G.I.-30 SEPT. 1976

GEOCRES No. 31D-368

DIST. 52 REGION

W.P. No. 689-93-00

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 69

LOCATION Hwy 69 North of
Muskoka Rd. 38

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

[redacted]

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Gerard Richmond
Bell.

16+400 — 16+590

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REMARKS

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FOUNDATION DESIGN SECTION

foundation investigation and design report

W.P.

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP	689-93-00	DIST	52
HWY	69	STR SITE	N/A

Swamp Crossings
Muskoka Rd. 38 Northerly to Musquash River

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GEOCRES 31D-368

DATE FEB 03 1998

FOUNDATION INVESTIGATION REPORT
For
Hwy 69 Swamp Crossings
From Muskoka Rd 38 Northerly to the Musquash River
W.P. 689-93-00, Site No. N/A
Highway 69, District 52, Huntsville

INTRODUCTION

This report summarizes the results of a field investigation carