							
5.7	** see description below **		8	SS	73								18 28 40 14
131.6													
6.6	End of Borehole												
	** Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Hard **												

RECORD OF BOREHOLE No 43

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 934; E 297 372 ORIGINATED BY BB
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
138.7	Ground Surface												
0.0	Gravelly Sand Some Silt Trace Clay Very Loose		1	SS	2								
136.6			2	SS	1								
2.1	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Firm to Hard		3	SS	4								
			4	SS	33								
134.3			5	SS	25								
4.4	Gravelly Sand Some Silt Trace Clay Dense to Very Dense		6	SS	44								
			7	SS	43								
132.1			8	SS	103								
6.6	End of Borehole • End of Cone Test El.132.0												

RECORD OF BOREHOLE No 44

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E; Co-ords N 4 846 958; E 297 378 ORIGINATED BY BS
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 06 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
138.8	Ground Surface												
0.0	Gravelly Sand Trace Organics		1	SS	4								0 60 33 7
	Some Silt		2	SS	4								37 39 21 3
	Trace Clay		3	SS	14								
	Very Loose to Compact		4	SS	18								0 24 63 13
135.9	Clayey Silt		5	SS	45								
2.9	Silty Sand to Sandy Silt		6	SS	52								
	Trace Gravel		7	SS	90								
	Trace Clay		8	SS	35								
	Occ. Plastic Silt Interbeds												
133.2	Compact to Very Dense												
5.6	Clayey Silt to Silt												
132.1	With Sand, Trace/Some Gravel												
	Occ. Silty Sand Seams, Hard												
6.7	End of Borehole												

RECORD OF BOREHOLE No 45

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 970; E 297 383 ORIGINATED BY BS
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BS
 DATUM Geodetic DATE 89 09 06 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
137.0	Ground Surface													
0.0	Gravelly Sand Some Silt Trace Organics		1	SS	7		136							43 40 14 3
134.9	Trace Clay Loose to Compact		2	SS	19		135							
2.1	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds		3	SS	18		134							2 82 14 2
			4	SS	18		133							
			5	SS	40		132							
131.8	Compact to Dense		6	SS	45		131							
5.2	Clayey Silt to Silt With Sand, Trace/Some Gravel		7	SS	95									
130.4	Occ. Silty Sand Seams Hard		8	SS	65									
6.6	End of Borehole													

RECORD OF BOREHOLE No 46

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 984; E 297 382 ORIGINATED BY BB
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, Hollow Stem Auger & BW Casings COMPILED BY BB
 DATUM Geodetic DATE 89 09 11 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
137.4	Ground Surface											
0.0	Gravelly Sand Some Silt Trace Clay Trace Organics Loose to Very Dense	0.0-0.2	1	SS	7		136					46 40 11 3
135.3		0.2-0.4	2	SS	75		135					
2.1	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Hard	0.4-0.6	3	SS	96		134					
		0.6-0.8	4	SS	111		133					
133.0		0.8-1.0	5	SS	33		132				23.1	10 30 50 10
4.4		1.0-1.2	6	SS	15		131					
		1.2-1.4	7	SS	13		130					
		1.4-1.6	8	SS	27		129					
		1.6-1.8	9	SS	12		128					
127.6		1.8-2.0	10	SS	5							
9.8	End of Borehole											
	* GWL not established. Artesian condition encountered at El. 130.5m. Artesian Head at El. 140.4m. Borehole backfilled with Bentonite/cement slurry											

RECORD OF BOREHOLE No 47

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 980; E 297 391 ORIGINATED BY BB/BS
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, Hollow Stem Auger & BW Casings COMPILED BY BB
 DATUM Geodetic DATE 89 09 06,08 CHECKED BY DD

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 7 kN/m ³	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					
137.5	Ground Surface													
0.0	Gravelly Sand Some Silt Trace Clay Trace Organics Very Loose to Compact		1	SS	3		136							
135.4			2	SS	28		135							
2.1	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Very Stiff		3	SS	26		134							6 33 51 10
			4	SS	21		133							
132.3			5	SS	16		132							
			6	SS	17		131							8 33 48 11
5.2			7	SS	7		130							8 31 53 8
			8	SS	7		129							5 53 40 2
			9	SS	17		128							
	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds Very Loose to Dense		10	SS	5		127							2 76 17 5
			11	SS	**		126							
			12	SS	34		125							
			13	SS	9		124							
	Some/With Gravel		14	SS	8		123							
120.7							122							
16.8	End of Borehole						121							
	* CWL not established. First Artesian condition encountered at El. 131.0m. Artesian head at El. 137.5m Second Artesian condition encountered at El. 120.7m. Artesian head at El. 141.5m. Borehole backfilled with Bentonite/cement slurry. ** Disturbed by Artesian Pressure													

RECORD OF BOREHOLE No 48

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 846 995; E 297 388 ORIGINATED BY BB
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 11 CHECKED BY DD

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 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
136.9	Ground Surface																
0.0	Gravelly Sand Some Silt Trace Clay Trace Organics Very Loose	0.0-2.0	1	SS	3												
135.2			2	SS	21												
1.7	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Very Stiff to Hard		3	SS	58												
			4	SS	107												
132.5			5	SS	122												
4.4			6	SS	35												
			7	SS	32												
	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds Compact to Very Dense		8	SS	51												
			9	SS	47												
127.3			10	SS	18												
9.6	End of Borehole																
	* Artesian condition encountered at El. 129.3m. Artesian head at El. 140.0m. Borehole backfilled with bentonite/cement slurry																

RECORD OF BOREHOLE No 49

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E; Co-ords N 4 846 991; E 297 397 ORIGINATED BY BB
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT UNIT			REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _P	W	W _L	
136.8	Ground Surface												
0.0	Gravelly Sand Some Silt, Trace Clay Trace Organics Compact		1	SS	12								
135.4			2	SS	56.								
1.4			3	SS	34								
	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Very Stiff to Hard		4	SS	49								5 36 48 11
			5	SS	73								
			6	SS	18								
131.2			7	SS	18								2 35 49 14
5.6	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds Very Loose to Compact		8	SS	15								0 41 53 6
128.7			9	SS	2								
8.1	End of Borehole												
126.4													
10.4	End of Cone Test								105/23cm				

RECORD OF BOREHOLE No 50

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 847 002; E 297 399 ORIGINATED BY DC
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 06-11 CHECKED BY DD

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	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
138.6	Ground Surface												
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Black Very Stiff		1	SS	21								0 20 73 7
137.2													
1.4	Gravelly Sand Some Silt, Trace Clay Trace Organics, Compact		2	SS	13		137						
136.0			3	SS	15	SEAL	136						16 56 24 4
2.6			4	SS	42		135						0 35 61 4
	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds		5	SS	42		134						
			6	SS	43		133						
	Dense to Very Dense		7	SS	50		132						
	Clayey Silt Zone		8	SS	59		131						
130.5			9	SS	85								
8.1	End of Borehole												
	* GWL not established Probably at El. 136.0m												

RECORD OF BOREHOLE No 51

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 847 014; E 297 408 ORIGINATED BY DC
 DIST 5 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 11 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
138.8	Ground Surface																
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Black Occ. Gravely Sand Zones Firm to Stiff		1	SS	10	*										53	15 21 53 11
136.7			2	SS	5		137									17.3	16 42 36 6
2.1	Gravely Sand, Some Silt Trace Clay, Compact		3	SS	17	SEAL	136										66 22 10 2
135.9			4	SS	56		135										
2.9			5	SS	34		134										
	Silty Sand to Sandy Silt Trace Gravel Trace Clay Occ. Plastic Silt Interbeds Dense to Very Dense		6	SS	50		133										
			7	SS	59		132										
			8	SS	49		131										
130.7			9	SS	52												
8.1	End of Borehole																
	* GWL not established Probably at El. 136.0m																

RECORD OF BOREHOLE No 52

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 847 032; E 297 422 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
138.9	Ground Surface												
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Black Soft		1	SS	3								0 40 59 1
137.1			2	SS	11								16 47 32 5
1.8	Gravelly Sand Some Silt Trace Clay Trace Organics Very Loose to Dense		3	SS	26								
135.2			4	SS	44								
3.7	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Hard		5	SS	70								
			6	SS	61								
132.3			7	SS	63								
6.6	End of Borehole												

RECORD OF BOREHOLE No 53

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 847 050; E 297 442 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
138.9	Ground Surface												
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Block Very Soft		1	SS	2								
137.5			2	SS	6								
1.4	Gravelly Sand Some Silt Trace Clay Trace Organics Very Loose to Compact		3	SS	16								
135.7			4	SS	48								
3.2			5	SS	59								
			6	SS	70								
			7	SS	70								
			8	SS	57								
130.8	Clayey Silt to Silt With Sand Trace / Some Gravel Occ. Silty Sand Seams Hard		9	SS	46								
8.1	End of Borehole												

RECORD OF BOREHOLE No 54

1 OF 1

METRIC

W.P. 88-78-02 LOCATION Ramp S-E: Co-ords N 4 847 063; E 297 462 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test & Hollow Stem Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 13 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
139.1	Ground Surface											
0.0	Peat / Organic Silt With Sand, Trace Gravel Trace Clay, Block Very Soft to Soft		1	SS	4							
137.0			2	SS	2							
2.1	Trace Organics		3	SS	11							
			4	SS	87							
	Gravelly Sand Some Silt, Trace Clay Compact to Very Dense		5	SS	23							
133.9			6	SS	103							
5.2	Clayey Silt to Silt With Sand, Trace/Some Gravel Occ. Silty Sand Seams Hard		7	SS	83							
132.5			8	SS	72							
6.6	End of Borehole											
	* GWL not established											

SEND
TO

Dave Dundas
 Senior Foundation Engineer
 Foundation Section, EMD
 Attention: Betty Bennett

RECEIVED

OCT 09 1989

DEPT

DESIGN

DATE

FROM

Karan Granetz Geotechnical Section 6th Oct 89

SUBJECT

WT 88-78-02 Hwy 407 & Kipling Ave Interchange.
 Cut Stability and Slope Treatment.

At our Sept. 7/89 meeting in your Office re the above, the location of the borings were noted as per your memo to File. However, a site visit with the consultant and surveyors to locate said borings resulted in the relocating of a few holes. This was in order to make the location accessible for the drilling equipment.

In addition to these 19 BHs, we have asked the consultant to drill 5 additional holes. Four of these are on Hwy 407 between Sta. 13+900 and 14+130 Vol. 1
 REPLY (Cut Section) and one on Martin Grove Connection at Sta. 9+870 ±, a fill section.

We are requesting slope geometry and any special slope Treatment for the 407 Cut Section. At Sta. 9+870, Martin Grove Rd Connection, preliminary investigation showed some peat deposit. At this location, we are requesting Treatment for

REPLY FROM

REPLY DATE

SEND
TO

292

FROM

DEPT.

DATE

SUBJECT

RE: W 88-78-02 Hwy 407 Kipling Int.

any potential settlement of the fill.

Listed below is the revised borehole locations with elevations

1) Ramp NE, Elev. Q		2) Ramp W - N.S. & E.W.		3) Ramp S.W. & E.W.	
10+309	157.61	10+300	160.75	10+238	155.82
10+259	158.35	10+360	160.81	10+275	155.72
10+206.4	159.59	10+420	160.01		
		10+480	159.10		
		10+540	158.26		

REPLY ④ Ramp E - N.S. Elev. Q ⑤ Martin Grove Rd Conn. Elev. Q ⑥ Hwy 407 Elev. Q

10+672	156.88	9+580	162.41	13+925	160.94
10+628	157.37	9+640	162.77	13+975	161.25
10+560	155.95	9+700	162.12	14+025	161.01
10+500	154.65	9+725	161.53	14+075	159.45

⑦ Kipling Ave Ext Elev. Q

9+870 140.45

10+120 157.96

Attached is the profile of 407

REPLY FROM

REPLY DATE

K. Ganeh

20

MEMO

To: File

Date: 1985 09 07

Re: WP 88-78-02

Hay 407 / Kipling Ave IC
Cut Stability for Central Region Catch.

In our meeting with Keron Genest we agreed that the geotechnical borings would be extended at the following locations to provide information for stability. It is understood that split spoon samples will be collected at 5' intervals and that RCB issues will be turned in cohesive materials where $N < 15$. A total of $\frac{1}{3}$ of the samples will be tested for grain size, moisture content and Atterberg Limits. The consultant will use his discretion in selecting the samples to be tested in order to produce accurate logs of the subsurface conditions. Groundwater conditions especially exterior pressures are very important and this input will be required for our evaluation. Piezometer installation may be required at selected borings.

1) Ramp NE	2) Ramp W-N-S	3) Ramp SW	4) Ramp E-N-S
0+320	0+300	0+230	0+680
0+260	0+360	0+270	0+620
0+200	0+420		0+560
	0+480		0+500
	0+540		

5) Martingame Ext

9+580

9+640

9+700

9+760 if possible

6) Kipling Extension

10+120

Items 1 through 4 were requested in
memo of 89 07 20. Items 5 and 6 were
requested by Central Reg. Central in our
meeting of 89 09 07.

Brochures should be extended 6 m
below the proposed cut depth.

D. H. Dundas
Sr. Foundation Engineer

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M13-92
30M13-92A

DIST. 6 REGION _____

W.P. No. 88-78-12/33

CONT. No. _____

W. O. No. _____

STR. SITE No. 37-1338

HWY. No. 407

LOCATION Hwy 407/KIPLING AVE
E.B. & W.B. LANES

No. of PAGES - _____

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____



Important Note
For Information and
Compliance

- The Project for WP 88-78-27 was ABANDONED.
- KEEP THESE FOUR B.H. Logs for Information only.
- ORIGINAL FIELD BORING LOGS are FILED IN WP 88-78-12/33

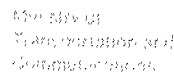
SULVERT C. END

RECORD OF BOREHOLE No 4

METRIC

WP 88-78-27 LOCATION Sta 10+068.0 (Kip), 98 32.0m Lt ORIGINATED BY BS
DIST 6 HWY 407 BOREHOLE TYPE CONE TEST H.S. AUGIER COMPILED BY BB
DATUM GEODETIC DATE 89.09.05 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
139.0	GROUND SURFACE																
	PEAT / ORGANIC SILT With Sand Some Gravel Trace Clay Very Soft		1	SS	2		138										
136.9 2.1	GRAVELLY SAND Some Silt Trace Clay Compact		2	SS	0												
			3	SS	7		136										40 40 10 2
135.3 3.7	CLAYEY SILT to SILT With Sand Trace Gravel Occ sand seams Firm to Hard		4	SS	40												
			5	SS	45		134									22.7	3 36 50 11
133.1 5.9	SILTY SAND to SAND Trace / Some Gravel Trace Clay Loose to Very Dense		6	SS	15												
			7	SS	6		132										17-69 13 1
			8	SS	5												
			9	SS	17												
129.4 9.6	END OF BOREHOLE		10	SS	52		130										



(Filed Apr 15)

METRIC

W F 88-78-27 LOCATION Sta 10+046.0 (K0), 9% 13.5 m Lt ORIGINATED BY BS
DIST 6 HWY 407 BOREHOLE TYPE CONE TEST, HS AUGER COMPILED BY BB
DATUM GEODETIC DATE 89-08-31 CHECKED BY

[illegible]

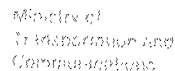


RECORD OF BOREHOLE No 9

METRIC

W.P. 88.78.27 LOCATION Sta. 9+938.5 (K.P.), 7/8 6.0m Rt ORIGINATED BY DC
DIST 6 HWY 407 BOREHOLE TYPE CONE TEST, H.S. AUGER COMPILED BY BB
DATUM Geodetic DATE 89.09.05 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			IN' VALUES	20 40 60 80 100					
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE					
138.8 0.0	GROUND SURFACE								10 20 30				
137.4 1.4	GRAVELLY SAND Some Silt Trace Organics Trace Clay Compact	1	SS	15		138							40 39 16 5
		2	SS	80									
	CLAYEY SILT to SILT With Sand Trace Gravel Occ. sand seams Hard	3	SS	89		136							
		4	SS	90									
		5	SS	113									
		6	SS	110		134							
		7	SS	94	15cm SEAL								
131.9 6.9	SILTY SAND to SAND Trace Gravel, Trace Clay Very Dense	8	SS	95		132							
130.7 8.1	END OF BOREHOLE	9	SS	80									
	* ARTESIAN CONDITION! ENCOUNTERED AT EL. 131.0m±												
	ARTESIAN HEAD TO EL. 139.0m±												



METRIC

W P 88.78.27 LOCATION Sta 9+921.0 (Kip) % 30.0m Rt ORIGINATED BY DC
DIST 6 HWY 407 BOREHOLE TYPE CONE TEST, H.S. AUGER COMPILED BY BB
DATUM GEODETIC DATE 89.09.14 CHECKED BY DD

[illegible]



Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 88-78-12/33

DIST 6

HWY 407

STR SITE 37-1338

Kipling Avenue Overpass

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FOUNDATION INVESTIGATION REPORT
For
Kipling Avenue Overpass
Highway 407, Vaughan Township
W.P. 88-78-12/33, Site No. 37-1338
District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the proposed Highway 407 and Kipling Avenue Interchange. The investigation was carried out at the request of Central Region Structural Section for the Kipling Avenue Overpass structure. The report applies to the proposed structure and approaches between Sta. 14+210 and Sta. 14+505 (Highway 407 chainage).

SITE DESCRIPTION

The proposed Highway 407 and Kipling Avenue Interchange is situated in Vaughan Township, approximately 700 m north of the intersection of Kipling and Steeles Avenues. The site is located in an old river valley carved by a branch of the Humber River. At present, the valley consists of a meandering Rainbow Creek and adjacent flood plains. In the vicinity of the Highway 407 and Kipling Avenue Interchange, the valley floor ranges in width from 110 m to 200 m. Rainbow Creek varies in width from 1.0 m to 8.0 m north and south of the structure site and is 3.0 m to 6.0 m wide in the vicinity of the proposed structure. During the investigation, the creek was approximately 0.3 m deep, but rose to a depth exceeding 0.5 m following a heavy rainstorm. Rainbow Creek flows south-easterly through the site, and is redirected to flow in an easterly direction as it approaches the CNR embankment. Rainbow Creek eventually flows into the Humber River further east of the site.

The slopes of the valley vary from as steep as 0.5H:1V to as flat as 6H:1V and rise to heights of 22 m on the southwest side and 19 m on the

north-east side. The valley floor is densely covered by trees and brush with occasional open spaces covered by tall grasses and shrubs. The creek bed is composed largely of gravel and sand, but also contains cobbles and occasional boulders.

The site lies within the physiographic region known as the South Slope (after Chapman and Putnam, 1984) and it consists largely of glacial deposits.

Investigation Procedures

i) Field

The field investigation for the Kipling Avenue overpass was conducted between 89 08 22 and 89 09 14. A total of twelve boreholes were advanced for the overpass structure, eight of which were accompanied by dynamic cone penetration tests. The boreholes were advanced using two track-mounted auger machines equipped with 83 mm I.D. hollow stem augers and B-size casing (75 mm O).

Samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1587-8).

Two piezometers were installed at the proposed abutment locations to facilitate periodic monitoring of the groundwater elevations.

The elevations and co-ordinates of the boreholes were provided by MTO's Central Region Surveys and Plans Office.

ii) Laboratory

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden including:

Natural Moisture Content
Atterberg Limits
Grain Size Distribution
Bulk Unit Weight
Organic Material Content

The results of the laboratory testing are plotted on the Record of Borehole sheets and are also summarized in Figures 1 through 5.

SUBSURFACE CONDITIONS

The boreholes advanced for the Kipling Avenue Overpass structure reveal surficial deposits consisting of gravelly sand and organic material. The gravelly sand deposit was encountered across the site extending for a thickness of 0.8 m to 2.6 m. The boreholes advanced furthest west of the creek contain a surficial deposit of peat/organic silt material that varies from 1.4 m to 2.9 m thick and overlies the gravelly sand deposit. The gravelly sand material is typically underlain by a clayey silt to silt deposit. The clayey silt to silt extends for a thickness of 2.3 m to 6.7 m and acts as a confining layer to the underlying silty sand to sand aquifer. Many of the boreholes were terminated in the silty sand to sand deposit. The boreholes advanced deeper than 15 m revealed that the silty sand to sand deposit ranges from 6.1 m to 12.4 m in thickness and overlies a heterogeneous mixture of gravel, sand, silt material, the extent of which was not explored.

In general, the subsurface conditions across the valley floor are composed of a variety of water-laid deposits. The cohesive clayey silt to silt layers were frequently found to confine water-bearing silty sand strata that, when exposed, release a considerable amount of artesian pressure.

At this site, artesian conditions were encountered intermittently, rising up to 1.2 m above the ground surface. Where artesian conditions were not encountered, the groundwater levels was recorded approximately 1.5 m above the creek level.

The boundaries of the different strata, together with the field and laboratory test results, appear on the Record of Borehole sheets appended to this report. Refer to these sheets for the locations and elevations of the boreholes (BH 1, 2, 3, 6, 7, 8, 11 through 16). Stratigraphical sections of the subsurface conditions across the site are shown on Dwg. No. 887812/33-A. Detailed descriptions of the different strata are provided below.

Gravelly Sand

A surficial deposit of gravelly sand was encountered across the site in ten of the twelve boreholes advanced. The non-cohesive deposit contains some silt, trace clay and a trace of organics. In the immediate vicinity of the creek, the gravelly sand also contains occasional cobbles and boulders. The thickness of the deposit is fairly consistent across the site, ranging from 0.8 m to 2.6 m thick, and was typically encountered between El. 136 m and El. 138 m.

Results of the Standard Penetration Test indicate that 'N' values vary from 0 to 30, but range more commonly from 5 to 20. These values indicate that the state of compaction ranges from very loose to dense but more typically from loose to compact. The moisture content obtained from laboratory testing measured from 8% to 19%.

Refer to Figure 1 for a typical grain size distribution envelope for this material.

Peat/Organic Silt

West of Rainbow Creek, an organic deposit composed of peat and organic silt overlies the gravelly sand stratum. It is the surficial deposit at BH's 1, 2, 3, 6 and 14. At these locations, the organic material ranges from 1.4 m to 2.9 m in thickness, with the thickness increasing in a south-westerly direction. This cohesive stratum contains a large proportion of sand, some gravel and trace clay. Fragments of wood and rootlets were also encountered.

The 'N' values obtained from field testing range from 0 to 3 indicating a consistency that varies from very soft to soft. The material exhibits low to medium plasticity. The following physical properties were obtained from a single Atterberg Limits test:

Natural Moisture Content (%)	52.0
Liquid Limit (%)	39.5
Plastic Limit (%)	33.0

Clayey Silt to Silt

A clayey silt to silt deposit was encountered in all the boreholes except BH's 6, 7 and 14. The clayey silt to silt occurs as the surficial deposit in BH 16, but is generally present directly beneath the gravelly sand deposit. This cohesive stratum ranges in thickness from 2.3 m to 6.7 m and increases in thickness and extent in a northerly direction. The clayey silt to silt deposit contains a large proportion of sand, trace gravel and occasional sand seams.

'N' values ranging from 2 to in excess of 120 were obtained during field testing reflecting a consistency ranging from very soft to hard. More typically the 'N' values exceed 30 blows indicating a material that is hard in consistency. The clayey silt to silt exhibits slight to low plasticity as shown in Figure 2, Plasticity Chart. Laboratory testing yielded the following physical properties:

	<u>Range</u>	<u>Average</u>
Natural Moisture Content (%)	9.0-18.0	12.0
Liquid Limit (%)	12.0-23.0	16.0
Plastic Limit (%)	10.0-15.5	11.5
Unit Weight (kN/m ³)	22.1-23.2	22.7

Refer to Figure 3 for the grain size distribution envelope for this material.

Silty Sand to Sand

The most extensive deposit across the site is a silty sand to sand deposit that was encountered in twelve boreholes (BH 1, 2, 3, 6, 7, 8, 11 through 16). The full vertical extent of this deposit was explored in all boreholes except BH 14, 15 and 16. At the borehole locations, the thickness of the deposit varies from 1.1 m to 12.4 m. Generally, the silty sand to sand stratum decreases in thickness in a northerly direction. In BH 13, the stratum is 1.1 m thick and is interbedded within the clayey silt to silt deposit. At all other borehole locations it underlies the clayey silt to silt deposit. The silty sand to sand stratum contains trace to some gravel and trace clay. The composition of this deposit makes it sensitive to disturbance under conditions of unbalanced hydrostatic head.

The 'N' values for this material range from 0 to blows in excess of 120 per 30 cm. In some instances, the very low values are disturbed due to the artesian pressures encountered in this deposit. Typically, the 'N' values vary from 5 to 30, indicating a denseness ranging from loose to dense. The natural moisture content of the silty sand to sand, obtained from laboratory testing, ranges from 12% to 29% (18% average).

Refer to Figure 4 for the grain size distribution envelope for this material.

Heterogeneous Mixture of Gravel, Sand, Silt

A heterogeneous mixture of gravel, sand, silt was encountered beneath the silty sand to sand deposit in BH's 1, 2, 3, 6, 7, 8, 11 and 12 and beneath the clayey silt to silt deposit in BH 13, between El. 122.4 and El. 126.0 m. These borings were terminated in this deposit. In BH's 8 and 11, the depth of the deposit was inferred by augering resistance. The gravel, sand, silt deposit contains trace clay. Although no cobbles or boulders were encountered during the investigation, it is anticipated that their presence is probable. The nature of the deposit would indicate that it is a glacial till. It is largely non-cohesive but contains occasional cohesive pockets.

'N' values, obtained from field testing, range from 50 to over 120. The 'N' values are typically greater than 90, reflecting a relative density of very dense. The natural moisture content of the glacial till deposit obtained from laboratory testing ranges from 6.5% to 12%.

A grain size distribution envelope for this material is presented in Figure 5.

GROUNDWATER CONDITIONS

The variability in the subsurface deposition across the site has resulted in highly unpredictable groundwater conditions. Artesian conditions were encountered in some areas and not in others.

Generally, the groundwater table is close to the surface and is perched above the clayey silt to silt and silty sand to sand deposits. Closer inspection of the site revealed two, and possibly more, natural springs in the vicinity of the proposed structure location. These springs were identified by the orange residue that was apparent in the area of water flow.

In BH's 2, 8, 14, 15 and 16, the groundwater elevations were measured in the open boreholes upon completion of boring and varied from El. 137.5 m to El. 139.5 m. Piezometers were installed in BH's 1 and 13. The water levels in the piezometers, recorded at the end of the investigation, were at ground surface.

Artesian pressures were encountered in BH's 3, 6, 7 and 11, within the silty sand to sand stratum, between El. 128.7 m and El. 134.0 m. In BH 12, an artesian condition developed at El. 123.1 m, within the glacial till deposit. In each case, the artesian head extended from the ground surface to approximately 1.2 m above ground surface. The boreholes in which artesian conditions were encountered were plugged with a bentonite seal. In some instances a bentonite/cement slurry was required to seal the artesian pressures.

The groundwater elevations recorded at the time of the investigation are tabled below and are plotted on the Record of Borehole sheets and stratigraphical sections.

<u>Borehole</u>	<u>Elevation (m)</u>
1	140.0
2	139.3
3	138.2
6	not established (artesian)
7	137.8 (artesian)
8	137.5
11	not established (artesian)
12	not established (artesian)
13	139.2
14	139.5
15	138.0
16	138.0

The elevation of the creek, at the time of the investigation, was approximately 136.5 m. The creek level experienced a fluctuation in the order of 0.5 m following a period of heavy rainfall.

DISCUSSION

It is proposed to construct a single span bridge for the Highway 407 crossing at Kipling Avenue. The structure is proposed to be approximately 60 m in width with a span length of $48\pm$ m. The grade of Highway 407 is set at El. 149.5, 9.5 m to 12.3 m above the existing ground level. The profile grade of Kipling Avenue is set at approximate El. 142 m.

RECOMMENDATIONS

Structure Foundations

Both spread footing and deep foundation alternatives were considered at this structure site. The major concern at this site is the effect of the artesian groundwater conditions on the structure foundation.

Because of the variably weak nature of the subsurface material, spread footings on the original ground were found to be unsuitable since the subsoil in the vicinity of the proposed footings could not adequately support spread footing foundations. In addition, the construction of spread footings would involve extensive excavation and probable intersection of the aquifer. Breaching the artesian zone could lead to disturbance of the founding soil and result in a considerable reduction in bearing capacity.

Spread Footings on Granular 'A' Pad

The structure may be founded on spread footings perched within the approaches and placed on a compacted Granular 'A' core. The base of the footing should be placed at or above El. 145.0 m. The Granular 'A' core should have a minimum thickness of 3.0 m. The recommended bearing capacities for the footings on a granular core, as per the O.H.B.D.C., are as follows:

West Abutment

Factored Bearing Capacity at U.L.S.	800 kPa
Bearing Capacity at S.L.S. Type II	300 kPa

East Abutment

Factored Bearing Capacity at U.L.S.	900 kPa
Bearing Capacity at S.L.S. Type II	350 kPa

The following are approximate ground elevations at the proposed abutment locations:

East Abutment	El. 138.0 m
West Abutment	El. 140.0 m

A friction angle of 35° may be assumed to determine sliding resistance between the footing and the compacted Granular 'A' core.

Topsoil and organic material should be removed for the entire width of the structure under the plan limits of the proposed footings and approach embankments. The organic material was present to El. 137 m± in the boreholes advanced west of Rainbow Creek. Further west, the depth of the organic material was not explored and may be deeper than El. 137 m. East of the creek the vertical extent of sub-excavation is estimated to be El. 137.5 m. The exposed base should be covered with a non-cohesive granular blanket as soon as possible to avoid softening and disturbance of the underlying material. Backfill and fill placed to the elevation of the base of the granular pad should be non-cohesive, free-draining and well compacted. The perched footings should have adequate cover for frost protection. Refer to Figure 6 for the placement of footings on a granular pad and the fill requirements.

This alternative minimizes the amount of excavation required to construct the bridge, thereby eliminating the likelihood of disturbing the underlying aquifer. In addition, by locating the footings further away from the creek, the likelihood of encountering artesian conditions is reduced. However, with the spread footings founded within perched abutments on considerable heights of fill, there is an increased potential for differential settlements.

Steel H-piles

Alternatively, the abutments may be founded on end-bearing piles equipped with driving shoes. The piles should be driven below El. 123.0 at the West

Abutment and below El. 125.0 m at the East Abutment. Below these elevations pile driving should be controlled by the Hiley Formula as per MTO Standards SS 103-10 or SS 103-11. The following design values for HP 310 x 110 and HP 310 x 79 steel H-piles are recommended:

	<u>HP 310 x 110</u>	<u>HP 310 x 79</u>
Factored Bearing Capacities at U.L.S.	1280 kN/pile	920 kN/pile
Bearing Capacity at S.L.S. Type II	920 kN/pile	660 kN/pile
Ultimate Pile Capacity (for Hiley Formula)	3450 kN/pile	2475 kN/pile

The axial capacity of the piles has been reduced due to the possible effects of the artesian condition on the frictional capacity of the piles.

The lateral capacities of the piles may be determined using the horizontal component of the pile batter.

Pile driving will intersect the artesian zone and, as a result, special provisions will be required to control loss of fines from the underlying soil. It is anticipated that when the piles penetrate the aquifer, water will seep up along the shaft of the pile to the surface. A drainage medium should be provided in the areas where piles are to be driven, and placed prior to pile driving.

The details of the drainage requirements are sketched in Figure 7. The scheme should include a means of drainage into the proposed culvert.

The piles should be re-tapped after a minimum period of two weeks after the initial driving. The same energy used for the original driving should be used for the re-tapping. If substantial loss of set has occurred, this office should be contacted for further recommendations.

Breaching the artesian zone may pose some environmental concerns which should be considered if this alternative is chosen. However, with high mast lighting proposed at this interchange, deep foundation construction appears inevitable.

Slope Stability

The fills required to achieve the profile grade of Highway 407 in the vicinity of the structure are in the order of 10m±. Prior to the placement of the fill, all surficial organic material should be removed under the plan limits of the embankments and sub-excavated for an additional width beyond the embankment equal to the depth of sub-excavation. Refer to Figure 8 for a typical section. The sub-excavated material should be replaced with granular backfill. Temporary excavations should be inclined at 1.5H:1V or flatter.

Slope stability calculations were carried out using Total Stress Analysis (Fig. 10). No slope stability problems are anticipated provided that 2H:1V slopes are maintained and that a mid-height berm be incorporated where the height of fill exceeds 6.0 m. The berm widths increase with the height of fill and are charted in Figure 9. The berms should be incorporated into the side slopes of the approach embankments from the forward slopes at the abutment as smoothly and quickly as possible. Stability of the forward slopes is based on the assumption that the abutment will be less than 4.0 m high with a 2.0 m wide bench at the top of the slope.

To protect the slopes of the Highway 407 embankments across the valley from erosion due to regional storm flooding, the lower slopes should be treated with a 600 mm granular blanket overlain by 600 mm of rock protection to the potential high water level, approximate El. 142.0 m, (as per Marshall Macklin Monaghan memo to Central Region Planning and Design dated 89-11-13). The granular blanket is not required if the embankment fill is composed of granular material. In addition, slope vegetation should be established as soon as possible after placement of the fill in order to control surficial erosion.

Settlement

Because of the extensive fills proposed at this site, it is anticipated that there will be settlement within the subsoil, and also within the

embankment fill itself. Additional settlement may be expected if there is eventual drainage of the aquifer following construction of this interchange.

It is difficult to predict the amount of settlement that will occur because of the variability in the subsurface conditions. This variability creates a great many parameters and assumptions that prevent the possibility of accurate calculation. As a result, the prediction for settlement is based on our experience. To minimize post construction settlements it is recommended that the approach embankments be pre-loaded for a minimum three month duration. The pre-load embankment should extend at least 20 m behind the proposed structure abutments for the full width of the final embankment geometry. A height of 6.0 m above original ground is recommended for the pre-load embankment. To avoid having to reconstruct the embankment, it is suggested that the material used to construct the pre-load embankment be that which will be used for the final embankment. With this procedure, it is anticipated that most of the settlement will occur during embankment construction and pre-loading. The residual or post-construction settlement is estimated to be less than 1% of the total embankment height. Differential settlements are expected to remain within the tolerable range.

Unwatering

The footings/pile caps should be constructed in the 'dry'.

Because of the sensitivity of the subsurface material to conditions of unbalanced hydrostatic head and the presence of an aquifer, the Contractor should be advised not to breach the artesian layer. Excavation should proceed with considerable care so as not to initiate a blow-out condition. It should also be noted that the integrity and type of dewatering scheme is the responsibility of the Contractor.

Frost Protection

The footings require a minimum of 1.2 m of earth cover for frost protection.

Earth Pressure

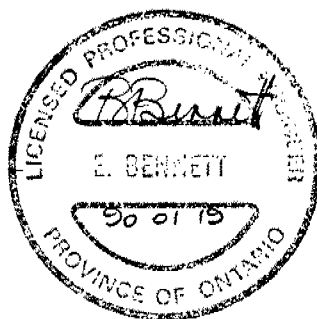
Backfill to the structure abutments should consist of granular material in accordance with MTO Special Provision No. 109F03, for which the following properties apply:

	ϕ	γ
Granular 'A'	35°	22.8 kN/m ³
Granular 'B'	30°	21.2 kN/m ³

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the O.H.B.D.C.. An active condition (K_a) may be assumed to apply.

MISCELLANEOUS

The fieldwork for this investigation was carried out by B. Sedgwick, University of New Brunswick, Engineering Student, D. Colquhoun, Engineer on a Jamaican Exchange Program and B. Bennett, Foundation Engineer. The drilling equipment was owned and operated by Master Soil Investigations Limited of Toronto, and Marathon Drilling Company Limited of Ottawa. The report was prepared by Ms. B. Bennett under the general supervision of Mr. D. Dundas, Senior Foundation Engineer. The report was reviewed by Mr. D. Dundas and approved by Mr. M. Devata, Chief Foundation Engineer.



B. Bennett
B. Bennett, P.Eng.
Foundation Engineer

M. Devata
M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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
WS	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

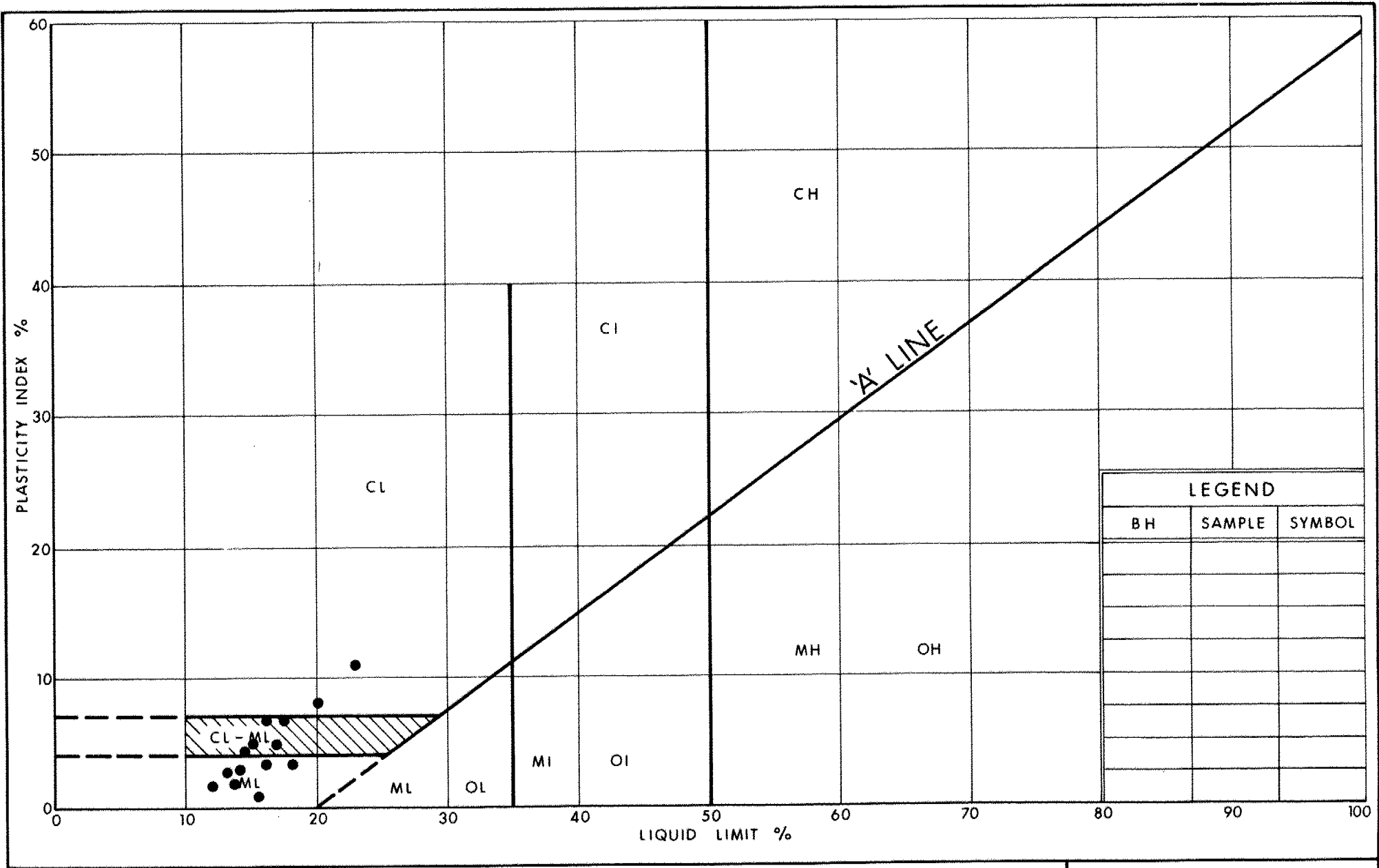
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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 = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

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

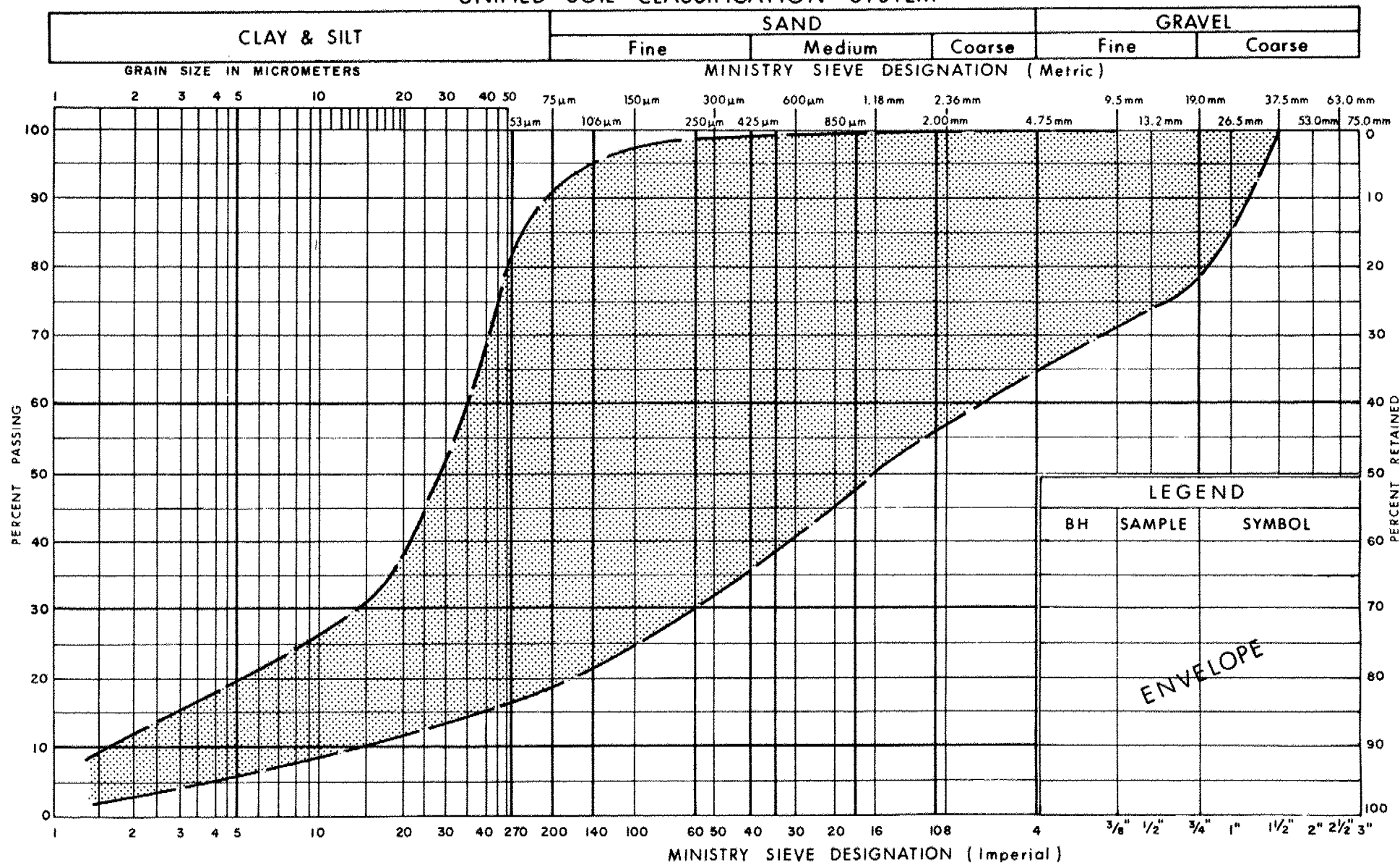
PHYSICAL PROPERTIES OF SOIL

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



LEGEND		
BH	SAMPLE	SYMBOL

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

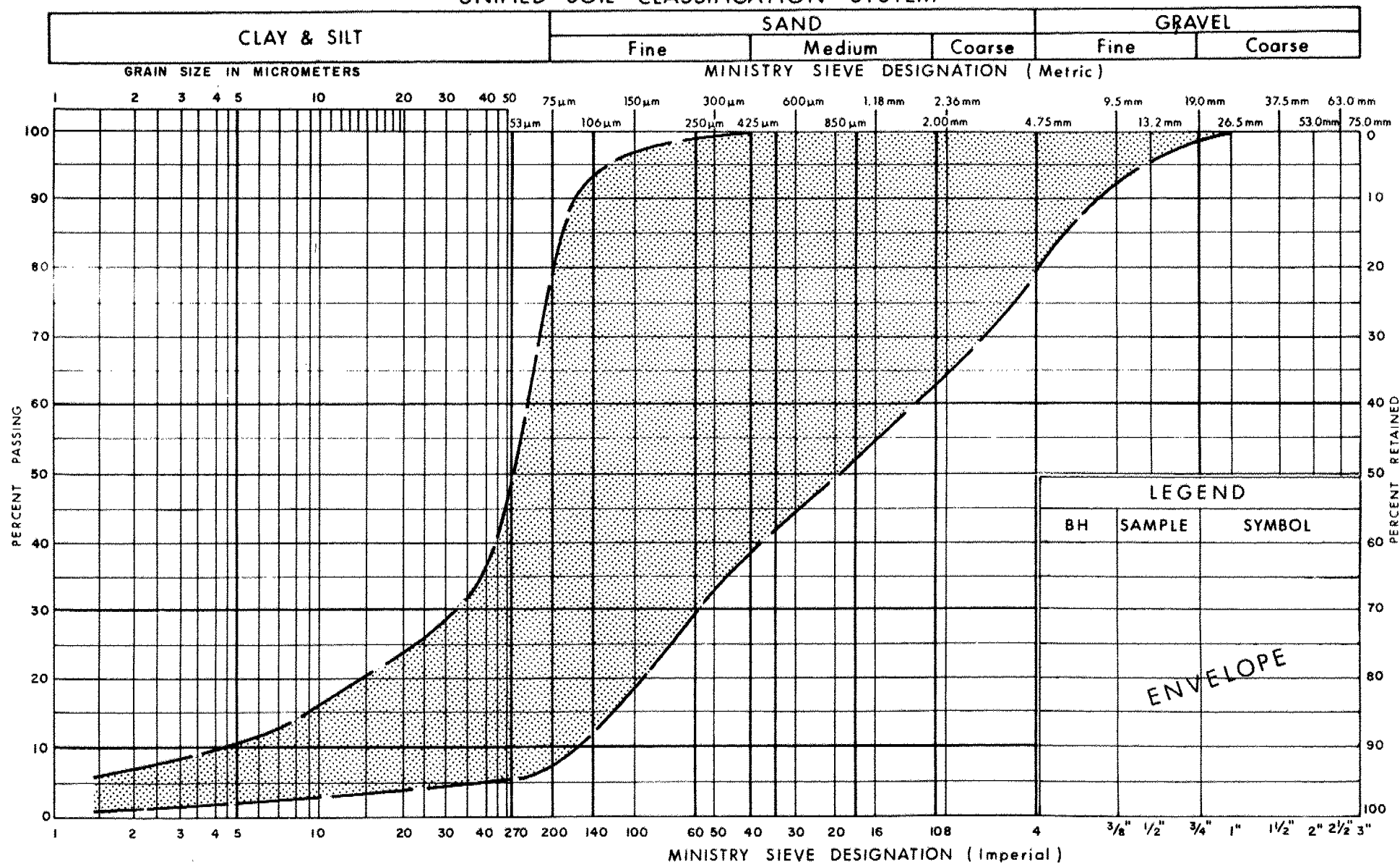
GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

SOME/WITH SAND, TRACE GRAVEL, OCCASIONAL SAND SEAMS

FIG No 3

W P 88-78-12/33

UNIFIED SOIL CLASSIFICATION SYSTEM

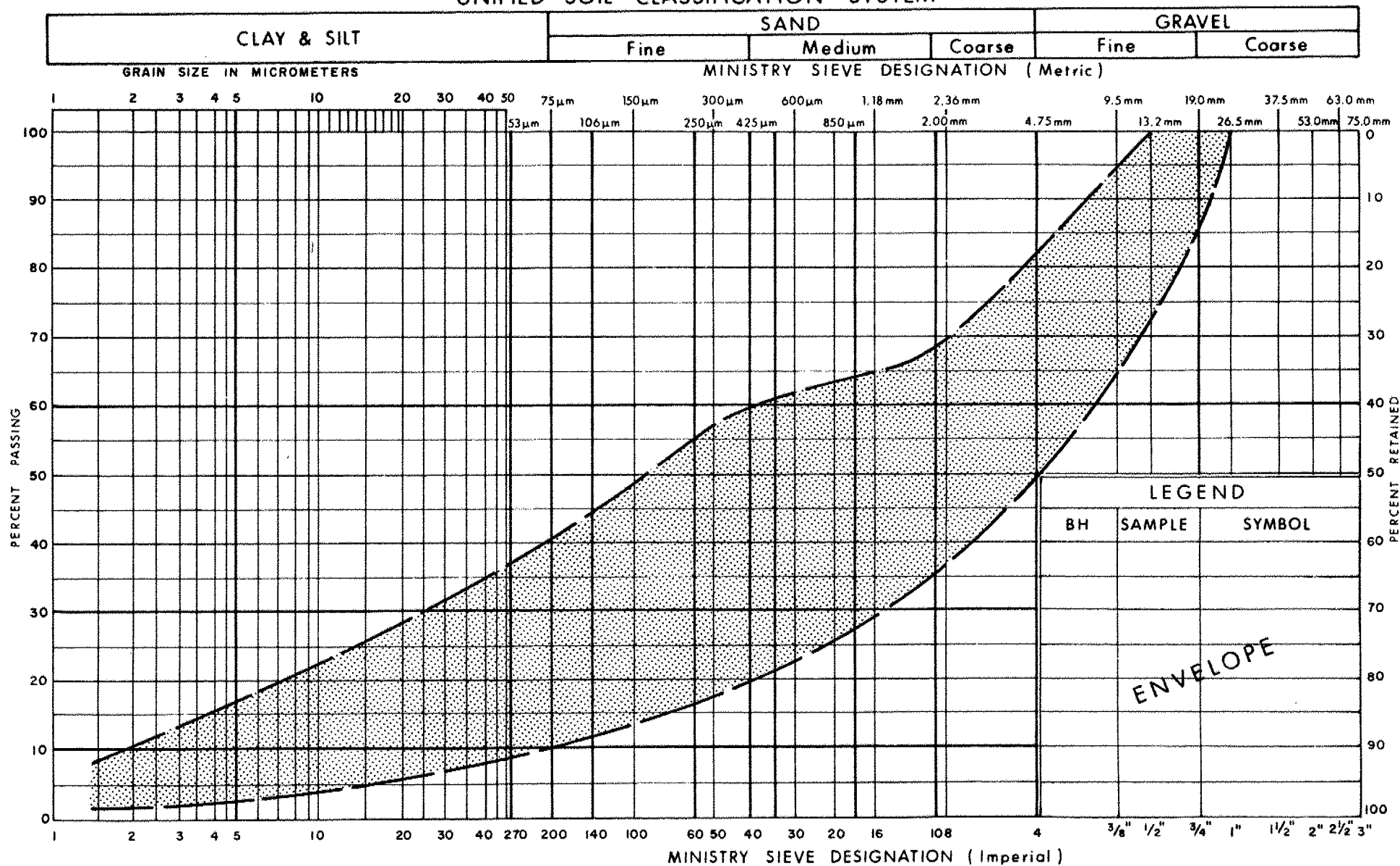
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Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND
TRACE / SOME GRAVEL, TRACE CLAY

FIG No 4

W P 88-78-12/33

UNIFIED SOIL CLASSIFICATION SYSTEM



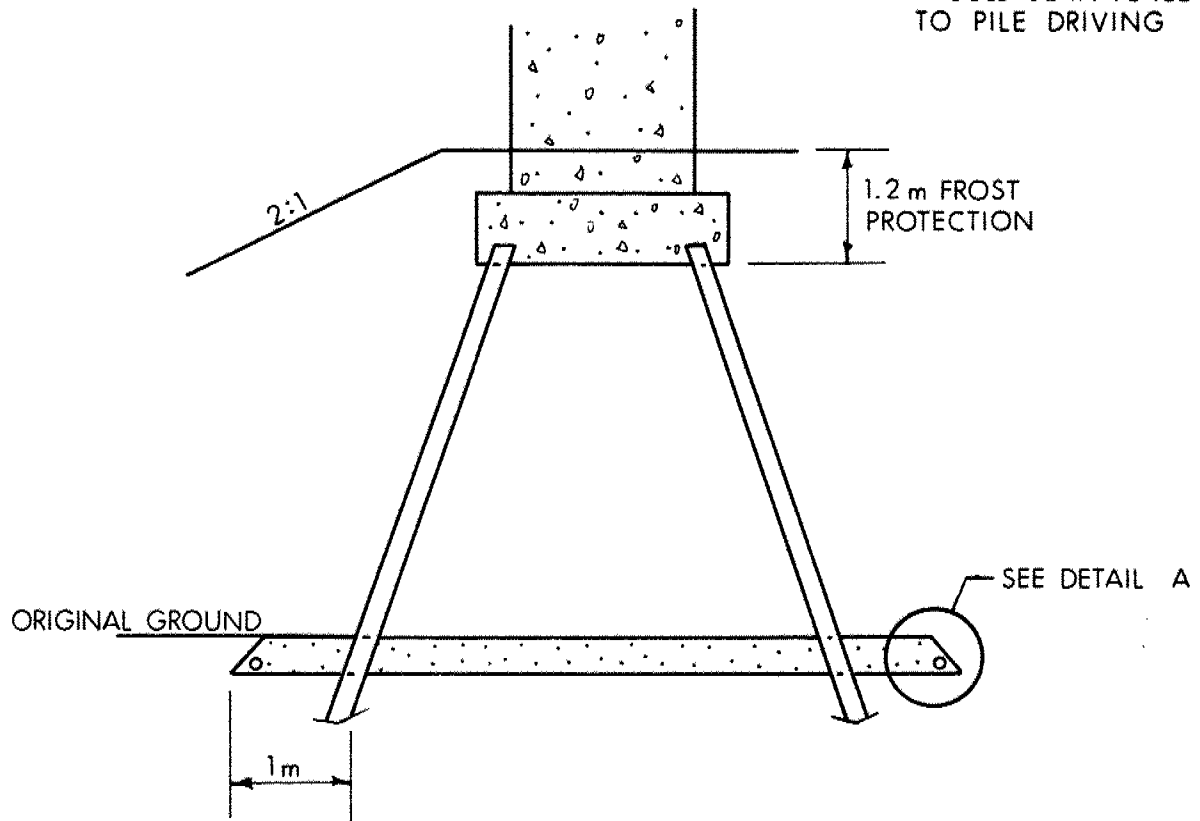
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Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF GRAVEL, SAND AND SILT,
TRACE CLAY

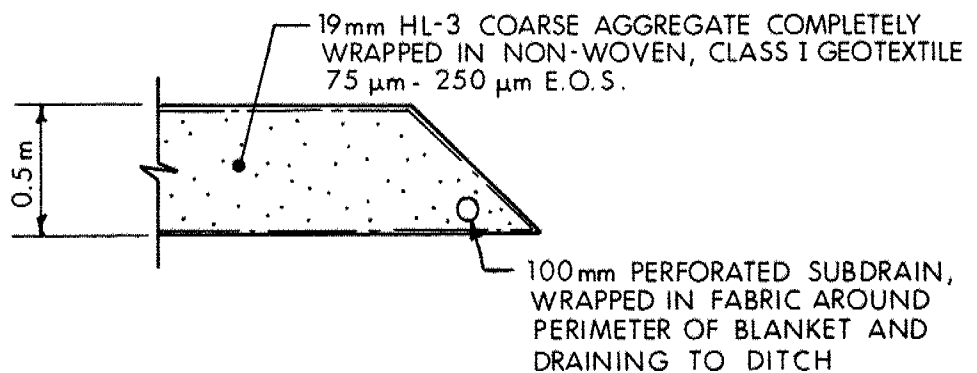
FIG No 5

W P 88-78-12/33

NOTE: THE DRAINAGE BLANKETS SHOULD BE IN PLACE PRIOR TO PILE DRIVING



ABUTMENT SECTION (TYP)



DETAIL A

FIG 7 - DRAINAGE BLANKET DETAILS FOR
ABUTMENTS AND PIERS

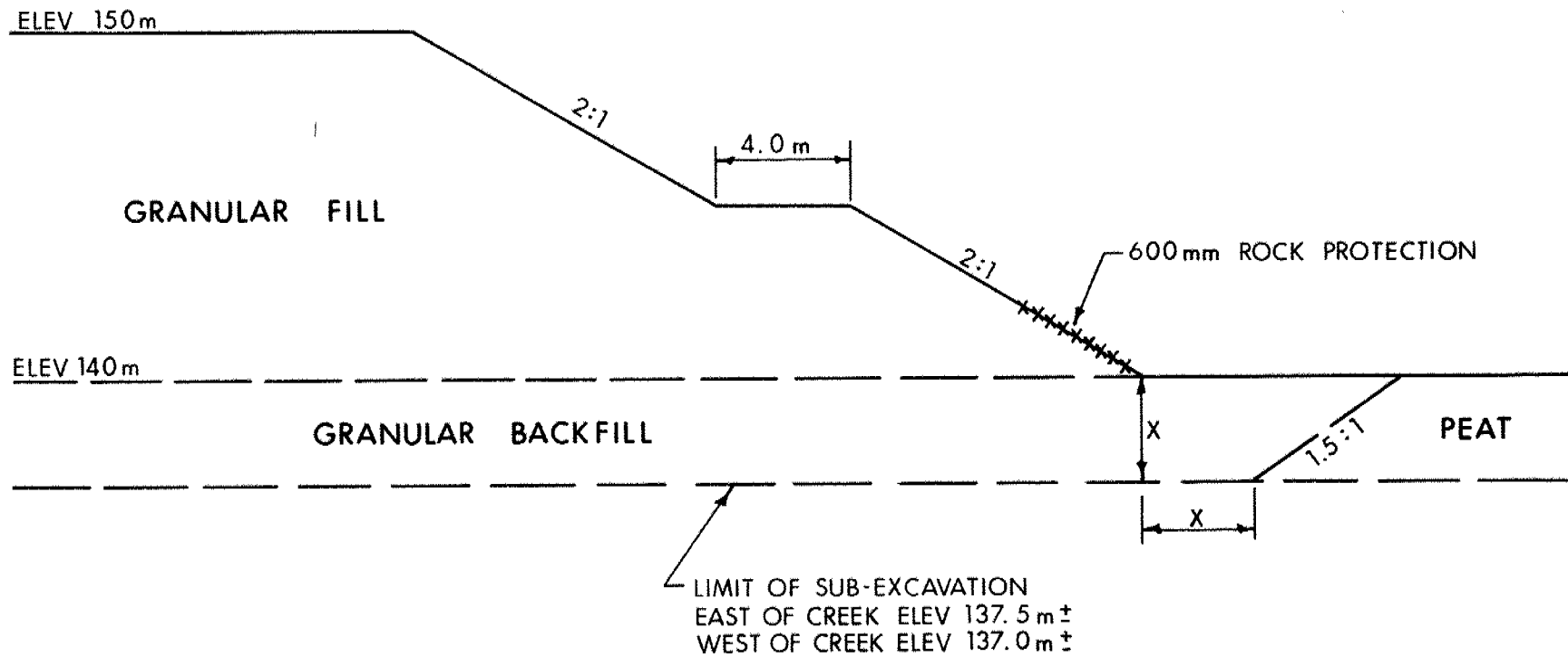


FIG 8 - SLOPE GEOMETRY & SUB-EXCAVATION DETAIL

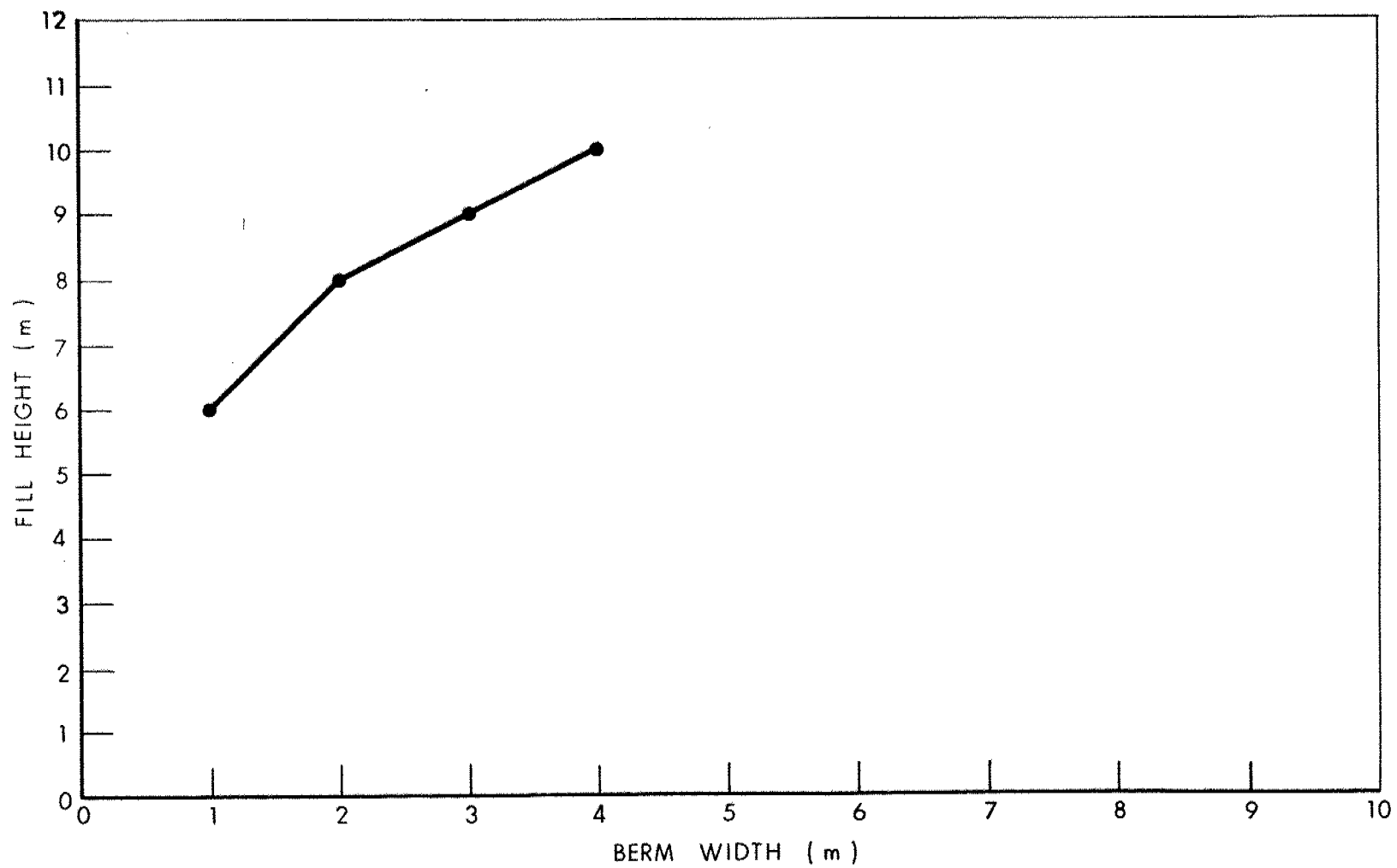


FIG 9 - FILL HEIGHT versus BERM WIDTH

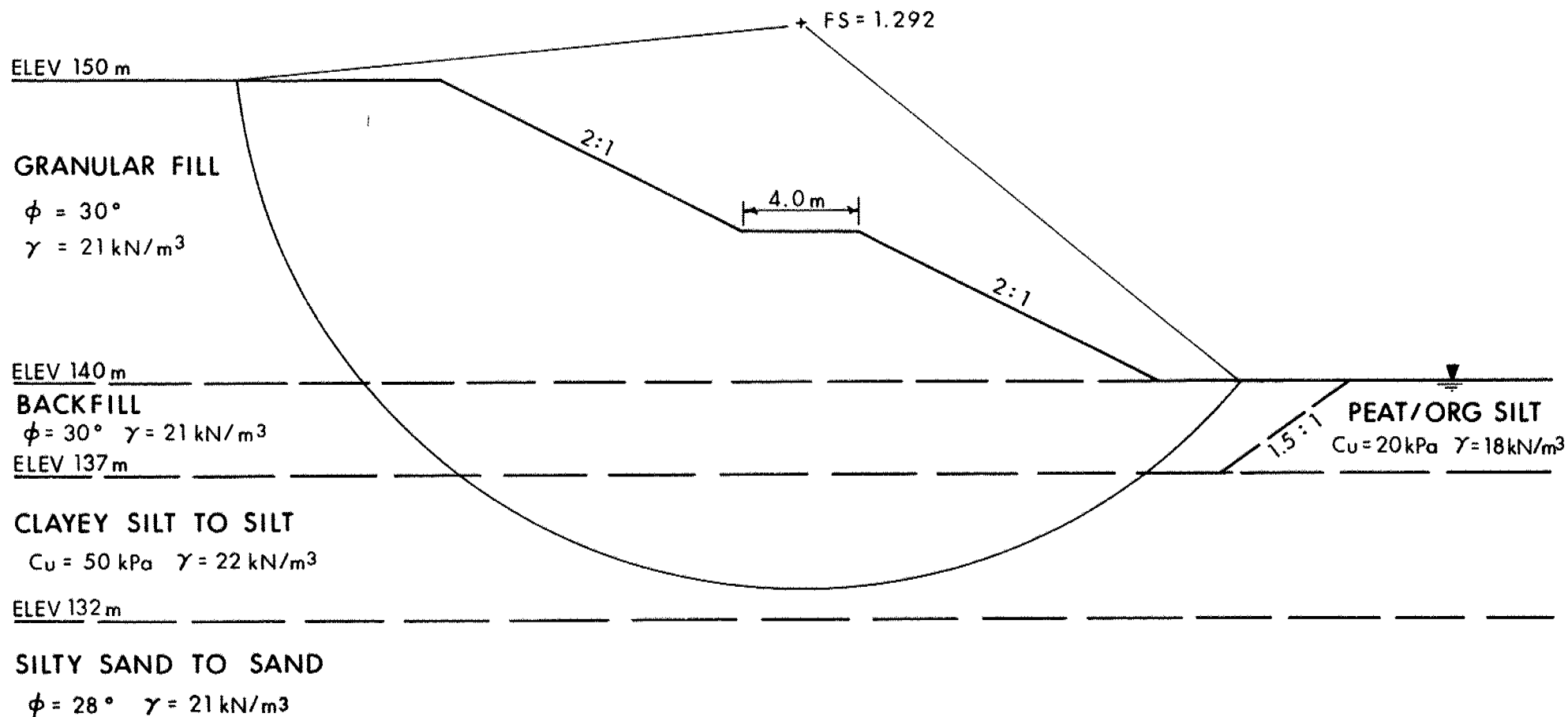


FIG 10- TOTAL STRESS ANALYSIS

RECORD OF BOREHOLE No 1

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 846 988.5 E 297 295.5 ORIGINATED BY BS
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test. HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 08 29 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
140.0	Ground Surface											
0.0	Peat/Organic Silt With Sand Some Gravel Trace Clay Very Soft to Soft	N	1	SS	0		138					25 38 34 3
137.1		N	2	SS	0							
2.9	Gravelly Sand, Some	N	3	SS	3							
136.3	Silt, Trace Clay Compacted	N	4	SS	16							
3.7		N	5	SS	4		136					39 25 25 11
	Clayey Silt to Silt	N	6	SS	4							26 30 33 11
	With Sand	N	7	SS	36							
	Trace Gravel	N	8	SS	68		134					
	Occ. Sand Seams	N	9	SS	39							
	Soft to Hard	N					132					
130.1		N	10	SS	74							
9.9		N					130					1 92 5 2
	Silty Sand to Sand	N	11	SS	22							
	Trace Gravel	N	12	SS	30		128					
	Trace Clay	N										
	Compact to Dense	N	13	SS	28		126					
124.0		N	14	SS	21		124					
16.0	Heterogeneous Mixture of Gravel, Sand, Silt	N										
122.8	Trace Clay V. Dense**	N	15	SS	113							16 70 12 2
17.2	End of Borehole											
	** (Glacial Till)											

RECORD OF BOREHOLE No 2

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 023.5 E 297 282.5 ORIGINATED BY BB
DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BB
DATUM Geodetic DATE 89 08 22 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
139.4	Ground Surface													
0.0	Peat/Organic Silt With Sand, Some Gravel Trace Clay, V. Soft	N N N N	1	SS	1									
138.0		N N N N												
1.4	Gravelly Sand Some Silt Trace Clay Very Loose to Compact	N N N N	2	SS	0		138							
		N N N N	3	SS	10									
135.7		N N N N	4	SS	21		136							11 58 27 4
3.7	Clayey Silt to Silt With Sand Trace Gravel Occ. Sand Seams Soft to Hard	N N N N	5	SS	3									6 38 44 12
		N N N N	6	SS	30		134							
132.5		N N N N	7	SS	61									
		N N N N	8	SS	18		132							9 41 46 4
6.9	Silty Sand to Sand Trace Gravel Trace Clay Compact to Very Dense	N N N N	9	SS	53									
		N N N N	10	SS	60		130							
		N N N N	11	SS	61									
		N N N N	12	SS	18		128							
		N N N N	13	SS	53		126							
		N N N N	14	SS	60		124							
123.4		N N N N	15	SS	60		122							38 48 12 2
16.0	Heterogeneous Mixture of Gravel, Sand, Silt Trace Clay Very Dense (Glacial Till)	N N N N	16	SS	50									
120.8		N N N N												
18.6	End of Borehole													

RECORD OF BOREHOLE No 3

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 044.5 E 297 271.5 ORIGINATED BY BS
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 08 24 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
138.8	Ground Surface												
0.0	Peat/Organic Silt With Sand												
137.3	Some Gravel Trace Clay Very Soft		1	SS	0								47 39 12 2
1.5	Gravelly Sand		2	SS	11								
135.9	Some Silt Trace Clay Compact		3	SS	18								5 36 54 4
2.9	Clayey Silt to Silt With Sand Trace Gravel Occ. Sand Seams Firm to Hard		4	SS	62								
			5	SS	11								
			6	SS	6								
			7	SS	8								0 19 72 9
			8	SS	17								
131.9													
6.9	Silty Sand to Sand Trace Gravel Trace Clay Very Loose to Dense		9	SS	11								0 89 10 1
			10	SS	5								
			11	SS	**								
			12	SS	23								
			13	SS	26								
			14	SS	36								0 22 77 1
123.0	Heterogenous Mixture of Gravel, Sand, Silt Trace Clay Very Dense (Glacial Till)		15	SS	60/10cm								34 48 13 5
120.3			16	SS	70/23cm								
18.5	End of Borehole												
	* Artesian Condition Encountered at El. 129.0, Artesian Head to El. 140.0 CWL Rdg. Taken 89 08 31												
	**Rods Sank Under Own Weight - Disturbed Conditions												

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 846 998.0 E 297 304.0 ORIGINATED BY BS
DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY BS
DATUM Geodetic DATE 89 08 28 CHECKED BY DD

SOIL PROFILE			SAMPLES			*GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
								SHEAR STRENGTH kPa									
139.3	Ground Surface																
0.0	Peat/Organic Silt With Sand, Some Gravel	N	1	SS	1												
137.9	Trace Clay Very Soft	N	2	SS	1												
1.4	Gravelly Sand Some Silt Trace Clay	A	3	SS	4												
	Very Loose to Compact	B	4	SS	11												
135.6		C	5	SS	8												
3.7		D	6	SS	5												
	Silty Sand to Sand	E	7	SS	3												
	Trace Gravel	F	8	SS	0												
	Trace Clay	G	9	SS	6												
	Very Loose to	H	10	SS	24												
	Very Dense	I	11	SS	8												
		J	12	SS	70												
		K	13	SS	74												
		L	14	SS	96												
123.3		M	15	SS	93												
16.0	Heterogeneous Mixture of Gravel, Sand, Silt	N															
122.1	Trace Clay Very Dense	N															
17.2	End of Borehole																
	* (Glacial Till)																
	** Borehole Backfilled With Bentonite Cement Slurry																
	Artesian Condition Encountered at El. 133.4m																
	Artesian Head to El. 139.3m																

RECORD OF BOREHOLE No 7

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 027.5 E 297 293.5 ORIGINATED BY BS
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 08 23 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 10 20 30					
138.4	Ground Surface													
0.0	Gravelly Sand Some Silt Trace Clay Loose to Compact		1	SS	14									28 37 29 6
136.3			2	SS	6									4 58 30 8
2.1			3	SS	4									7 74 15 4
	Silty Sand to Sand		4	SS	2									3 83 10 4
			5	SS	2									
	Trace Gravel		6	SS	7									
	Trace Clay		7	SS	2									
			8	SS	2									
	Very Loose to Very Dense		9	SS	34									
			10	SS	32									
			11	SS	38									
			12	SS	35									
			13	SS	67									
123.8														
14.6	Heterogeneous Mixture of Gravel, Sand, Silt Trace Clay Very Dense (Glacial Till)		14	SS	91									51 38 9 2
			15	SS	80									
120.1														
18.3	End of Borehole * Artesian Conditions Encountered at Approx. El. 134.0m Artesian Head to El. 139.3m CWL Rdg. Taken 89 08 31													

RECORD OF BOREHOLE No 8

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 051.5 E 297 285.5 ORIGINATED BY BS
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BS
 DATUM Geodetic DATE 89 08 25/26 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
138.7	Ground Surface																
0.0	Gravelly Sand Some Silt Trace Clay Trace Organics Loose to Compact		1	SS	9		138										0 64 30 6
136.6			2	SS	11												
2.1	Clayey Silt to Silt With Sand		3	SS	57		136										
			4	SS	50												
	Trace Gravel		5	SS	48												
	Occ. Sand Seams		6	SS	64		134										6 34 48 12
	Very Stiff to Hard		7	SS	29												5 42 43 10
131.8			8	SS	55		132										
6.9	Silty Sand to Sand		9	SS	27												2 88 7 3
	Trace Gravel Trace Clay		10	SS	34		130										
	Compact to Very Dense		11	SS	99/	25cm	128										
			12	SS	25		126										
	Some Gravel		13	SS	69		124										25 34 30 11
122.4																	
16.3	Heterogeneous Mixture of Gravel, Sand, Silt Trace Clay						122										
120.4	Probably Very Dense																
18.3	End of Borehole																

RECORD OF BOREHOLE No 11

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 011.5 E 297 320.5 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 08 28 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
137.8	Ground Surface																
0.0	Gravelly Sand Some Silt, Tr. Organics		1	SS	19												45 40 12 3
136.4	Trace Clay Compact		2	SS	26												8 32 50 10
1.4	Clayey Silt to Silt With Sand		3	SS	54												
	Trace Gravel Occ. Sand Seams		4	SS	25												
	Very Stiff to Hard		5	SS	65												7 51 33 9
			6	SS	60												1 16 76 7
131.9			7	SS	20												
5.9	Silty Sand to Sand		8	SS	14												21 63 12 3
	Trace/Some Gravel		9	SS	39												
	Trace Clay		10	SS	67												
	Compact to Very Dense		11	SS	66												
			12	SS	87												
124.8																	
13.0	Probably Het. Mixture of Gravel Sand, Silt																
122.6	(Glacial Till)																
15.2	End of Borehole																
	* Artesian Condition encountered at El. 128.7m±																
	Artesian Head to El. 138.0m±																
	Borehole Backfilled with Bentonite/Cement Slurry.																

RECORD OF BOREHOLE No 12

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 036.0 E 297 310.0 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY BB
 DATUM Geodectic DATE 89 08 23/25 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
138.3	Ground Surface																GR SA SI CL
0.0	Gravelly Sand Some Silt Trace Clay Trace Organics Compact		1	SS	23		138										48 30 17 5
136.2			2	SS	18												5 32 51 12
2.1	Clayey Silt to Silt With Sand Trace Gravel Occ. Sand Seams V. Stiff to Hard		3	SS	23		136										
			4	SS	31												
133.9			5	SS	19	Seal	134										4 56 32 8
4.4	Silty Sand to Sand		6	SS	10												10 67 20 3
	Trace/Some Gravel		7	SS	5												
	Trace Clay		8	SS	19		132										
	Loose to Very Dense		9	SS	42		130										
			10	SS	75		128										
			11	SS	22		126										
125.3			12	SS	23		124										
13.0	Heterogeneous Mixture of Gravel, Sand, Silt Trace Clay Very Dense (Glacial Till)		13	SS	110												
123.1																	
15.2	End of Borehole * Artesian Condition Encountered at El. 123.1m± Artesian Head to El. 138.6m±																

RECORD OF BOREHOLE No 13

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 063.5 E 297 302.0 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE Cone Test, HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 08 30/31 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

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/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
139.2	Ground Surface													
0.0	Gravelly Sand													
	Clayey Silt Zone		1	SS	9		138							0 22 68 10
	Some Silt, Trace Clay		2	SS	30									
	Trace Organics													
136.6	Loose to Dense		3	SS	26									1 19 45 35
2.6	Silty Clay Zone													
	Clayey Silt to Silt		4	SS	100	25cm	136						22.1	
	With Sand		5	SS	125									
	Trace Gravel													
	Occ. Sand Seams		6	SS	100	25cm	134							
133.3	Hard		7	SS	88									
5.9	Silty Sand Trace Clay		8	SS	43									
132.2	Trace Gravel Dense													
7.0														
	Clayey Silt to Silt		9	SS	60		132							34 46 17 3
	With Sand													
	Trace Gravel		10	SS	78		130							
	Occ. Sand Seams													
	Hard		11	SS	52		128							
			12	SS	52									
126.2														
13.0	Heterogeneous Mixture of Gravel, Sand, Silt Trace Clay Very Dense		13	SS	113	25cm	126							
			14	SS	112	26cm	124							
	(Glacial Till)													
121.9			15	SS	146	23cm	122							
17.3	End of Borehole													

RECORD OF BOREHOLE No 14

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 846 993.5 E 297 300.5 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE H.S. Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 13/14 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.7	Ground Surface																
0.0	Peat/Organic Silt With Sand Some Gravel						140										
138.9	Trace Clay V. Soft		1	SS	1												
1.8			2	SS	3		138										
	Silty Sand to Sand		3	SS	16												
	Gravelly Sand, Some Silt. Tr. Clay. Compact		4	SS	15	Seal											33 56 10 1
136.3	Trace Organics		5	SS	20		136										
4.4	Silty Sand to Sand Trace Gravel Trace Clay Very Loose to Compact		6	SS	1*												0 93 6 1
			7	SS	12		134										4 88 7 1
			8	SS	23												
132.6			9	SS	28												
8.1	End of Borehole																
	*Disturbed Value																

RECORD OF BOREHOLE No 15

METRIC

W P 88-78-12/33 LOCATION Co-ords: N 4 847 024.5 E 297 290.5 ORIGINATED BY DC
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY BB
 DATUM Geodetic DATE 89 09 14 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
139.2	Ground Surface																
0.0	Gravelly Sand Some Silt Tr. Clay, Tr. Organics Compact		1	SS	13		138										
137.2			2	SS	10												
2.0	Clayey Silt to Silt With Sand Some Gravel Occ. Sand Seams Soft to Hard		3	SS	7		136										28 33 33 6
			4	SS	9												3 43 44 10
			5	SS	35												
133.4			6	SS	2	Seal	134										8 43 44 5
5.8	Silty Sand to Sand Trace Gravel Trace Clay Loose to Compact		7	SS	6												0 93 (7)
			8	SS	11												
131.3			9	SS	38		132										
7.9	End of Borehole																

METRIC

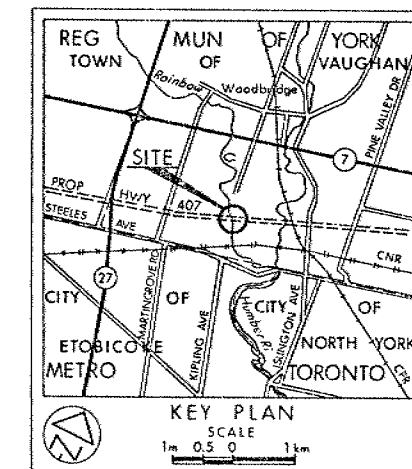
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 88-78-12/33

KIPLING AVE

SHEET

BORE HOLE LOCATIONS & SOIL STRATA



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 89.08
- Head
- Encountered
- W.L. in Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	140.0	4846988.5	297295.5
2	139.4	4847023.5	297282.5
3	138.8	4847044.5	297271.5
6	139.3	4846998.0	297304.0
7	138.4	4847027.5	297293.5
8	138.7	4847051.5	297285.5
11	137.8	4847011.5	297320.5
12	138.3	4847036.0	297310.0
13	139.2	4847063.5	297302.0
14	140.7	4846993.5	297300.5
15	139.2	4847024.5	297290.5
16	139.2	4847047.0	297279.5

NOTE

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

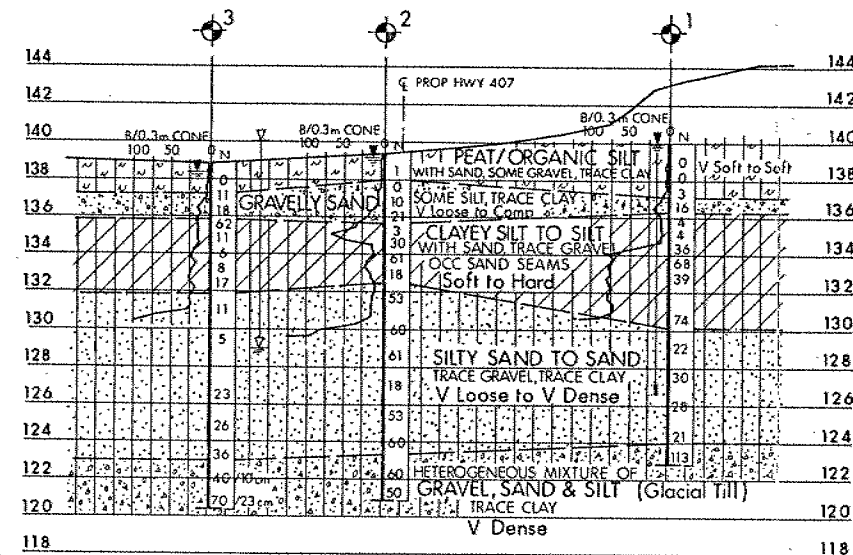
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION
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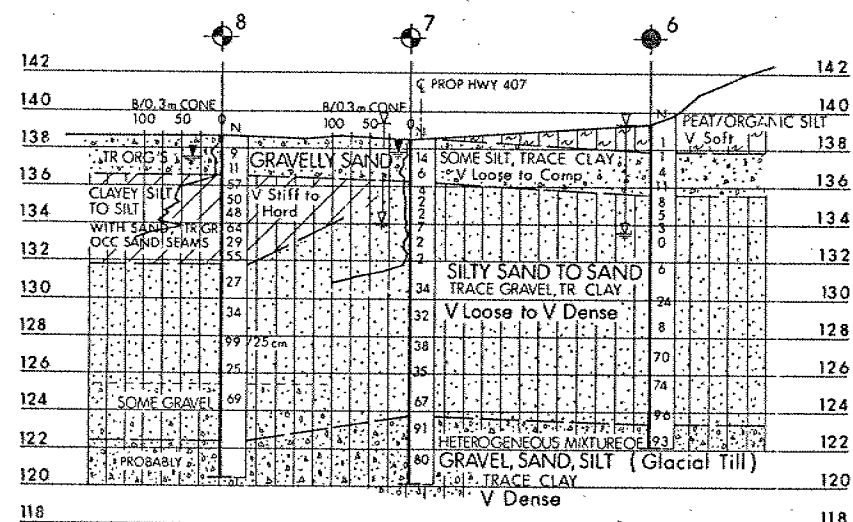
Geocres No 30M13-92

HWY No 407	CHECKED	DATE 1989.12.01	DIST 6
SUBWD BB	CHECKED	DATE 1989.12.01	SITE 37-1336
DRAWN SQ	CHECKED	DATE 1989.12.01	DWG 887812/33-A

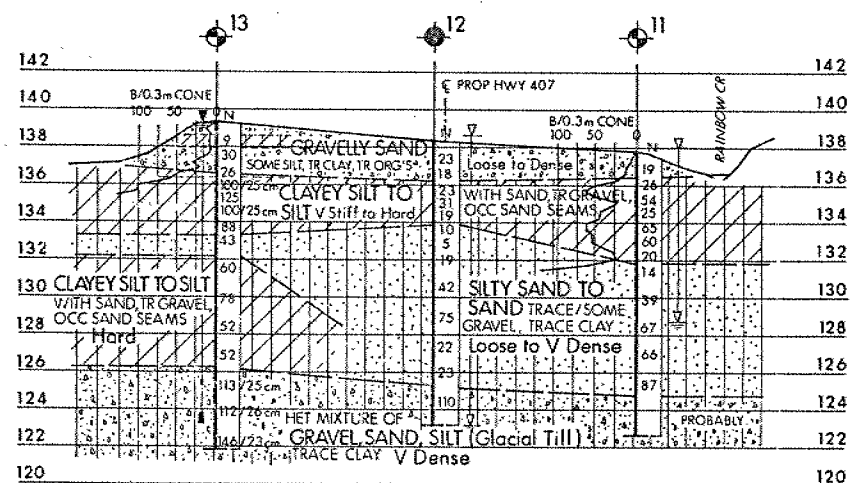
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A-A

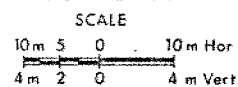


B-B

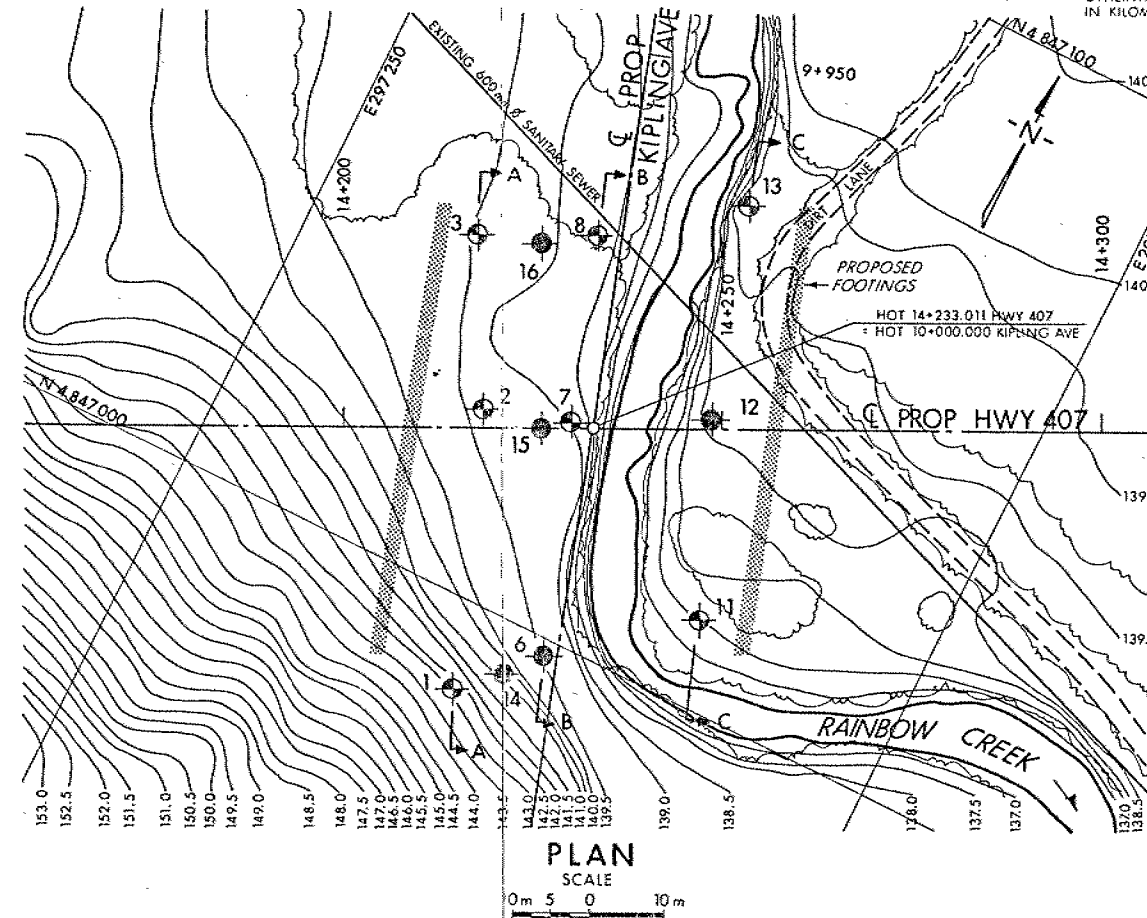


C-C

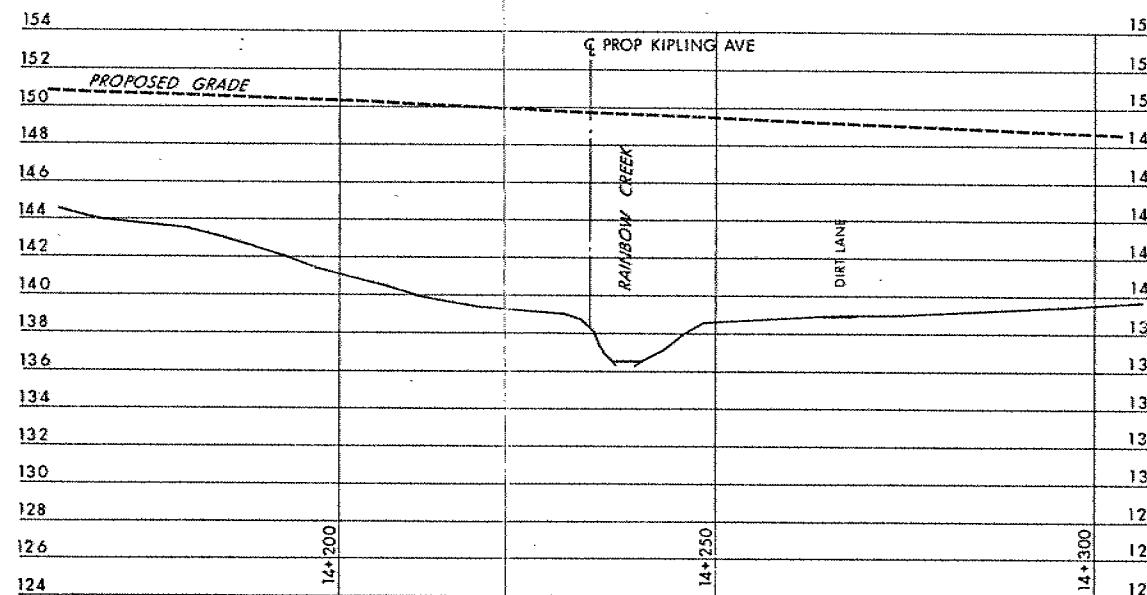
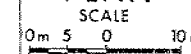
SECTIONS



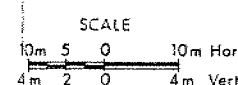
NOTE: SUBSOIL FOR BORE HOLES
14, 15 & 16 REFER TO RECORD OF BORE HOLE



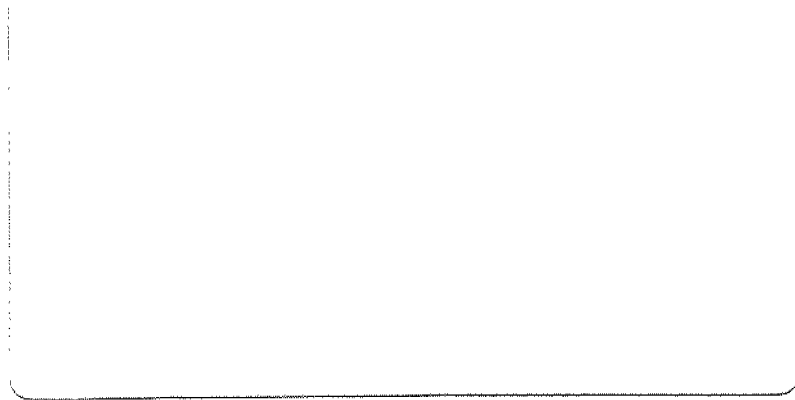
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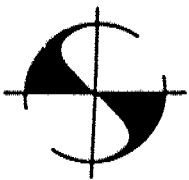
PROFILE PROP HWY 407



Geocres No 30 M13-92A



STRATA ENGINEERING CORP.



STRATA ENGINEERING CORP.

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RESEARCH . ENGINEERING . SCIENCE

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Hwy. 407 / Kipling Ave. Interchange Cuts

From Martin Grove Road E'ly to Humber River

W.P. 88-78-02

Geotechnical Section, Central Region

Ministry of Transportation, Ontario

GEOCREES No 30M13-92A

S-89-264

1990 01 12

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Hwy. 407 / Kipling Ave. Interchange Cuts
From Martin Grove Road E'ly to Humber River
W.P. 88-78-02

Geotechnical Section, Central Region
Ministry of Transportation, Ontario

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by the Geotechnical Section, Central Region, Ministry of Transportation, Ontario, under Consultant Agreement No: 4212-2589-317, to provide geotechnical engineering services in connection with proposed deep earth cuts associated with interchange ramps and connections at Hwy. 407 and Kipling Avenue, north of existing Hwy. 7.

The terms of reference originally provided to Strata were to investigate the nature of the cut materials by means of sampled boreholes drilled to a minimum depth of 1.5m below the design profile grade level. Suggestions were provided by the Geotechnical Section as to the number of boreholes to be drilled at each cut location.

Subsequently, the terms of reference were revised, eliminating some of the boreholes, adding new ones, and deepening them by 6m to satisfy criteria for slope stability analyses by the Foundation Design Section of the Ministry. To this end, it was agreed that the report should include Borehole Log Sheets and Figures prepared to Foundation Design Section standards.

A Proposal and cost estimate based on the revised borehole locations and depths was submitted by Strata on 1989 09 13.

After commencement of the field work, a request was received to increase the number of boreholes to determine the extent and thickness of peaty soils in a low marshy area adjacent to Martin Grove Rd. Connection across Rainbow Creek, as well as to identify frost susceptible materials more extensively through the various cuts. This resulted in an increase in the number of boreholes from an original of 24 to a final total of 34.

It was also agreed that this report should be factual in nature and that recommendations need not be provided. This report is submitted in compliance with the above revised terms of reference.

2.0 SITE AND GEOLOGY

The site is located north of existing Highway 7, between Martin Grove Road and the Humber River. The Highway 407/Kipling Avenue interchange involves several ramps and connections, some of which will be through relatively deep (>10m depth) cuts.

The geology of the area consists of a relatively young clayey silt till (Wildfield Till) overlying glacio-fluvial till-like deposits of silts and sands, intermixed with older tills, and lenses and seams of coarser sands and gravels.

The bedrock of this area is grey Georgian Bay shale of Upper Ordovician Age, occurring below elevation 130m.

The terrain is undulating to rolling in nature. The highest ground in the area has an elevation in the order of 160m, with Rainbow Creek at about elevation 137m. Existing slopes are generally steep and apparently stable. The area has an extensive tree and bush cover, except in the swampy terrain.

3.0 SCOPE OF WORK

The scope of work for the present investigation is summarized below. The maximum depth of cut is shown for each assigned ramp, connection or main alignment, together with the borehole numbers assigned in this report to satisfy the Foundation Design Section requirements:

1. Martin Grove Road Connection, approx. Sta. 9+550 - 9+900
Max. Depth of Cut: 13m; Boreholes: 1-13;
2. Ramp E-NS, approx. Sta. 10+460 - 10+710
Max. Depth of Cut: 14m; Boreholes: 14-17;
3. Ramp S-W, approx. Sta. 10+170 - 10+330
Max. Depth of Cut: 13m; Boreholes: 18 and 19;
4. Ramp N-E, approx. Sta. 10+110 - 10+350
Max. Depth of Cut: 13m; Boreholes: 20-22;
5. Ramp W-NS, approx. Sta. 0+250 - 0+590
Max. Depth of Cut: 11.5m; Boreholes: 23-29;
6. Hwy. 407, approx. Sta. 13+900 - 14+130
Max. Depth of Cut: 7.5m; Boreholes: 30-33;
7. Kipling Avenue, Sta. 10+120; Borehole: 34.

4.0 FIELD AND LABORATORY WORK

4.1 Field Work

The site was initially visited on 1989 09 20 jointly by personnel from Strata Engineering Corp. and the Geotechnical Section, Central Region, MTO. The nature of the terrain, proposed grades, and strategies for drilling were discussed and agreed upon.

The boreholes were surveyed and staked in the field on 1989 09 27 by others. In locating revised boreholes in the field, reference was made to the staking available at the time for the previously designated borehole locations, and the distances measured by chaining.

The drilling and sampling field work for this assignment was commenced on 1989 10 02 and completed on 1989 10 27. On 1989 10 20, we were advised to add certain boreholes in the swampy terrain and to revise certain boreholes in the various cuts. On 1989 11 23, revised ground elevations at some borehole locations were received from the project design consultants.

The locations and elevations of boreholes given in this report and the appended borehole log sheets have been either provided to us by others or interpolated from a plan of the site and profiles supplied to us. It is recommended that the elevations in particular be re-checked at the first available opportunity to ensure that they correspond to the stations listed for each borehole location.

The boreholes were drilled with a bombardier mounted power auger machine using solid stem augers. Samples of the soil were obtained at 1.5 m intervals in the Standard Penetration Test, the N values being recorded in blows/0.3m. In some boreholes, in the interest of expediency, no samples were obtained to within a few metres of the profile grade. However, in all boreholes, auger cuttings were obtained for certain laboratory testing.

Observations of groundwater levels were made at time of drilling as well as after completion of each borehole. It was found that standpipes were not required for most boreholes, which tended to remain open. No artesian groundwater conditions were observed in any of the boreholes, although some sub-artesian conditions are suspected in the low swampy areas.

Groundwater level observations were made up to 1989 11 16. The borehole log sheets show the latest available groundwater level in each borehole and the level of borehole caving, if any. Notes are provided in the Remarks column of the log sheets to clarify the nature of the water table, whether sub-artesian or perched, as dictated by field observations.

4.2 Laboratory Work

The samples recovered from the field drilling program were transported to our Richmond Hill facility for further visual examination and classification under the MTO-Unified Soil Classification System. Several representative soil samples, both from the split-barrel SPT testing and from auger cuttings were selected for laboratory testing, which consisted of the following:

- moisture contents
- Atterberg Limits
- Grain Size Analyses (both sieving and hydrometer)
- Standard Proctor densities

The results of the laboratory testing program are shown on the appended borehole log sheets as well as on Figures 1 to 6.

Where appropriate, reference to the results are given and discussed in the text of the report.

For the more granular or gravelly soil samples, Proctor tests were conducted in a 150mm diameter mould, compacting each of three layers with 56 blows of the Standard 5.5 kg hammer.

The Standard Proctor density tests were carried out on composite samples representative of each major stratum encountered across the entire job site, rather than by each cut or ramp location. Geologically, the soils are similar and a clayey silt in one cut is likely to be similar to a clayey silt from another cut, especially when one considers the small area encompassed by this investigation, in geological terms. However, we should be approached for further detailed site or depth specific testing, if such is felt to be necessary at a later stage.

All laboratory tests were conducted in conformity with the latest ASTM designation.

The soil samples were sequentially numbered in the field during drilling. However, for purposes of this report, the samples were re-numbered after arbitrarily assigning borehole numbers (as specified under Section 3.0, Scope of Work, above), in keeping with standard MTO Foundation Design Section practice. A cross-reference file is being maintained to ensure that the field numbering system can be correlated to the Borehole and Sample numbering system used and given in this report.

Water samples were not obtained for testing for pH, SO_4 , or Cl^- . These values may be required for selection of an appropriate Portland cement type for any concrete to be placed in contact with the subgrade. It is understood other investigations are underway at this location by both MTO and others and it may be advisable to keep this water quality testing requirement in mind.

5.0 SUBSURFACE CONDITIONS

5.1 General

The subsurface conditions across the various locations drilled are more or less similar, with some differences mainly in thickness, texture and plasticity of the various soil components.

Preliminary information on soil conditions encountered in this investigation was forwarded to the Geotechnical Section, Central Region MTO on 1989 11 22. The information consisted of:

- Borehole locations and peat thickness in the swamp;
- Preliminary information on the occurrence of frost susceptible materials at profile grade level;
- Topsoil thicknesses encountered in the boreholes.

Since that time, certain tests have been conducted to determine the percentages of sand, silt and clay, and plasticity characteristics. Therefore, the soil classification has been revised in certain cases from that which might have been indicated earlier, based on these tests. It is therefore recommended that further decisions with respect to grade revisions and re-use of cut materials be made on the basis of the soil descriptions and boundaries given in this report.

The soil strata encountered in the various cuts consist sequentially of a clayey silt glacial till, followed by a non-cohesive fine-grained frost susceptible soil, with inclusions of clayey silts, sands and gravelly zones throughout. Typical occurrences and characteristics are given below.

5.2 Clayey Silt Glacial Till

This material was encountered immediately below the topsoil in each borehole drilled through the proposed cuts, except in the low lying swampy area.

It consists of a clayey silt with sand and trace of gravel, which is grey brown in colour. Occasional reddish brown streaks are present along fracture surfaces, indicating desiccation.

The moisture content of this material ranged between 10% and 22%, being typically 15%.

The plasticity characteristics of the deposit are shown on Figure 1. The soil is fairly plastic, and in some cases, borders on a silty clay. It will be noted that the plastic limit of the soil is at or near the natural moisture content.

5.2 Clayey Silt Glacial Till - continued:

The N values in this deposit show it to be generally hard in consistency, with localized very stiff to stiff zones. The undrained shear strength of the soil is estimated to be in excess of 100kPa.

The soil, at time of sampling, had a moisture content 2-3% below the optimum value for Standard Proctor density. The result of one typical Std. Proctor test on a composite sample is given below:

Max. Dry Density - 17.7 kN/m³
Optimum Moisture - 17.0% .

5.3 Silty Sand to Sandy Silt

The clayey silt glacial till stratum is underlain at most locations by a silty sand to sandy silt deposit. Results of gradation analyses for the overall average deposit are shown on Figure 3.

The main feature of this deposit is its extensive variability with depth. The soil components range from almost pure silt (see Figure 4) to silty sand with gravel (see Figure 5).

In several boreholes, relatively thick (1.0m - 2.5m) zones of coarse sands and gravels were encountered, and where distinction as to occurrence was fairly well recognized in the field, they are shown within the dashed lines in the description column of the log sheets, or as distinct strata.

In some boreholes, the silty sand-sandy silt deposit showed distinct laminar features, suggesting an inter-stadial lacustrine depositional environment. In some samples, the random orientation of laminates suggests a fluvial origin. Therefore, these deposits are glacial in origin and in some cases exhibit a till-like texture.

The colour of the deposit ranged from a light tan-brown to grey, becoming generally grey with depth, and dark grey in a few cases, suggesting the presence of trace organics or sulfides. In some boreholes, reddish-brown zones were also encountered.

The moisture content values ranged from about 5% to over 20%, being typically around 10%.

The N values in this deposit ranged from about 50 blows/0.3m to over 100 blows/0.3m, indicating the deposit to be generally very dense. On only two occasions were N values noted to be below 50 blows/0.3m.

5.3 Silty Sand to Sandy Silt - continued:

In the boreholes drilled along Martin Grove Rd. Connection (BH 1-4), the soil was essentially a silty sand with gravel (see Figure 5). The same type of material was also encountered below the peat and organic silt in the boreholes placed in the low lying swampy ground bordering Rainbow Creek (BH: 5-13 inclusive).

The following values were obtained in a Standard Proctor test conducted on a sandy silt composite sample:

Maximum Dry Density - 18.2 kN/m^3
Optimum Moisture - 11.2%.

A Standard Proctor density test on the component whose grain size distribution is shown on Figure 5 (silty sand with gravel) gave the following values:

Maximum Dry Density - 18.9 kN/m^3
Optimum Moisture - 13.0%.

A Standard Proctor test on a sand and gravel type material gave the following values:

Maximum Dry Density - 21.7 kN/m^3
Optimum Moisture - 7.5%.

5.4 Laminated Clayey Silt-Silt

Along Martin Grove Rd. connection (BH: 1-4), Ramp W-NS (BH: 25, 26, 28, 29), and Hwy.407 (BH: 30-32) a laminated clayey silt to silt deposit was found at depth either below the clayey silt glacial till or below the silty sand stratum. This deposit is distinctly laminated and has a varved appearance, the colour ranging from brown to dark grey in a cyclical banding.

The moisture content of this material ranged between 5% and 15%, being typically 10%.

Atterberg Limits test results on whole (not separated) samples are given in Figure 6, and show this soil to be a clayey silt to silt (CL-ML).

The N values in excess of 50 blows/0.3m suggest the consistency of the soil is hard throughout.

Due to the generally hard consistency of the deposit, it was not possible to recover relatively undisturbed thin-walled tube samples for triaxial testing to determine the effective angle of internal friction of the soil and cohesion intercept.

5.5 Organic Soils

Peat and organic silt were encountered in Boreholes 5 to 13 inclusive in the low lying swampy areas adjacent to the proposed Martin Grove Rd. connection.

The peat is black in colour and fibrous in texture. Its moisture content ranged between 195% and over 400%.

The organic silt is dark grey in colour and its moisture content ranged between 45% and over 90%.

Vane tests were conducted to determine the undrained shear strength (c_u) in situ. c_u values of 15kPa to 35kPa were noted in the peat and about 45kPa in the organic silt. Based on these tests, and N values of between 1 and 3 blows/0.3m, the consistency of these organic deposits is considered to be very soft to soft, being occasionally firm.

6.0 GROUNDWATER CONDITIONS

The groundwater conditions were observed during drilling, upon completion of each borehole and a week to two weeks after completion of each borehole.

In most cases, the groundwater table stabilized at the elevations shown on the borehole log sheets. However, in some cases, a perched condition was noted, as for example in Boreholes 20, 29, and 32. The perched water table is considered to be the result of water trapped in a relatively permeable zone (sand and gravel) situated above a relatively impermeable stratum (clayey silt or silt).

In Borehole 7 in the swamp, a sub-artesian or pseudo-sub-artesian condition is suspected from the relatively low N value obtained for a sample of silty sand to sandy silt. Since all the N values in this deposit were found to be consistently high, the one low N value (10 blows/0.3m) suggests boiling of the sand under an unbalanced hydrostatic head. For this reason it is suspected that there might be springs in the silty sand stratum underlying the peat/organic silt, through hydraulic connection with higher water tables in the same strata at higher elevations. Because the water did not rise above the ground level, and because this may be an isolated phenomena, the condition is described as sub-artesian or pseudo-sub-artesian.

In the boreholes placed within the cuts, some caving occurred, indicative of the prevailing water table in the non-cohesive strata. However, no artesian conditions were observed. Had artesian conditions been encountered, we would have placed sealed piezometers in the affected boreholes.

7.0 DISCUSSION

The extent and depths of the proposed cuts were described earlier under Section 3.0 of this report.

Based on the data obtained in this investigation, the following general discussion is offered for further actions requiring decisions with respect to slope stabilization, erosion control, use of excavated materials and groundwater control during construction. As stated in Section 1.0, no recommendations are being offered at this time in this report.

7.1 Martin Grove Road Connection

The soil conditions in the proposed cut are represented by Boreholes 1 to 4 inclusive. A stratigraphic plot shows an unconformity with respect to the thickness of the clayey silt glacial till at Borehole 3. A simple stratigraphic interpolation would suggest that the base of this deposit be encountered at about elevation 158, when in fact it was encountered at elevation 152. Therefore, one might suspect either a natural variability across the cut in the thickness of this material, or further detailed borings may be required to delineate the extent of this apparent unconformity.

From the proposed profile grade, it may be concluded that the subgrade will be within the clayey silt glacial till deposit at Boreholes 1 and 3 and within a silty sand with gravel stratum at Boreholes 2 and 4.

The cut will be about 1.5m below the prevailing water table in Boreholes 2 and 4 and some 3.5m and 1.5m above the prevailing water table in respectively Boreholes 1 and 3.

7.2 Ramp E-NS

The soil conditions along this cut are shown on the log sheets for Boreholes 14 to 17 inclusive. It would appear that the entire cut will have the subgrade situated in the extremely frost susceptible silty sand to sandy silt deposit (BH 14-16) or in the moderately frost susceptible clayey silt to silt laminated stratum (BH 17).

However, the subgrade will be located some 5m to 6m above the prevailing groundwater table.

7.3 Ramp S-W

The soil conditions in this cut are represented by Boreholes 18 and 19. At BH 18, the subgrade will be in the frost susceptible silty sand-sandy silt stratum, whereas at BH 19, it will be in the low frost susceptible clayey silt glacial till stratum.

In the entire cut, the subgrade will remain about 6m to 8m above the prevailing water table.

7.4 Ramp N-E

The soil conditions in this cut are represented by Boreholes 20 to 22. It appears that the subgrade will be situated entirely within the highly frost susceptible silty sand-sandy silt deposit.

At Borehole 20, the subgrade will be located some 3m below the water table, whereas at Boreholes 21 and 22 it will be some 4m to 6m above the prevailing water table. However, a perched water table condition is suspected at BH 20. Therefore, the entire cut in this perched water table location could probably be drained by gravity drainage.

7.5 Ramp W-NS

The soil conditions in this cut are represented by Boreholes 23 to 29 inclusive.

The subgrade conditions along the entire length of the cut, at subgrade level, will be quite variable, ranging from silty sand-sandy silt to laminated clayey silt-silt to sand and gravel to clayey silt glacial till. Therefore, to achieve uniformity of performance of the pavement, this high variability should be considered in design.

On the positive side, the groundwater table is situated some 2m to 5.5m below the proposed subgrade level.

7.6 Highway 407

The subsurface conditions in this cut are represented by Boreholes 30 to 33 inclusive. At BH 30 and 31, the subgrade will likely be situated within the highly frost susceptible sandy silt-silty sand deposit, whereas at BH 32 and 33 the subgrade will be located within the relatively frost free sand and gravel sequences found within the silty sand deposit. It would be prudent to assume that the entire subgrade will be in frost-susceptible materials, as the occurrence of the sand and gravel lenses may be quite random. The entire subgrade will be some 1.5m to 5m above the water table.

7.7 General Remarks

1. Borehole 34 was drilled at the location suggested along Kipling Avenue. Since its use is not known, no discussion is offered at this time.

2. Failures of deep cut slopes along the Don Valley Parkway, many years after it was constructed, suggested that the highly consolidated clays were failing at their residual shear strength values of about 16° . The slopes were designed for an effective angle of shearing resistance of about 26° .

The same consideration might apply in the proposed cuts whose bases will be situated within the highly consolidated laminated clayey silt to silt stratum. Also, there is tendency for failures to occur along planes of weaknesses, which in this deposit would be along horizontal planes. Therefore, the traditional Bishop's circular arc method of stability analysis might not be relevant, and consideration should be given to analysis based on a sliding wedge or Janbu type failure mode, using residual angles of friction in the range of 12° to 16° .

3. It is suggested that stability analyses be carried out in the effective stress mode for all cuts.

4. The silty sand-sandy silt deposit (see Section 5.3 of this report) is considered to be not only highly frost susceptible, but also, highly erodable. Suitable protective covers should be provided to protect against accelerated erosion of this soil when it is exposed in the cut faces.

5. The clayey silt glacial till (see Section 5.2 of this report) may be susceptible to softening when exposed to the elements, particularly free standing water. Hence, suitable surface runoff and/or protective arrangements should be incorporated in design.

6. For concrete proposed to be in contact with the soil below the water table, it is suggested that a water analysis be carried out (see Section 4.2 of this report).

7. The mineral soil underlying the organic soils in Boreholes 5 to 13 inclusive is generally competent, and consists of dense to very dense non-cohesive materials. However, by request, the borehole depths were limited in this investigation to about 6m. Therefore, for any high fills contemplated in this area, further deeper borings should be made to ensure that the entire sequence below the surficial organics is competent to support the proposed fills safely and with tolerable long term settlements.

8.0 CLOSURE

The assistance of Mr. K. Ganesh of the Central Region Geotechnical Section in making arrangements and providing valuable advice is gratefully acknowledged.

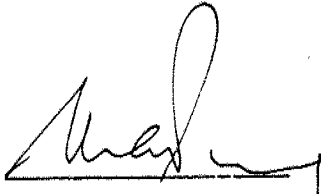
The field drilling and subsurface soil sampling program was supervised by Messrs: Don Mullett and Sen Senathirajah, working under the general guidance of Mr. Michael Percy, P. Eng.

The drill rig was rented from Eastern Soil Investigation Limited of Ajax, Ontario.


The entire project was under the general management and guidance of Mr. C. Mirza, P. Eng.

Respectfully submitted:

STRATA ENGINEERING CORP.



H.J. Percy, M.S., P. Eng.
Project Manager



C. Mirza, M.S., P. Eng.
Senior Principal

Report Distribution:

MTO Central Region Geotechnical Section: 10 copies
Strata File: S-89-264: 1 copy

1990 01 12





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

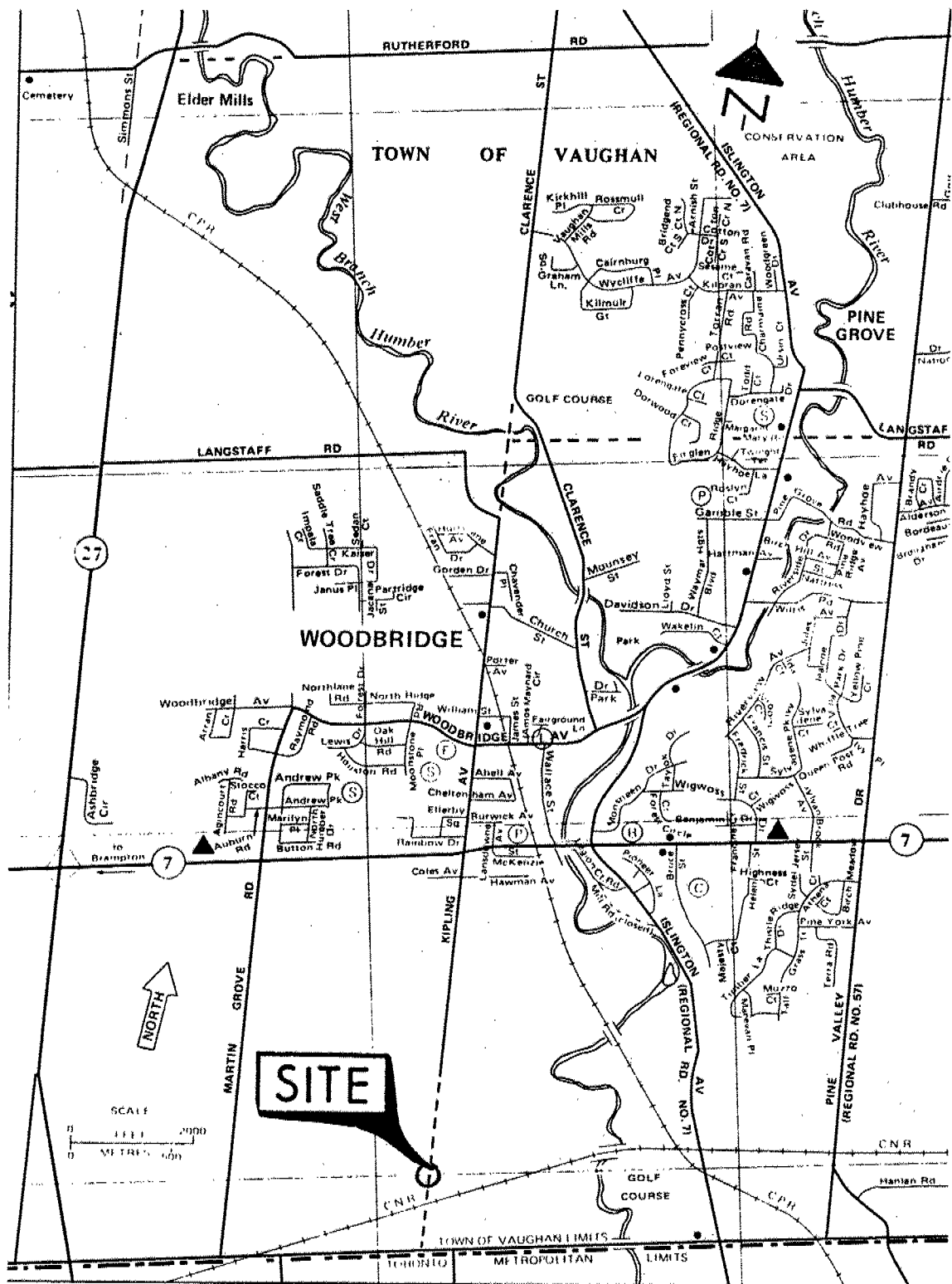
STRESS AND STRAIN

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

f: failure

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						



KEY PLAN



RECORD OF BOREHOLE No 1

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA 9 + 580 C.L. ORIGINATED BY DM
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY SS
DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPo						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
162.4	Ground Surface													
0.0	300 mm Topsoil		1	SS	70		162							
	Clayey Silt with some sand (Glacial Till) Grey-Brown occ. seams light brown silt and sand Hard		2	SS	102		160							
			3	SS	88		158							
			4	SS	91	/28cm	156							
			5	SS	60	/15cm	154							
			6	SS	100	/10cm	152							
155.1	Silty Sand with gravel Brown occ. gravelly zones V. dense		7	SS	80	/15cm								
7.3			8	SS	90									
152.0	Clayey Silt (Glacial Till) Grey Hard		9	SS	75	/15cm								
10.4														
150.1	Sand & Gravel V.Dense													
12.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 2

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 640 C.L. ORIGINATED BY DM
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY SS
DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40					
162.8	Ground Surface													
0.0	300 mm Topsoil		1	SS	33									
	Clayey Silt with some Sa occ. gravel (Glacial Till) Random seams of Lt. Br. Si and Sa V. stiff to Hard Grey-Brown		2	SS	43									
			3	SS	62									
157.3			4	SS	48									
5.5	Silty sand with gravel Tr. clay V. Dense occ. gravel lenses Brown		5	SS	59									
			6	SS	100	10cm								
			7	SS	112									
152.6														
10.2	Clayey silt-silt some Sa, occ. grav. (Glacial Till) Grey Hard		8	SS	75	/15cm								
150.6			9	SS	90	/15cm								
12.2	Si sand & gravel Brown V. dense		10	SS	72	/15cm								
147.9														
14.9	Sandy silt. Brown													
147.3	V. dense		11	SS	100	/8cm								
15.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 ÷ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA 9 + 700 C.L. ORIGINATED BY MJP
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 02 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
162.1	Ground Surface														GR SA SI CL
0.0	300 mm Topsoil						162								
	Clayey silt with some sand, occ. gravel (Glacial Till)		1	SS	60	/15cm	160								
	Grey-Brown Hard		2	SS	70	/15cm	158								
			3	SS	125		156								
	occ. seams of fine sand and silt		4	SS	72	/15cm	154								
			5	SS	100	/10cm	152								
	Sand with some gravel V. Dense		6	SS	82		150								
151.7							148								
10.4	Si sand with gravel. Grey V. dense		7	SS	100	/13cm	146								
150.5															
11.6	Laminated silt to a clayey silt Grey. Hard		8	SS	137										
149.1															
13.0	Silty sand to sandy silt Grey to Brown V. dense occ. gravel seams		9	SS	68	/15cm									
			10	SS	115	/15cm									
145.1															
17.0	End of Borehole		11	SS	104	/10cm									

OFFICE REPORT ON SOIL EXPLORATION

W.L. on
1989 10 26
0 25 60 15

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 742 C.L. ORIGINATED BY MJP
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
DATUM Geodetic DATE 1989 10 17 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
161.0	Ground surface													GR SA SI CL
0.0	300 mm Topsoil													
	Clayey silt with some Sand, Tr. gravel (Glacial Till) Hard. Grey-Brown		1	SS	159		160							
158.0			2	SS	168	/25cm	158							
3.0	Sandy silt, to Silty sand Tr. clay V. dense Lt. Brown		3	SS	170		156							0 30 64 6
			4	SS	100	/15cm	154							
153.4			5	SS	120	/5cm	152							
7.6	Silty sand with gravel Brown V. dense		6	SS	100	/10cm	150							W.L. on 1989 10 26 26 54 (20)
150.3			7	SS	100	/10cm	148							0 22 48 30
10.7	Silt Tr. clay Grey V. dense		8	SS	115	/15cm	146							0 2 86 12
148.6			9	SS	125	/10cm	144							
12.4	Sandy silt to silty sand with gravel Grey, V. dense		10	SS	130	/10cm								
145.8			11	SS	110	/10cm								
15.2	Clayey silt-silt with sand, some gravel (Glacial Till) Hard		12	SS	100	/8cm								
142.5														
18.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 800 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
141.5	Ground surface																
0.0	Peat Fibrous, Black Soft		1	SS	4		140										W.L. on 1989 10 26
138.3	org.silt.occ.Peat V. Soft		2	SS	3												
3.2			3	SS	22		138										
3.4	Silty sand, some gravel grey V. dense occ. coarse sand and gravel seams		4	SS	121		136										
134.9			5	SS	133												
6.8	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION


+3, x5: Numbers refer to
Sensitivity.

20
15 ± 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 825, °/s 15m Lt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)				
141.2	Ground surface									10 20 30			GR 5A SI CL	
0.0	Peat Fibrous		1	CS	-		140							W.L. on 1989 10 27
0.6	Black V. Soft org. silt		2	CS	-									
139.3	Dk. Brown-Grey		3	SS	4									
1.9	Tr. shells, soft													
	Silty Sand some gravel		4	SS	18									
	Grey													
	Compact to V. Dense						138							
	occ. coarse sand and gravel seams		5	SS	128									
135.2	Silty Sand. Grey							136						
6.0	V. dense		6	SS	80	15cm								
6.4	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 825; 0/s 15m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
141.2	Ground surface							20	40	60	80	100					
0.0	Peat, Fibrous Black V. soft		1	SS	2		140										W.L. on 1989 10 26
139.4			2	SS	2												
1.8	org. silt Dk. Brown-Grey soft-firm		3	SS	7		138										
137.8			4	SS	41												
3.4	Silty sand some gravel Grey Dense occ. coarse sand and gravel seams		5	SS	45		136										
134.6			6	SS	10												possible sub-artesian condition
6.6	End of Borehole																

+3, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 840 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa						
140.8	Ground surface														GR SA SI CL
0.0	Peat, Fibrous Black V. Soft						140								W.L. on 1989 10 26
139.0	org. silt v. soft		1	SS	1	/46cm								W= 49%	
1.8	Grey		2	SS	13		138								
138.2			3	SS	110										
2.6	Silty sand some gravel Grey V. dense occ. coarse sand and gravel seams		4	SS	135		136								
134.5			5	SS	90	/15cm									
6.3	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 9

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. Connection STA. 9 + 850; 0/s 15m Lt. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
140.5	Ground Surface																
0.0	Peat, Fibrous Black V. Soft						140										W.L. on 1989 10 27
139.0	org. silt		1	SS	1	46cm											
1.50k	Brown-grey soft		2	SS	3												
1.9	Silty sand Some gravel Grey compact-V.dense occ. coarse sand and gravel seams		3	SS	22		138										
			4	SS	66												
			5	SS	92	15cm	136										
134.2			6	SS	89	15cm											
6.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 850; 0/s 15m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)					
140.5	Ground surface													GR SA SI CL
0.0	Peat, Fibrous Black V. Soft		1	SS	2		140							W.L. on 1989 10 25
138.7			2	SS	6									
1.8	Organic silt													
137.5	Grey soft-firm						138							
3.0	Silty sand some gravel grey		3	SS	24									
	compact-V. dense													
	occ. coarse sand		4	SS	79		136							
	and gravel seams													
134.3			5	SS	100	/10cm								
6.2	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 865; 0/s 18 m Lt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
140.2	Ground surface													GR SA SI CL
0.0	Peat, Fibrous Black Soft		1	TW	PM		140	+3.5						W.L. on 1989 10 25
138.7	org. silt		2	TW	PM			+2.3						W=415%
138.1	Grey Firm		3	TW	PM			+1.9						W=336%
2.1	Silty sand some gravel Grey V. dense		4	SS	31		138							W=91%
			5	SS	107		136							
			6	SS	87	/15cm								
133.8	occ. coarse sand and gravel seams		7	SS	116	/15cm	134							
6.4	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 12

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 865; 0/s 18 m Rt. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80	100
140.2	Ground surface																
0.0	Peat, Fibrous Black V. Soft		1	TW	PM		140	1.8									W=215%
138.9			2	SS	2												W=299%
138.3	org. silt. grey Firm		3	SS	7												W=49%
1.9	Silty sand some gravel Grey Dense-V. Dense		4	SS	35		138										
			5	SS	119	/15cm	136										
	occ. coarse sand and gravel seams																
133.8			6	SS	100	/13cm	134										
6.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 13

METRIC

W P 88-78-02 LOCATION Martin Grove Rd. connection STA. 9 + 875 C.L.

ORIGINATED BY MJP

DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger

COMPILED BY DAM

DATUM Geodetic DATE 1989 10 17

CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	WL	WATER CONTENT (%)					
140.1	Ground surface																
0.0	Peat, Fibrous		1	SS	5											W.L. on	
138.4	Black-Dk. Brown		2	SS	36											1989 10 17	
	V. soft - soft		3	SS	42												
1.7	org. silt Grey Firm		4	SS	69												
1.8	Silty sand		5	SS	100												
	some gravel																
	Grey																
	Dense-V. Dense																
	occ. coarse sand																
	and gravel seams		6	SS	95												
133.7																	
6.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 14

METRIC

W P 88-78-02 LOCATION Ramp E-N, S STA 10 + 672 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 23 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
156.9	Ground surface																
0.0	300 mm Topsoil																
	Clayey Silt, some sand Tr. Gravel (Glacial Till) Grey-Brown Hard		1	SS	73		156										
	occ. si sa layers becoming grey with depth		2	SS	70	/5cm	154										
			3	SS	37		152										
150.2			4	SS	100												
6.7	Sandy silt to silty sand Tr. Clay Light Brown		5	SS	100	/10cm	150										
			6	SS	114	/15cm	148										
	Grey V. Dense Tr. clay		7	SS	100	/13cm	146										
			8	SS	120	/23cm	144										
	occ. to some gravel		9	SS	80	/8cm	142										
141.4			10	SS	85	/15cm											
15.5	Fine to Medium sand with silt Grey V. Dense		11	SS	95	/15cm	140										
			12	SS	83	/15cm	138										
136.9			13	SS	112	/21cm											
20.0	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

W.L. on
1989 10 26



RECORD OF BOREHOLE No 15

METRIC

W P 88-78-02 LOCATION Ramp E-N,S STA 10 + 628 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 19 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
157.4	Ground surface							20	40	60	80	100				
0.0	300 mm Topsoil															
	Clayey silt with some sand (Glacial Till) Grey-Brown		1	SS	80		156									
			2	SS	53		154									
	occ. Red-Brown sand and gravel seams		3	SS	64		152									
	Grey		4	SS	67		150									
	Hard		5	SS	150	/23cm	150									
148.3			6	SS	110	/10cm	148									
9.1	Brown silty sand to sandy silt		7	SS	110	/15cm	146									2 68 25 5
	occ. gravel		8	SS	100	/15cm	144									6 39 51 4
	Tr. clay		9	SS	120	/15cm	142									0 60 34 6
	V. Dense		10	SS	100	/15cm	140									
140.6			11	SS	112	/15cm	138									
16.8	Grey occ. seams of gravel		12	SS	135	/15cm	138									W.L. on 1989 10 26
137.5			13	SS	110	/13cm										
19.9	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16

METRIC

W P 88-78-02 LOCATION Ramp E-N,S STA 10 + 560 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 18 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)
								SHEAR STRENGTH kPa										
							○ UNCONFINED + FIELD VANE											
							● QUICK TRIAXIAL × LAB VANE											
156.0	Ground surface													GR SA SI CL				
0.0	300 mm Topsoil																	
	Grey-Brown		1	SS	52													
152.8			2	SS	23													
3.2	Grey																	
	Clayey silt with some sand, occ. gravel (Glacial Till)		3	SS	35													
	V. Stiff-Hard		4	SS	71													
	occ. seams of sand and fine gravel		5	SS	73													
			6	SS	50													
145.3			7	SS	110	/15cm												
10.7	Silty sand to sandy silt with some gravel Brown to Grey V. Dense		8	SS	100	/15cm								12 38 45.5				
			9	SS	100	/15cm												
			10	SS	100	/10cm												
			11	SS	170	/25cm												
138.9			12	SS	170	/18cm								W.L. on 1989 10. 26				
17.1	End of Borehole																	

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17

METRIC

W P 88-78-02 LOCATION Ramp E-N,S STA 10 + 500 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 18 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
154.7	Ground surface												
0.0	300 mm Topsoil												
	Clayey silt with some sand Tr. gravel (Glacial Till)		1	SS	85								
	Grey Brown		2	SS	42								
	Hard with Laminated silt and Clayey silt seams		3	SS	46								
	and		4	SS	52								
	occ. seams of sand and gravel		5	SS	61								
			6	SS	61								
144.7 10.0	Grey		7	SS	72								
			8	SS	41								
141.0													
13.7	Silty sand to sandy silt, occ. gravel		9	SS	135/25								
139.2	V. Dense Grey		10	SS	90/15								
15.5	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

← Borehole
caved

W.L. on
1989 10 26

RECORD OF BOREHOLE No 18

METRIC

W P 88-78-02 LOCATION Ramp S-W; STA 10 + 238 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 24 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
155.8	Ground Surface																
0.0	300 mm Topsoil																
	Clayey silt with some sand occ. gravel (Glacial Till)		1	SS	75		154										
	Grey Brown to Grey		2	SS	76		152										
	Hard occ. seams of red Br. sand		3	SS	78												
			4	SS	115	/10cm	150										
148.2			5	SS	140	/20cm	148										
7.6	Silty sand to sandy silt V. Dense		6	SS	120	/10cm	146										
	gravelly zone		7	SS	120	/18cm	144										
	Light Brown to Grey		8	SS	92	/15cm	142										
			9	SS	100	/13cm											
			10	SS	100	/10cm	140										
138.6			11	SS	180												
17.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

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



RECORD OF BOREHOLE No 19

METRIC

W P 88-78-02 LOCATION Ramp S-W; STA 10 + 200 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 24 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100					W _p	W	W _L		
149.5	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand, occ. gravel (Glacial Till)		1	SS	51		148										
146.5	Brown, Hard		2	SS	78		146										
3.0	Silty sand to sandy silt Lt. Brown wet silt		3	SS	71		144										
	Clayey silt to silt, Tr. Gravel		4	SS	93	/15cm	142										
	Grey V. Dense		5	SS	110	/20cm	140										
			6	SS	120	/20cm											
138.6			7	SS	130	/25cm											
10.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 20

METRIC

W P 88-78-02 LOCATION Ramp N-E; STA 10 + 206 C.L. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
 DATUM Geodetic DATE 1989 10 06 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100					
159.6	Ground surface															
0.0	300 mm Topsoil															GR SA SI CL
	Clayey Silt with some sand occ. gravel (Glacial Till)		1	SS	68											
	Grey-Brown		2	SS	41											
	Hard		3	SS	88											
	Sand and gravel Brown V. Dense		4	SS	77	/5cm										
	Grey		5	SS	53											
150.8	Hard		6	SS	100	/10cm										
8.8	Sandy silt Tr. gravel Brown occ. f. sand or silt lamination		7	SS	100	/10cm										
			8	SS	100	/15cm										
146.6			9	SS	100	/13cm										
13.0	Grey		10	SS	100	/15cm										
			11	SS	110	/15cm										
142.7																
16.9	End of Borehole															

+3, x5; Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 21

METRIC

W P 88-78-02 LOCATION Ramp N-E; STA 10 + 259 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 10 to 11 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
158.4	Ground surface													
0.0	300 mm Topsoil													
	Clayey silt some sand, Tr. gravel (Glacial Till)		1	SS	110									
	Grey Brown Hard		2	SS	106									
			3	SS	53	/15cm								
152.0			4	SS	45									
6.4	Grey		5	SS	103	/23cm								
			6	SS	100	/8cm								
149.2			7	SS	100	/13cm								
9.2	Silty sand to sandy silt Tr. clay V. dense Grey		8	SS	100	/15cm								
			9	SS	75	/8cm								
			10	SS	100	/13cm								
			11	SS	130	/13cm								
	occ. coarse sand and gravel seams		12	SS	59									W.L. on 1989 10.27
139.6	End of Borehole													
18.8														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 22

METRIC

W P 88-78-02 LOCATION Ramp N-E; STA 10 + 309 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DM
DATUM Geodetic DATE 1989 10 13 CHECKED BY MJP

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
157.6	Ground surface																
0.0	300 mm Topsoil																
	Clayey Silt with some sand, occ. gravel (Glacial Till)		1	SS	92		156							o			
	Grey-Brown		2	SS	65		154							o			
	Hard		3	SS	58									o			
152.1	Grey		4	SS	81		152							o			
5.5			5	SS	126	/20cm	150							o	o		
149.7	Sandy Silt to silty sand Tr. clay		6	SS	88	/15cm	148							o	o		
7.9	Brown		7	SS	84	/15cm	146							o			
	V. Dense		8	SS	95	/15cm								o			
144.5			9	SS	100	/15cm	144							o			
13.1	Grey		10	SS	100	/10cm	142							o			
			11	SS	100	/13cm											
	Sand and gravel V. dense		12	SS	100	/10cm	140										
139.1			13	SS	107												
18.5	Sand, some gravel Grey V. Dense		14	SS	80	/15cm	138										
137.5																	
20.1	End of Borehole																

+3, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 23

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 540 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 12 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		SHEAR STRENGTH kPa					W _p W W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%) 10 20 30							
158.3	Ground surface																
0.0	300 mm Topsoil						158										
	Clayey silt some sand Tr. gravel (Glacial Till)		1	SS	91		156										
	Hard		2	SS	100	/15cm	154										
	Grey-Brown to Grey		3	SS	61		152										
			4	SS	45		150										
			5	SS	73		148										
149.2			6	SS	100	/8cm	146										
9.1	Sand and gravel Tr. silt, clay V. dense		7	SS	100	/5cm	144										
147.6			8	SS	100	/15cm	142										
10.7	Sandy silt to silty sand Brown to Grey Brown V. dense		9	SS	75	/10cm	140										
			10	SS	98	/15cm											
			11	SS	100	/8cm											
139.9			12	SS	130	/15cm											
18.4	End of Borehole																

← Borehole
Caved
No water
above
cave level



RECORD OF BOREHOLE No 24

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10. + 510 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 16 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE - PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
158.9	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand Tr. gravel (Glacial Till)						158										
	Grey Brown-Grey Hard						156										
							154										
							152										
150.4							150										
8.5	Sand and gravel																
148.8	Brown V. dense																
10.1	Silty sand						148										
	clayey silt (Glacial Till)		1	SS	100	/8cm											
	Grey Brown		2	SS	100	/10cm											
	to sandy silt		3	SS	120	/15cm											
	Brown-grey brown V. dense		4	SS	117	/13cm	146										
144.4																	
14.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

Borehole
augered
without
sampling
to 11.9 m

Borehole
dry upon
completion



RECORD OF BOREHOLE No 25

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 480 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 11 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	100	100	100	100		
159.1	Ground surface													
0.0	300 mm Topsoil													
	Clayey silt with some Sa, Tr. gravel (Glacial Till)		1	SS	94		158							
	Grey-Brown		2	SS	45		156							
	Hard		3	SS	120		154							
			3A	CS	-									
			4	SS	85		152							
			5	SS	100	/13cm	150							
	seams of fine sand		6	SS	160	/23cm	148							
148.7			7	SS	100	/10cm	146							
10.4	Silty sand to sandy silt Tr. clay		8	SS	100	/15cm	144							
	Light Brown to grey		8A	CS	-									
	V. dense		9	SS	120	/14cm	142							
144.3	occ. seams of reddish brown sand		10	SS	100	/5cm								
14.8	Clayey silt-silt with some sand occ. gravel (Glacial Till)		11	SS	130	/15cm								
	Grey, hard													
*	sand and gravel		12	SS	100	/10cm								
140.6	V. dense													
18.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 26

METRIC

W P 88-78-02 LOCATION Ramp W-N.S. STA 10 + 450 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
DATUM Geodetic DATE 1989 10 16 CHECKED BY CM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 27

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 420 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
DATUM Geodetic DATE 1989 10 05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
160.0	Ground surface													
0.0	300 mm Topsoil													
	Clayey silt some sand occ. gravel (Glacial Till)		1	SS	61		158							
			2	SS	40		156							
	Grey-brown to Grey		3	SS	60	5cm	154							
			4	SS	60		152							
	Hard		5	SS	55		150							
	occ. seams of sand and gravel		6	SS	99		148							
150.0			7	SS	80	10cm	146							
10.0	Sandy silt to silty sand Tr. clay		8	SS	75	5cm	144							
	Grey		9	SS	70	8cm								
	V. dense		10	SS	80	8cm								
143.1			11	SS	90	10cm								
169	End of Borehole													Borehole caved. No water above cave level.

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 28

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 360 C.I. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
160.8	Ground surface							20 40 60 80 100		10	20	30		
0.0	300 mm Topsoil						160							
	Clayey silt, some sand occ. gravel (Glacial Till) Hard. Grey-Brown		1	SS	72	/15cm	158							
			2	SS	67		156							
	occ. seams of grey silt and sand Dense		3	SS	46		154							
155.3			4	SS	80	/8cm	152							
5.5	Sand and gravel Brown. V. dense Tr. clay, silt		5	SS	110	/18cm	150							
152.9	Medium-coarse sand		6	SS	110	/23cm	148							
7.9	Red-Brown. V. dense		7	SS	78		146							
152.1			8	SS	93	/15cm								
8.7	Laminated silt and clayey silt with occ. fine sand seams Grey, Hard or V. dense		9	SS	100	/3cm								
147.5			10	SS	90	/10cm								
13.3	Sand and gravel													
146.5	grey. V. dense													
14.3	F. sand. Grey													
145.3	V. dense													
15.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

Borehole
caved.
No water
above caved
level.

RECORD OF BOREHOLE No 29

METRIC

W P 88-78-02 LOCATION Ramp W-N,S; STA 10 + 300 C.I. ORIGINATED BY KSS
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
 DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
160.8	Ground surface																GR SA SI CL
0.0	300mm Topsoil																
	Clayey silt some sand, occ. gravel (Glacial Till) Grey Brown Hard		1	SS	43		160										
			2	SS	46		158										
	occ. seams of grey silt and sand V. dense		3	SS	90		156										
155.0			3A	CS	-												2 20 71 7
5.8	Sand and gravel Brown V. dense Tr. clay, silt		4	SS	100	/13cm	154										
152.3			5	SS	83												
8.5	Laminated silt and clayey-silt		6	SS	74		152										W.L. on 1989 10 26 (probably perched)
	Grey Hard		7	SS	59	/15cm	150										← Borehole caved. W.L. on 1989 10 04
	Sand and gravel		8	SS	77		148										
146.6			9	SS	82												
14.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 30

METRIC

W P 88-78-02 LOCATION Hwy. 407, STA 13 + 925 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
160.9	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand, occ. gravel (Glacial Till)		1	SS	88		160										
	Grey-Brown		2	SS	62		158										
	Hard																
155.9			3	SS	96		156										
5.0	Silty sand V. dense		4	SS	76	/15cm											
	Sand and gravel V. dense Brown		5	SS	100	/8cm	154										
	Silty sand V. dense		6	SS	105												
152.5			7	SS	44		152										
8.4	Laminated silt-clayey silt		8	SS	47												
	Grey Tr. sand																
150.2			9	SS	138		150										
10.7	Sand and gravel Grey. Dense																
	Laminated silt and clayey silt. Hard		10	SS	74												
148.2																	
12.7	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 31

METRIC

W P 88-78-02 LOCATION Hwy. 407, STA 13 + 975 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 04 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
161.3	Ground surface															
0.0	300 mm Topsoil															
	Clayey Silt some sand Tr. gravel (Glacial Till)		1	SS	72											
	Grey-brown		2	SS	126											
	Hard		2A	CS	-											0 18 45 37
			3	SS	75											
155.8																
5.5	Sandy silt- silty sand V. dense		4	SS	103											
	Silty sand with gravel, Tr. clay V. dense		4A	CS	-											35 35 24 6
			5	SS	100	/13cm										
	Several silt and sand seams Grey		6	SS	117											W.L. on 1989 10 27
150.6	Hard or V. dense		7	SS	93	/15cm										
10.7	Sand and Gravel Tr. silt, clay V. dense, Grey															
	Laminated silt and clayey silt Dark grey to Grey		8	SS	92											
	Hard		9	SS	97											
145.9	F. Sa seam		10	SS	73	/15cm										
15.4	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 32

METRIC

W P 88-78-02 LOCATION Hwy. 407, STA 14 + 025 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 03 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										
								SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								10 20 30		
161.0	Ground surface																	
0.0	300 mm Topsoil																	
	Clayey silt some sand Tr. gravel (Glacial Till) Hard-stiff Grey-Brown		1	SS	43		160											
			2	SS	20		158											
156.9																		
4.1	Silty sand to sandy silt Brown		3	SS	101		156											
154.3	V. dense		4	SS	104		154											
6.7	Sand and gravel Tr. clay and silt Brown V. dense		5	SS	100	/10cm	152											
151.9			6	SS	119		150											
9.1	Laminated silt and clayey silt Dk. grey occ. sand seams Hard or V. dense		7	SS	80	/15cm	148											
			8	SS	101													
147.0			9	SS	122													
14.0	End of Borehole																	

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 33

METRIC

W P 88-78-02 LOCATION Hwy. 407; STA 14 + 075 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY MJP
DATUM Geodetic DATE 1989 10 03 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo								WATER CONTENT (%)
159.5	Ground surface							20	40	60	80	100				
0.0	300 mm Topsoil															
	Clayey silt, some sand															
	Tr. gravel		1	SS	29		158									
157.1	(Glacial Till)															
	Stiff. Grey Brown															
2.4																
	Sandy silt		2	SS	65		156									0 20 77 3
	to															
	Silty sand															
	with		3	SS	83											
	Sand and gravel						154									
	lenses		4	SS	105											
	throughout															
	Clayey silt		5	SS	47		152									0 10 50 40
	Hard															W.L. on
	Grey		6	SS	51		150									1989 11 16
	V. dense															and on
	Grey		7	SS	77											1989 10 03
	heavily laminated															
			8	SS	119	15cm	148									
145.7																
			9	SS	150	10cm	146									
13.8	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 34

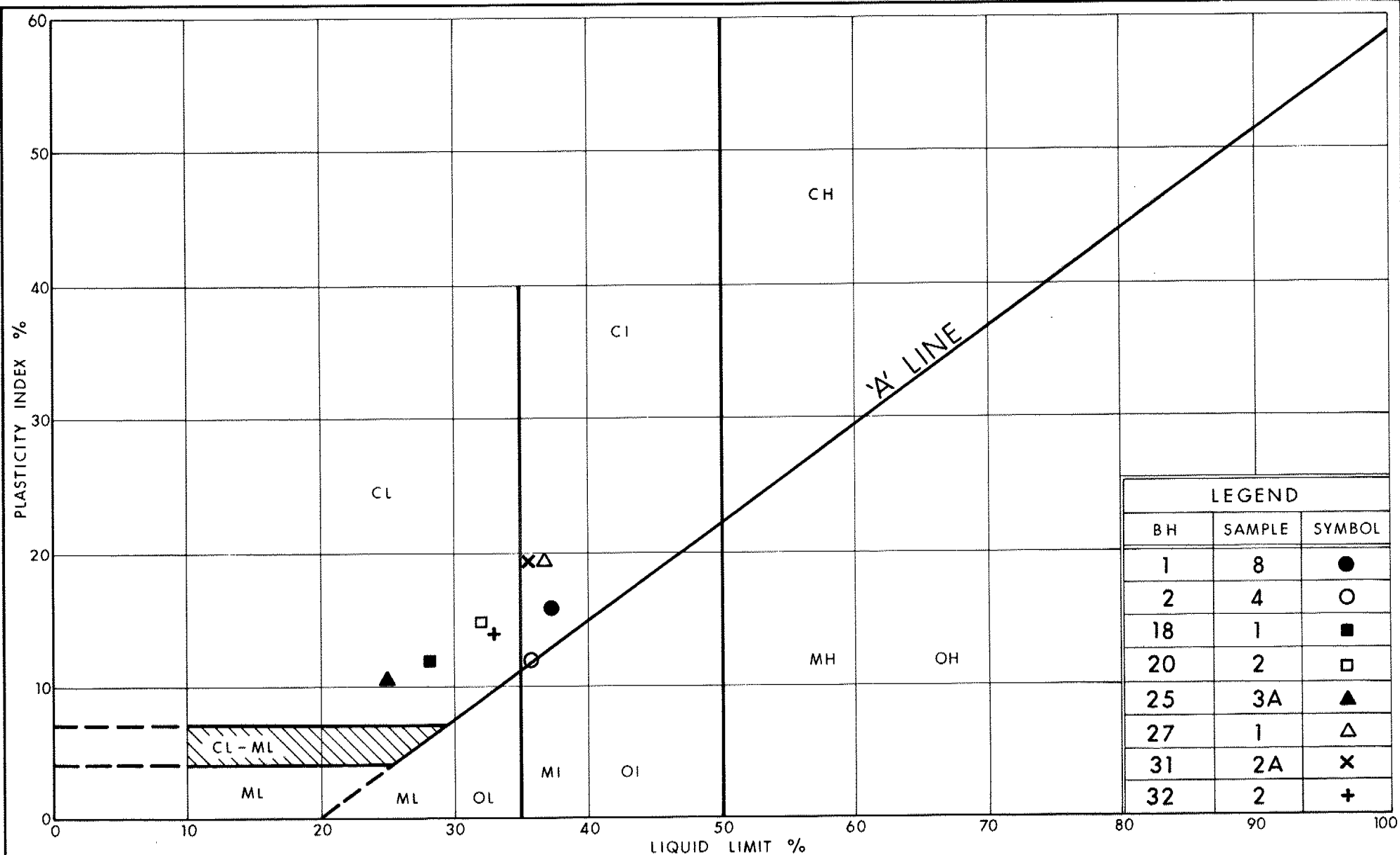
METRIC

W P 88-78-02 LOCATION Kipling Avenue; STA. 10 + 120 C.L. ORIGINATED BY KSS
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY DAM
DATUM Geodetic DATE 1989 10 12 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
158.0	Ground surface																
0.0	300 mm Topsoil																
	Clayey silt, some sand, occ. gravel (Glacial Till)		1	SS	53		156										
	Grey Brown with red mottling		2	SS	64		154										
	Hard		3	SS	100	/15cm	152										
	occ. sand seams		4	SS	72		150										
149.5			5	SS	82		148										
8.5			6	SS	110	/15cm	146										
	Sandy silt to silty sand		7	SS	100	/13cm	144										
	occ. gravel and sand seams		8	SS	110	/15cm	142										
	Yellow-Brown to Grey		9	SS	110	/15cm	140										
			10	SS	130	/13cm	138										
	V. dense		11	SS	110	/13cm	136										
			12	SS	130	/15cm	134										
141.0			13	SS	160	/20cm	132										
17.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

Borehole
caved
W.L. on
1989 10 27



Ontario

Ministry of
Transportation

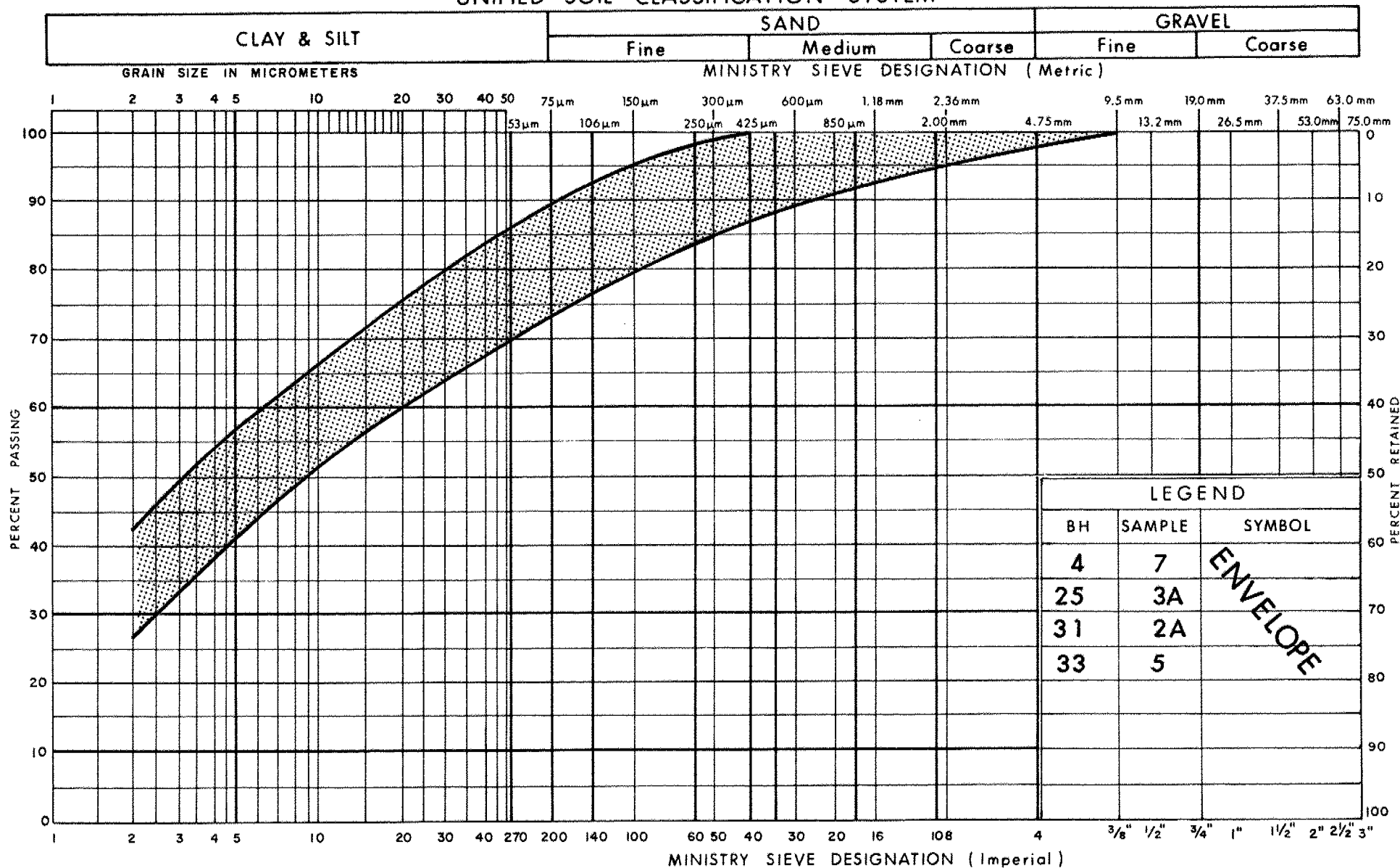
PLASTICITY CHART CLAYEY SILT (Glacial Till)

FIG No 1

W P 88-78-02

Hwy 407

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

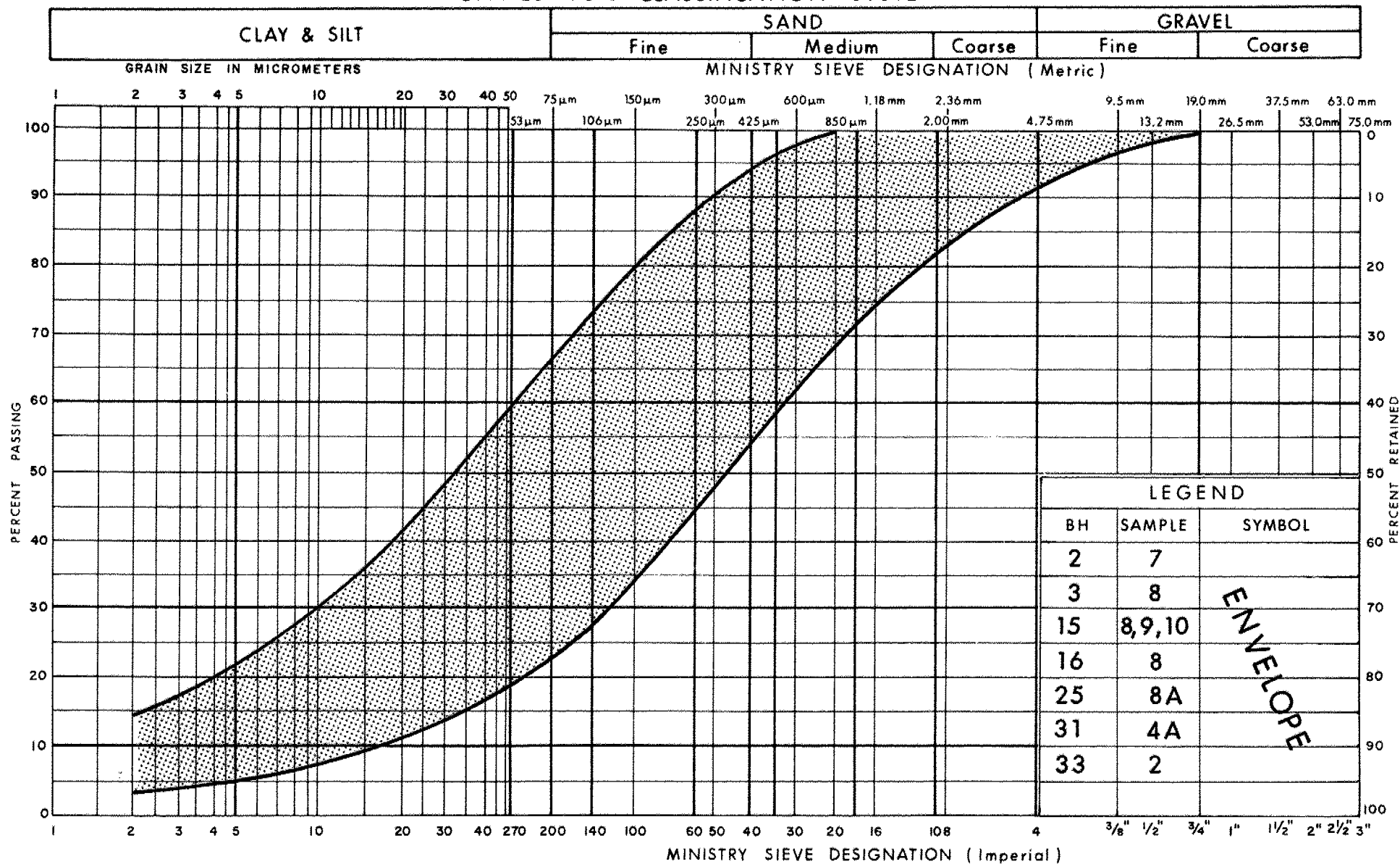
GRAIN SIZE DISTRIBUTION CLAYEY SILT WITH SAND (Glacial Till)

FIG No 2

W P 88-78-02

Hwy 407

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

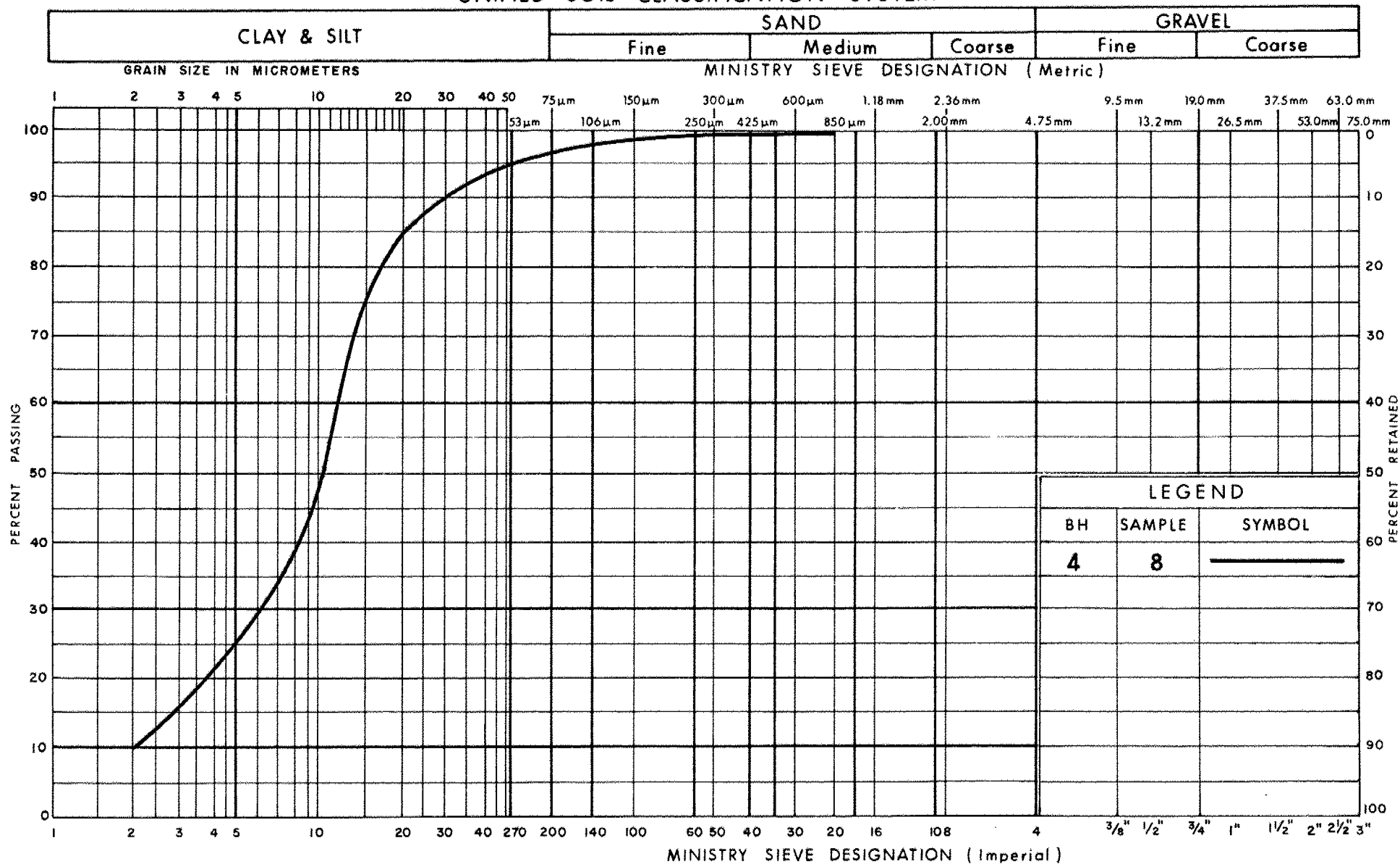
GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT

FIG No 3

W P 88-78-02

Hwy 407

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

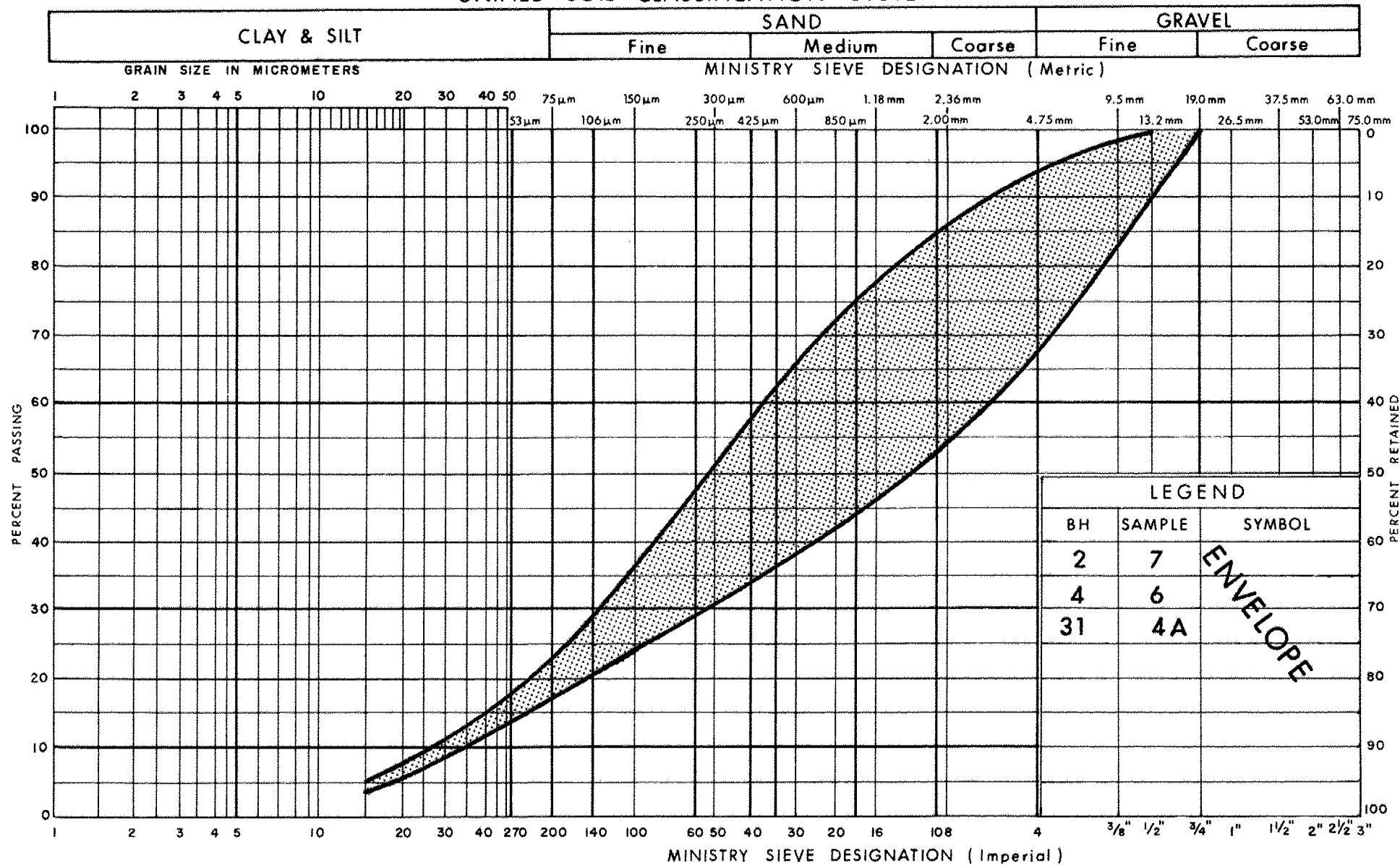
SILT

FIG No 4

W P 88 - 78 - 02

Hwy 407

UNIFIED SOIL CLASSIFICATION SYSTEM



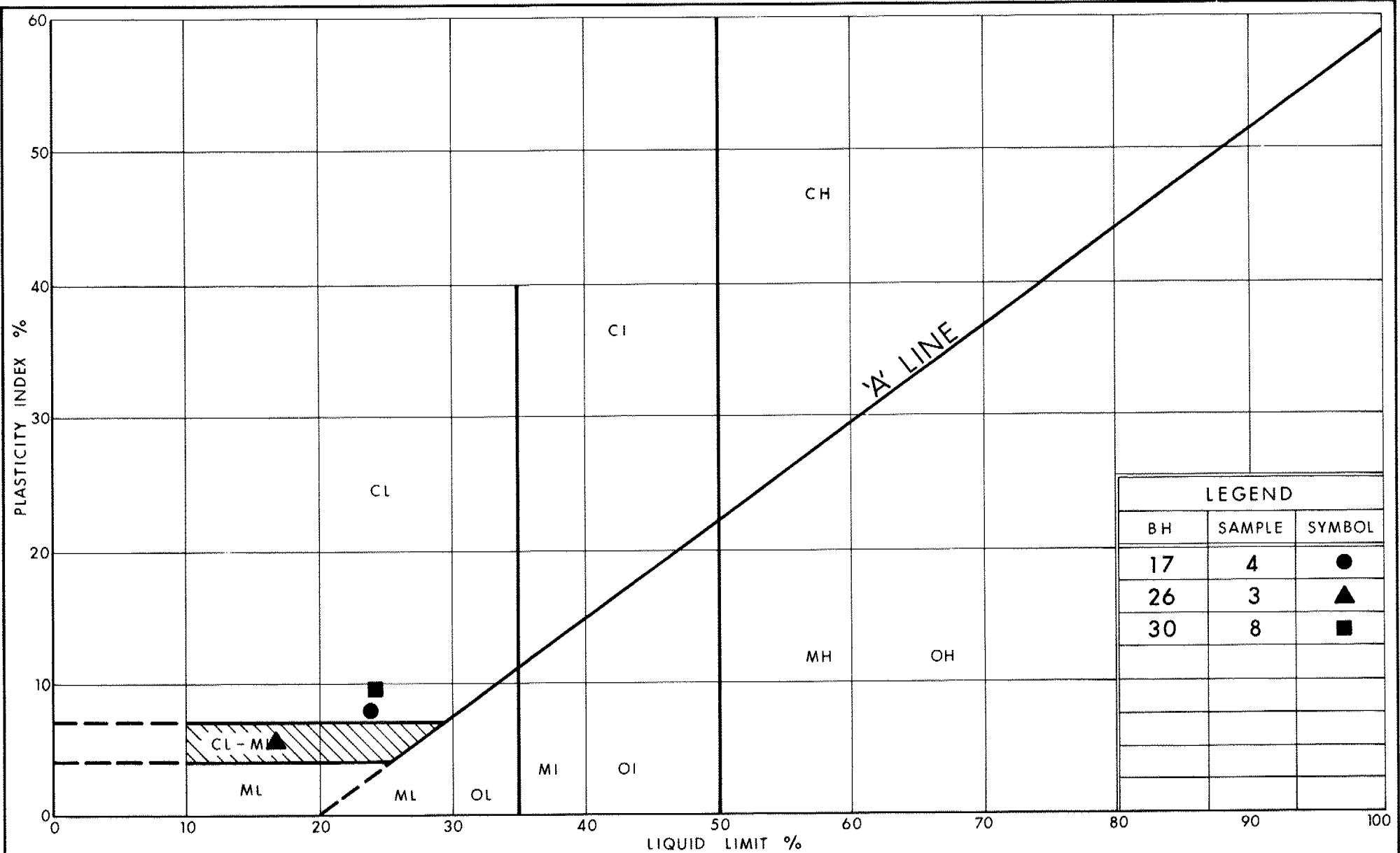
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND WITH GRAVEL

FIG No 5

W P 88-78-02

Hwy 407



Ministry of
Transportation

Ontario

PLASTICITY CHART Laminated SILT TO CLAYEY SILT

FIG No 6

W P 88-78-02

Hwy 407

This Memo is a different Project,
B.B. told to keep in this file
Apr 30/97

Keep this within this file
From B.B. Apr 30/97

MEMORANDUM



To: V.F. Boehnke
Head, Structural Section
4th Fl., Atrium Tower

Attn: L. Markovic
Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Abutment Footing Elevations
Highway 407 and Rainbow Creek Bridge
W.P. 88-78-02
District 6 (Toronto)

Date: 94 01 12

Further to our telephone discussion on Monday, Jan. 10, 1994, the abutment footing elevations provided in our memo dated 93 12 17, did not consider the change in profile grade of Highway 407. The original recommendations given in our Foundation Design and Investigation Report, dated January 22, 1990, were based on a Highway 407 profile grade of El. 149.5± at the creek crossing. Subsequent changes to the design have resulted in a profile grade elevation to approximately 145.0± at the Highway 407 and Rainbow Creek structure.

Based on this change in grade, the following foundation recommendations apply for a spread footing alternative and supersede those provided in our memo of December 17, 1993.

The abutment footings, both east and west, may be perched within the approaches and placed on a compacted Granular "A" core. The base of the footing should be placed at El. 141.0 or higher. The Granular "A" pad should have a minimum thickness of 3.0 m. The bearing resistances and sliding resistance factor provided in the original report still apply. In addition, site preparation and construction details should proceed as outlined in the original report.

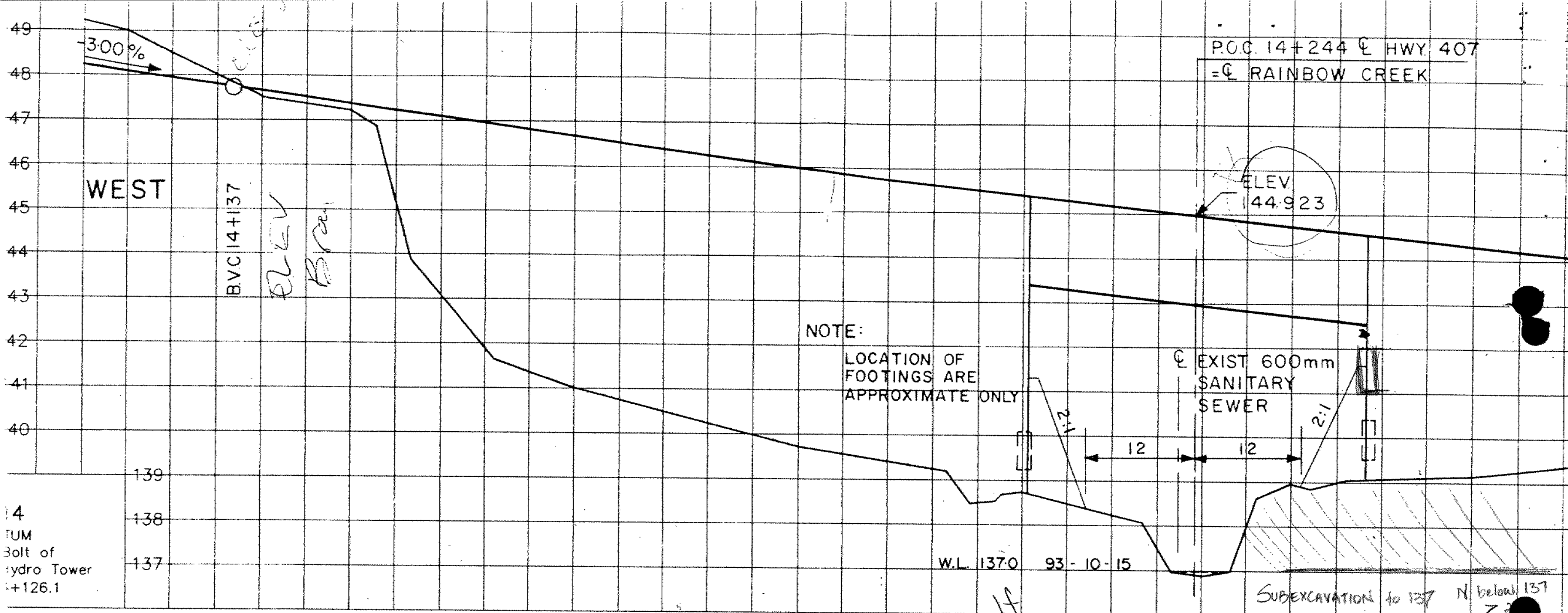
The profile grade change has resulted in a considerable reduction in fill heights, to the extent that a berm at the forward slopes is no longer required at this location. Stability analyses conducted using the most recent geometry has revealed that side and forwards slopes placed at 2H:1V or flatter will be stable. Only where fill heights exceed 6.0 m should the berm be incorporated as shown in Figure 9 of the original Foundation Investigation and Design Report.

If there are any questions regarding these recommendation changes, please call the undersigned.

A handwritten signature in black ink, appearing to read "B. Bennett".

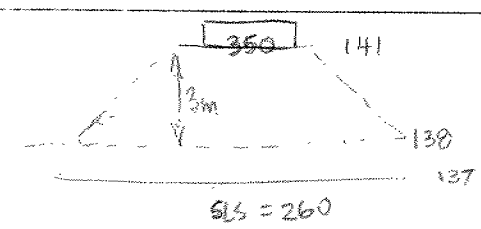
B. Bennett, P. Eng.
Foundation Engineer

BB/jb

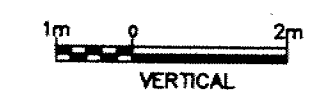


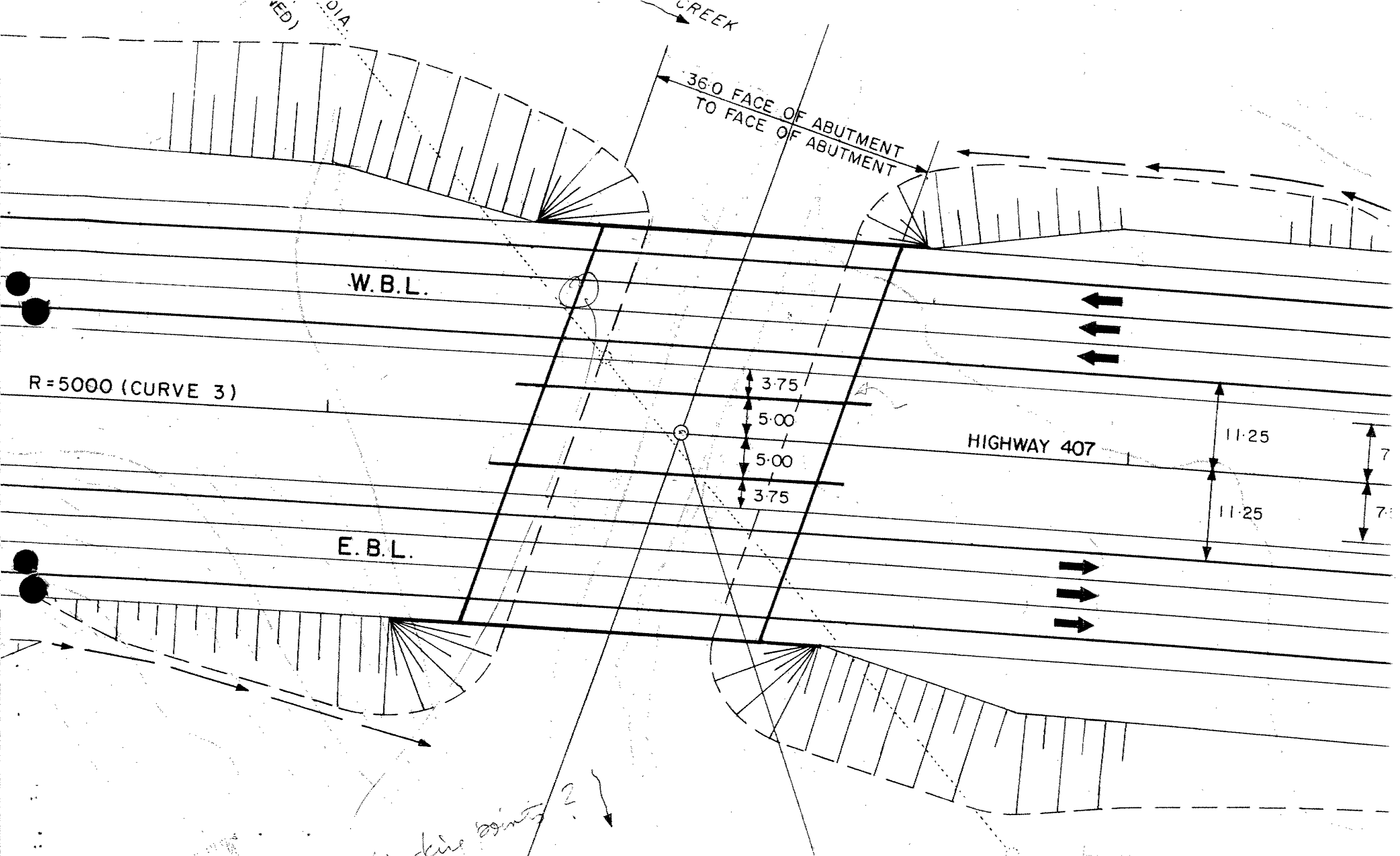
14
TUM
Bolt of
Hydro Tower
+126.1

Agreed that clearance - 2m min clearance



PROFILE OF C/L PROPOSED HWY. 407





NOTE to FILE

JAN 10 / 94

Re: WP 88-78-02 Hwy 407 across RAINBOW CREEK

Call from Lana Markovic re: spread ftg recommendations at Rainbow Cr & Hwy 407.

Report that was re-submitted in Dec. 1993 shows base of footing Elevation at 145.0.

The original profile grade of Hwy 407 at & Rainbow Creek was \sim El. 149

The new profile grade of Hwy 407 @ & Rainbow Creek is \sim 144.8 m.

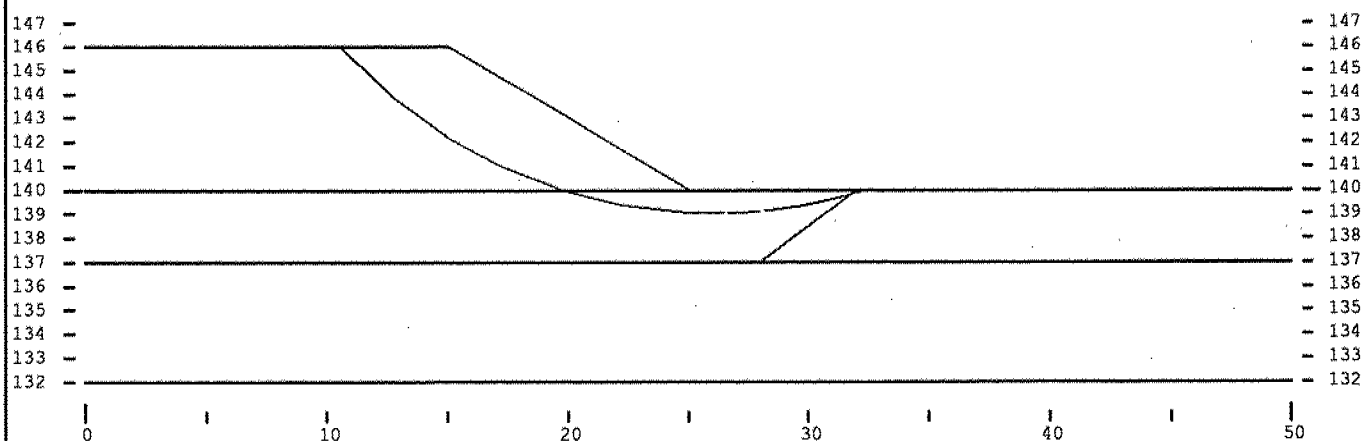
Hence, base of footing elevation changed ~~to~~ \rightarrow ftg can sit anywhere above El. 141; recommending El. 142

Granular mat'l should extend a min of 1m about the base of the ftg. and be placed as shown in dwgs. in Report.

Since profile grade is \approx 4.0m lower than previously suggested, the ~~so~~ resulting fill heights will range from 5 m at east abut to $6.0 \pm$ at west abutment.

As a result a term at this loc'n is no longer required.

Material	Unit Wt C	Phi	Piezo	Ru	+	Min. of Transportation - Downsview
	kN/m3 kPa	deg	Surf.			
Granular Fill	21 0	30	0	0	F = 1.524	88-78-00
Backfill	11 0	30	0	0		Highway 407
Organic Silt	8 20	0	0	0		94-01-11
Clayey Silt	12 50	0	0	0		Rainbow Creek
Silty Sand	11 0	28	0	0		



DATA FILE NAME.....

Job No.	88-78-00
Title	Highway 407
Date	94-01-11
Label A	Rainbow Creek
Label B	

Max Slice Width	10
Set Neg. Normals to zero	Y
No. of Materials	5
Seismic Acceleration	0
External Forces	0
Piezometric Surfaces	0
Unit Wt. of Pore Fluid	10

Material	Unit Wt	Cohesion	Friction Angle	Piezo Surface	Ru Value
# 1 -Granular Fill	21	0	30	0	0
# 2 -Backfill	11	0	30	0	0
# 3 -Organic Silt	8	20	0	0	0
# 4 -Clayey Silt	12	50	0	0	0
# 5 -Silty Sand	11	0	28	0	0

Upper Surface of Material # 1 (Granular Fill)

X-Coord	Y-Coord
0	146
15	146
25	140
50	140

Upper Surface of Material # 2 (Backfill)

X-Coord	Y-Coord
0	140
50	140

Upper Surface of Material # 3 (Organic Silt)

X-Coord	Y-Coord
0	137
28	137
32	140
50	140

Upper Surface of Material # 4 (Clayey Silt)

X-Coord	Y-Coord
0	137
50	137

Upper Surface of Material # 5 (Silty Sand)

X-Coord	Y-Coord
0	132
50	132

There are no explicit external forces in the data set.

MEMORANDUM

(416)235-3731

To: V.F. Boehnke, P. Eng. 1993 12 17
Head, Structural Section
Central Region

Attn.: S.R. Markovic, P. Eng.

From: Foundation Design Section
Room 315, Central Building
Downsview, Ontario

Re: Highway 407 EBL/Rainbow Creek Bridge (Site 37-1435/1)
Highway 407 WBL/Rainbow Creek Bridge (Site 37-1435/2)
W.P. 88-78-02
Hwy 407, District 6, Toronto

Further to your request for a Foundation Investigation at the above captioned projects, we have reviewed the available soil information at the site. Previously, we carried out several investigations at the site and in close vicinity of the proposed structures. The details of the investigations are as follows:

W.P. 88-78-13	Site No. 37-1341, Rainbow Creek Culvert No. 2 at Hwy 407/Kipling Ave Interchange, Geocres 37-1341, dated April 02, 1991
W.P. 33-89-01	Site No. 37-1342C, Rainbow Creek Tributary Culvert at Kipling Avenue, Geocres 30M13-100, dated April 04, 1990
W.P. 88-78-12/33	Site No. 37-1338, Kipling Avenue Overpass, Geocres 30M13-92, dated January 22, 1990

Based on the above investigations, in our opinion there is sufficient information available to provide Foundation recommendations for the proposed structures.

One of the investigations (W.P. 88-78-12/33) was carried out for Hwy 407 overpass at Kipling Avenue. The proposed structure was a 60m wide and 48m single span bridge.

It is understood that Kipling Avenue will not be extended through Hwy 407 as previously planned. Instead, Hwy 407 will cross over Rainbow creek at the same location. A bridge is proposed to carry Hwy 407 over the creek. The proposed bridge would be 64m wide with 36m span. The abutments would be open type with forward slope at 2H:1V. Creek bed elevation is at 137.5m. The ground surface elevation on the immediately east and west sides of the creek is 139.2m. The bridge would be located at station 14+245 Hwy 407 chainage.

Our recommendations apply to the bridge structure and its approaches within 20m of the structure, between station 14+205 and 14+285 Hwy 407 chainage.

The recommendations provided in the Foundation Report for Kipling Avenue Overpass (W.P. 88-78-12/33, Site No. 37-1338) would apply for this project. A copy of the Foundation Report is attached.

In summary, the structure can be founded on either spread footings or deep foundations. However, the deep foundation would have to be designed to accommodate artesian condition. Spread footings on native soil are not feasible due to the soft nature of the ground. However, the spread footing can be perched within the approaches and placed on a compacted Granular 'A' core. The base of the footing should be placed at or above El. 145.0m. The Granular 'A' core should have a minimum thickness of 3.0m. The recommended bearing capacities for the footings on a granular core, as per the O.H.B.D.C., are as follows:

West Abutment

Factored Bearing Capacity at U.L.S. = 800 kPa
Bearing Capacity at S.L.S. Type II = 300 kPa

East Abutment

Factored Bearing Capacity at U.L.S. = 900 kPa
Bearing Capacity at S.L.S. Type II = 350 kPa

A friction angle of 35° may be assumed to determine sliding resistance between the footing and the compacted Granular 'A' core.

For construction details and site preparation please refer to the attached report.

Steel H-Piles equipped with driving shoes are also feasible as an alternative. The piles would be driven below El. 123.0 at the west abutment and 125.0m at the East abutment. Below these elevations pile driving should be controlled by the Hiley Formula as per MTO Standards SS 103-10 or SS 103-11. The following design values for HP 310 X 110 and HP 310 X 79 steel H-Piles are recommended:

	<u>HP 310 X 110</u>	<u>HP 310 X 79</u>
Factored Bearing Capacities at U.L.S.	1280 kN/pile	920 kN/pile
Bearing Capacity at S.L.S. Type II	920 kN/Pile	660 kN/pile
Ultimate Pile Capacity (for Hiley Formula)	3450 kN/pile	2475 kN/pile

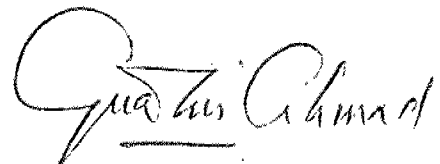
The axial capacities of the piles are reduced due to the possible effects of artesian condition on the frictional capacity of the piles.

The horizontal component of the battered piles may be utilized for the lateral capacities of the piles.

Pile driving would intersect artesian zone and therefore special provision would be required to control loss of fines from the underlying soil. The details of the drainage requirements are presented in Figure 7 (attached report).

For all other items such as slope stability, settlement, unwatering, frost protection and earth pressure, please refer to the attached Foundation Report. W.P. 88-78-12/33 dated January 22, 1990.

If you have any questions, please call our office.



K.S.Q. Ahmad, P. Eng.
Foundation Engineer

For

D.H. Dundas, P. Eng.
Sr. Foundation Engineer



Ontario

memorandum

MINISTRY OF TRANSPORTATION
Structural Section
1201 Wilson Avenue
Atrium Tower, 4th Floor
Downsview, Ontario, M3M 1J8
Telephone: 235-5506

OCT 12 1993

FOUNDATION DESIGN SECTION

TO: Mr. M. Devata
Chief Foundation Engineer
Foundation Design Section
3rd Floor Central Building

Date: October 8, 1993

Attn: Mr. D. Dundas
Senior Foundation Engineer

RE: W.P. 88-78-02 Highway 407 EBL / Rainbow Creek Bridge (Site 37-1435/1)
Highway 407 WBL / Rainbow Creek Bridge (Site 37-1435/2)

Foundation Request

As discussed at our meeting on 93/09/24, we require foundation recommendations for the above structures. For your reference, the following figures showing bridge location and configurations are enclosed:

- Figure 1 - Plan view 1:1000 scale showing bridge locations; the "old" Highway alignment and the structure locations from the old design are shown for reference.
- Figure 2 - Highway 407 cross-section at the bridges; please note that while the exterior lanes (marked in pink in the plan view) will not be paved at this time, it is not known whether the bridges will be configured to accommodate them as part of this contract. For the purpose of the foundation investigation, full width of Hwy. 407 should be assumed.
- Figure 3 - Rainbow Creek Bridges elevation showing the opening size and the abutment and footing locations.
- Figure 4 - Highway 407 profile plot in the vicinity of Rainbow Creek Bridges, showing the top-of-pavement profile and the existing ground profile at the bridge locations.

Could you please provide us with foundations recommendations for the above structures. As discussed on 93/09/24, preliminary recommendations are required by December 17, 1993 with the full Foundation Investigation and design Report to follow by March 04, 1994.

Should you have any questions or concerns regarding the above, please contact the undersigned.

S. R. Markovic

S. R. Markovic
Sr. Structural Engineer
for
V. F. Boehnke
Head, Structural Section

memo

To: File

Oct 5/50

Re: WP 88-78

407/Keplog

Jens' Memoir of Street Section
not with me

1) There is additional open culvert at north end of main culvert. We agreed she could proceed with design based on worst conditions provided for main culvert. She should send a request & we will put that in writing to also that it is subject to verification by more field work if necessary. We will assess existing boreholes to determine if more field work needed. This culvert is required due to new proposed for diversion channel to keep water away from York Toll slope.

2) Jens asked my opinion on design of diversion with flows of 64/5 mcs. She asked if armor stone on gasket hole was appropriate.

I told her I was skeptical about need for gasket hole as it might promote movement of stone.

I told her size of stone & amount of erosion was function of velocity. We discussed consequences of problem in channel & I suggested flaps connected as is being considered is rather necessary or preferable due to possibility of cracking cast & aesthetics.

I referred her to geosons & energy dissipation. I told her we would respond to formal request for design help from Struckema, Gekko or R.D. (It's up to the region).

3) York Till

We discussed retaining wall at York Till. She advised that Leuker Town of Remote Sensing had suggested 25 m width off crest for 50 years erosion resistance of slope. I told her the wall 14 m high appears was 2 parts: (1) in fill to make a road which could be R.E. (2) in cut to protect York Till which would be showing wall.

D. Dundas
Sr. Foundation Eng.

memorandum



To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 03 29

Attn: S. Markovic
Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Re: Sanitary Sewer
Kipling Avenue Interchange
W.P. 88-78-12/33, Site 37-1338
Hwy. 407, District 6, Toronto

Further to your memo of March 22/90, we have reviewed your concerns regarding the potential negative impacts of the proposed construction on the existing sewer.

From the plans you have forwarded, it is our understanding that;

- A 600 mm Ø sewer with invert at elev. 136+ m crosses diagonally under the east abutment of the proposed structure.
- Hwy. 407 is at elev. 148 to 150 m.
- Kipling Avenue is at elev. 140 to 142 m.
- The proposed abutment is at elev. 142+ m.

Based on these assumptions,

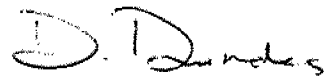
- Settlements beneath the sewer invert will be negligible.
- The dead load imposed by the proposed structure and embankment or the sewer will be less than 200 kPa. As you are aware, we do not have sufficient details to comment on live load. The integrity of the sewer will be dependent on its structural strength and thus will have to be evaluated by structural engineers.
- It would be prudent to limit any excavations to within 1 m of the sewer and to keep heavy construction equipment 3 m away from the sewer alignment.

Regarding your two possible scenarios, the sewer may remain at its present location if its structural strength can tolerate the additional loads. Otherwise, it could be realigned away from the Hwy. 407 fill and structure footing.

.... /2

If there are any questions, please advise.

DD/jb

A handwritten signature in dark ink, appearing to read "D. Dundas". The signature is written in a cursive style with a large initial "D".

D. Dundas, P. Eng.
Sr. Foundation Engineer

MINISTRY OF TRANSPORTATION

M E M O R A N D U M

To: Mr. M. Devata
Chief Foundation Engineer
Foundation Design Section
3rd Floor, Central Building

Date: March 22, 1990

Attn: D. Dundas
Senior Foundation Engineer

From: Structural Section
Central Region

Re: W.P. 88-78-02, Highway 407/Kipling Avenue Interchange
Foundation Design Requirements - existing sanitary sewer

The results of your analysis are urgently needed in order to finalize the Structural Design Report for the Highway 407 overpass structure at Kipling, and to enable the consultant to proceed with the detailed design.

The existing (Town of Vaughan) sanitary sewer (shown in Drawing 887812/33-A of the Foundation Design Report) runs approximately NW to SE underneath the proposed Highway 407/Kipling Avenue interchange. In our conversation of 90/02/22 and in the meeting with B. Bennett on 90/02/22, the following concerns were brought to your attention:

- Integrity of the sewer when subjected to Highway 407 fill loading and settlement;
- Integrity of the portion of the sewer subjected to dead and live loading of Kipling Avenue roadway and traffic;
- Effect of the structure placed on the granular fill over the sewer;
- Possible interference with the sewer during excavation and during construction of the interchange.

It was agreed that the Foundation Design Section would address the above concerns and would recommend the type of protection or treatment, if any, required to handle the anticipated temporary and permanent loading, deformations and/or interference.



Two of the possible scenarios were submitted for your consideration:

- a) The sewer remains in the existing location; (PLAN E73-407-4 and Sewer Alignment Detail Drawings S-1 to S-12 prepared by M.M.M. were forwarded to B. Bennett on 90/02/22).
- b) The sewer is reconfigured (if possible) to pass underneath the centerline of Kipling Avenue as to avoid placing it under Highway 407 fill.

Please advise us of the status of your analysis.

S. Markovic

S. Markovic
Senior Structural Engineer
for:
V. F. Boehnke
Head, Structural Section

SM/lf

memo

To: File

Date: 90 02 27

Re: WP 88-78-12/33

407/Kipling

Sewer Interference

On 90 02 22, Jane Mercurio of Structural Section asked for recommendations for protection of sewer and impact on structure for sewer. She was to follow up with memo.

On 90 02 26 Bob Berseloni asked for status of our response. I advised that we had not received formal request but that I would look at problem and call him on 90 02 27.

- Hwy 407 @ elev. 148
- Kipling Ave at elev. 140
- sewer at elev. 135[±]
- attached are 3 sections showing sewer
- attached is 1 plan showing sewer in relation to bridge
- the sewer cuts diagonally through east abutment
- the F.D. report recommends preloading
- the amount of settlement was not predicted due to variability in subsoil
- my initial estimate is that settlement under 10 m o.p. R/I will be less than 15cm
- the pipe is asbestos-cement & is delicate according to Bob Berseloni

Based on these details, and
figuring a more formal evaluation due
to the absence of a formal request
I recommend to Bob that

1) We could not predict settlement
without formal request but my
best estimate is 15 cm.

2) If he is concerned with that
magnitude of settlement he should
relocate sewer outside fill zones.

3) There are practical advantages to
this approach

- isolates bridge & sewer
- most positive prevention of
disturbance to sewer

4) Bob advised that P.D. had
suggested putting sewer with
encasement or (possibly?) cap
I advise that encasement seemed
impractical & that cap with caissons
might lead to extension problems which
we were trying to avoid.

5) Bob advised that P.D. said that
relocation was not possible due to
small grade of sewer. We agree
this was incorrect since there was
deep structure.

D. Dunder,
Sr. Engr. Etc.

Settlement

Average w_L for the clay to silt deposit 16%

Avg $w = 12\%$, Avg $\gamma = 22.7 \text{ kN/m}^3$

From Skempton,

$$C_c = 0.009(16 - 10) \\ = 0.054$$

Average thickness, H , of deposit 4.3m

Void Ratio e_0 : assuming fully saturated $e_0 = w G_s = 0.12(2.67) \\ = 0.32$

$$C_c = \frac{e_0 - e_1}{\log \frac{\sigma'_1}{\sigma'_0}} \quad \therefore e_1 = e_0 - C_c \left(\log \frac{\sigma'_1}{\sigma'_0} \right)$$

Overburden σ'_0 above pt $\frac{1}{2}(4.3) \Rightarrow \frac{1}{2}(4.3)(22.7 - 9.8) = 27.7 \text{ kPa}$

With placement of up to 10m of fill mat'l -
Fill $\gamma' = 21 - 9.8 = 11.2 \text{ kN/m}^3$

$$\sigma'_1 = 27.7 \text{ kPa} + 10(11.2) \approx 140 \text{ kPa}$$

$$\therefore e_1 = 0.32 - 0.054 \left(\log \frac{140}{27.7} \right) = 0.28$$

Settlement

$$\Delta H = \frac{\Delta e H_0}{1 + e_0}$$

$$= \frac{(0.32 - 0.28)(4.3)}{1 + 0.32} = 0.13 \text{ m} = 13 \text{ cm}$$

Maximum Settlement

Maximum thickness of deposit 6.7m

Highest $w_L = 23\%$

Highest $w = 18\%$

Void Ratio e_0 , assuming fully saturated

$$e_0 = w G_s = 0.18 (2.67) \\ = 0.48$$

$$C_c = 0.009 (23 - 10) = 0.117$$

Overburden σ'_0 above $\frac{1}{2}(6.7) \Rightarrow \frac{1}{2}(6.7)(22.7 - 9.8) = 43.2 \text{ kPa}$

With placement of 10m of fill mat'l $\sigma'_1 = 43 + 10(11.2) = 155 \text{ kPa}$

$$\therefore e_1 = 0.48 - 0.054 \left(\log \frac{155}{43} \right) \\ = 0.45$$

Settlement

$$\Delta H = \frac{\Delta e H_0}{1 + e_0}$$

$$= \frac{(0.48 - 0.45)(6.7)}{1 + 0.48}$$

$$= 0.136 \text{ m}$$

$$= 13 \text{ cm}$$

MEMO : To FILE

RE: MEETING AT MARSHALL, MACKLIN, MONAGHAN
WEDNESDAY JAN. 3, 1990

FOR: WP 88-78-02 → Hwy 407 / Kipling Av. I/C
WP 88-78-26 → CNR Subway / Detour

ITEMS COVERED PERTAINING TO FOUNDATIONS

- ① ENVIRONMENTAL STUDY TO BE CONDUCTED BY THACKERAY LANDFILL SITE
 - ② HIGH MAST LIGHTING POLE LOCATIONS.
 - ③ SCHEDULING
-

① ENVIRONMENTAL STUDY

- D. Ivanauskas presented the terms of reference for Consultant study of the physical extent of the Thackeray Landfill site w.r.t. Kipling Ave. and the CN detour
- Asked about the status of Foundations' Consultant's investigation at the CN and Kipling; I told them that as far as I knew the drilling was being carried out but uncertain if the job was completed.
- It appeared that MMM had already given the instructions to their Waste Mgmt Engineer to go ahead with study, as he had already done considerable research into the area. MMM has yet to submit proposal; does not appear that other Consultant's will be asked for submissions.

② H.M.L.

- Electrical Section concerned about how the subsurface conditions will affect the lbg scheme along Hwy 407 & the interchange.
- I informed them that the H.M.L. foundations in artesian conditions will be costly; that the fnd rely on the frictional component of the soil and that the artesian eliminates

this component.

- Lana asked to assess cost of constructing H.M.L post in artesian conditions to determine if the cost warrants changing the scheme.
- A suggestion was made to advance preliminary BH's in some areas to see if artesian conditions exist.
- This suggestion was overruled when I informed them that I could supply no field information until the middle of February.
- There existing scheme will be used and a request for fdr investigation for the H.M.L pole locations will be forthcoming.
- I informed them of the 12 wks required from the request date to complete fdr inv. report.

SCHEDULING.

- Regarding the embankment stability ~~req~~ for the cuts/fills at the ramps, requested by the Geotech Section, the consultant has not yet submitted report.
- Rec's for ~~water~~ new culvert alignment still due Feb. 16, although I informed the group that the fieldwork would not be starting until beginning of February. We had rec'd the revised plan for the culvert on Dec. 22, and since there are other jobs that have similar priority, other fieldwork was organized while we waited to receive the final plans.
- Informed Lana that report for Kipling /407 I.C. should be completed sometime next week.



Ontario

Action

Time

Date

Year

Month

Day

Memo

To

From (Name and City)

I.C.N. No.

Area Code

Telephone No.

Ext

Message Taken By

☐ Phoned☐ On☐ Hold☐ Please Call☐ Returned☐ Your Call☐ Will Call Back☐ Wishes Appointment☐ Waiting☐ in Person☐ Was Here☐ Will☐ Return☐ File☐ Draft Reply For
My Signature☐ Provide
More Details☒ For Your
Information☐ Type Draft☐ For Your Approval
and Signature☐ Keep Me
Informed☐ Per Discussion☐ Type Final☐ Circulate Initial
and Return☐ Take
Appropriate Action☐ Per Your Request☐ Make
Copies☐ Return
With Comments☐ Note and
See Me☒ Returned
With Thanks☐ Please Answer☐ Investigate
and Report☐ Note and
Return

Comments

FOR YOUR INFORMATION:

• HYDROLOGY INFORMATION
AND PROGRESS STATUS.• FOR SOYR AND REGIONAL WATER
LEVELS PLEASE SEE TABLE

If you require more detailed information, we will be receiving the hydrology reports by early to mid January 90.

Lana



Marshall Macklin Monaghan Limited

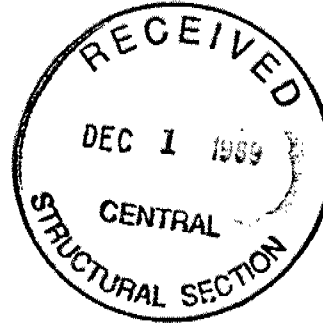
Consulting Engineers Surveyors Planners

November 13, 1989

File: 16-88061-D04

275 Duncan Mill Road
Don Mills, Ontario
Canada M3B 2Y1
(416) 449-2500
Telex 06-966695

Ministry of Transportation of Ontario
Central Region, Planning & Design
Atrium Tower
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8



Attention: **Mr. D. Solomon, P. Eng.**
Senior Project Manager

Dear Sirs

Subject: **W.P. 88-78-02**
Highway 407/Kipling Avenue Interchange
Rainbow Creek Crossing

Further to our Progress Review Meeting of November 1, 1989, we have arranged a meeting with Metropolitan Toronto and Regional Conservation Authority (MTRCA) for November 15, 1989 to discuss the stream crossings associated with the subject project. The following provides an overview of our updated culvert signing analysis for the various crossings of Rainbow Creek and the Rainbow Creek tributary. These findings and sizing recommendations will be presented to MTRCA to obtain concurrence with the flow scenario used to establish the culvert and bridge sizes. Once MTRCA has concurred with the basis for our design, we will finalize and issue the Drainage Report.

Background

Within the limits of W.P. 88-78-02, there are six stream crossings. The Rainbow Creek tributary crosses the Martin Grove Connection Road and Highway 407 west of Kipling Avenue, and then crosses Kipling Avenue immediately north of the CNR. Rainbow Creek crosses diagonally under the Highway 407/Kipling Avenue interchange, necessitating structures at the connecting road, Kipling Avenue and the S-E ramp.

As you are aware, the firm of Cosburn Patterson Wardman Limited (CPW) has recently completed a Master Drainage Study for the Rainbow Creek watershed on behalf of the Town of Vaughan. The results of this study indicate flows which are substantially higher than the original floodplains mapping for the watershed (See Table I). Evidently, MTRCA has not yet approved the new Drainage Study and it appears that it may take some time before approval is granted. Apparently they have questions/concerns with the very significant increases in flow, particularly under the Regional Storm conditions.

As the progress of the Marshall Macklin Monaghan Limited Drainage Study for the Rainbow Creek/tributary crossings has been delayed several months while we waited for the outcome of the CPW Study, the design schedules for the various structures have also been delayed. A further delay could seriously jeopardize the delivery date for the overall contract. It is therefore critical that the sizing of the structures be finalized as soon as possible. As discussed at our recent meeting, the following flow criteria will be presented to MTRCA for approval.



Structure Sizing

In accordance with MTO practice, the crossings have been sized to convey the 50 year flow without head. All structures have also been checked to ensure that the Highway is not overtopped under Regional Storm conditions. As discussed at our meeting of October 13, 1989, the culvert sizing for the main branch of Rainbow Creek has been established to convey the 50 year flow calculated by Cosburn Patterson Wardman. The crossings have been checked for overtopping of the road using the Regional storm flows from the original floodplain mapping.

The Highway 407 drainage strategy includes provision of a drainage channel north of the freeway to divert runoff from the Highway 27 area easterly to the Rainbow Creek Tributary. Since the original floodplain mapping did not include the 290 ha watershed diversion, which will be implemented as part of the overall Highway 407 construction, CPW flows were used for both 50 years and Regional flood conditions for the Rainbow Creek tributary.

The culvert sizes have been established using the FHWA Culvert Analysis Program HY-8 used by the Ministry of Transportation (MTO). The HEC - 2 model for the watershed was also used to assess the upstream impacts of the new crossings. The model indicates a localized increase in water levels upstream of the Martin Grove Connection Road. This increase is only a localized effect occurring for a short distance upstream and does not impact any buildings. The recommended culvert sizes and corresponding flows and water levels are summarized in Table 2 and 3.

Road Profile

We have reviewed potential modifications to the Martin Grove Road connection to raise the elevation of the bridge and maintain a sag within the limits of the stream valley. Our recommended profile is detailed on the enclosed drawings. The revised profile maintains a 1 percent grade westerly from the Kipling Avenue intersection to west of the proposed bridge. The low point in the road has been shifted westerly to approximately Station 9+ 970. Assuming a bridge deck thickness of 1.5 metres, the bridge will pass the Regional Storm flow as provided on the original floodplain mapping. Should flows be found to approach the CPW values this sag will provide a location for relief flow and thereby prevent submerging of the bridge deck. (Note: Sag does not extend below soffit elevation and therefore bridge deck will be partially under water if flow exceeds original floodplains mapping values for Regional Storm).

We trust the foregoing adequately outlines our findings and proposed culvert sizings. Should you have any questions or require additional data, please do not hesitate to call. We look forward to discussing these proposals with MTRCA.

Yours very truly

MARSHALL MACKLIN MONAGHAN LIMITED

R.D. Kivi, P. Eng.
Senior Project Engineer
Transportation Engineering

RDK:mp:L5/12
Enclosures

cc: J. Klowak
L. Markovic

TABLE 1: Rainbow Creek Peak Storm Flows

Return Period (yrs)	Main Branch		Tributary		At Humber River	
	CPW	Floodplain Mapping	CPW	Floodplain Mapping	CPW	Floodplain Mapping
5	59.8	19.9	19.6	1.80	73.7	22.50
10	85.8	25.6	28.1	2.20	104.3	28.80
25	105.3	33.6	34.1	2.80	127.7	37.8
50	122.5	40.3	38.7	3.40	149.1	45.2
100	130.8	47.1	41.5	3.90	159.0	52.9
Regional	296.7	173.8	50.2	20.80	341.90	192.80

TABLE 2: Culvert Sizing - Tributary of Rainbow Creek

Crossing	50 year Design Flow	Regional Design Flow	Upstream Invert (m)	Downstream Invert (m)	Culvert Length (m)	Upstream Low Chord Elevation (m)	Minimum Top of Road Elevation (m)	50 year Water Elevation (m)	Regional Water Elevation (m)	Culvert Size
Kipling Avenue	38.7	50.2	140.3	137.6	80	143.05	148.0	143.03	143.63	6.0m x 2.75m
Hwy 407	38.7	50.2	152.8	149.9	122	155.55	156.4	155.55	156.14	6.0m x 2.75m
Martin Grove Access	11.2	17.7	154.4	153.6	50	156.40	158.5	156.29	157.62	3.0m x 2.0m

TABLE 3: Culvert Sizing - Main Rainbow Creek

Crossing	50 year Design Flow	Regional Design Flow	Upstream Invert (m)	Downstream Invert (m)	Culvert Length (m)	Upstream Low Chord Elevation (m)	Minimum Top of Road Elevation (m)	50 year Water Elevation (m)	Regional Water Elevation (m)	Culvert /Bridge Size
407/Kipling	122.5	173.8	137.33	136.27	250	141.33	150	141.04	142.12	2-6.0mx4.0m
Martin Grove Access Road	122.5	173.8	138.0	137.68	60	142.70	144.2	141.27	142.37	25.0m span

Note: For 407/Kipling Crossing the top of Road elevation of Hwy 407 is 150.0m and low point of Kipling Avenue is 142.7m.

memorandum



To: Distribution **Date:** 1989 11 28

From: Foundation Design Section
Room 315, Central Building

RE: Minutes of Meeting
Highway 407/Kipling Avenue Interchange
W.P. 88-78-12/33, District 6

Held: November 27, 1989, 2:00 p.m.
Foundation Design Section

Purpose: To discuss alternatives to the proposed Highway/407 Kipling Avenue structure and adjacent culvert alignment

Attendance: V. Boehnke - Structural Section
G. Al-Bazi - Structural Office
M. Devata - Foundation Design Section
D. Dundas - " " "
B. Bennett - " " "

- Artesian conditions that were encountered during the subsurface investigation will pose a problem if this zone is penetrated by deep foundations or excavations. A drainage scheme would be required to prevent migration of fines.
- The subsurface conditions at the proposed structure location are not suitable for spread footings although deep foundations or perched abutments on granular pads may be feasible.
- It was suggested that a single span structure with perched abutments would minimize the excavation and deep foundation requirements.
- Given the profile grades of Kipling Avenue and Highway 407, a 48 m long single span structure was proposed.
- The proposal will require further examination to determine if the required structure details are satisfied, and to verify that the subsurface conditions at the proposed abutment locations have adequate bearing capacity for perched abutments on granular pads.
- The culvert alignment adjacent to the proposed centre pier could adversely influence the integrity of the footing if there is undermining by artesian flow.

- The Structural Section was asked to consider diverting the creek (culvert) to the east, away from the structure footings.
- The performance of the culvert in its present alignment was discussed in view of the artesian conditions encountered in the vicinity of the creek, and the low bearing capacity of the foundation soil in this area.
- The Structural Section is to assess the culvert re-alignment proposal, as well as the proposed abutment locations for a single span structure and its span length. The design information will be forwarded to the Foundation Design Section upon its determination so that analysis of the foundations can proceed.
- Regardless of the final culvert alignment, additional fieldwork will be required.
- The environmental implications of penetrating the artesian zone was touched on.
- The location of high mast lighting was also discussed. The light standards will be founded on deep foundations that will require some means of drainage.



B. Bennett, P. Eng.
Foundation Engineer

BB/mmj

c.c. - Attendees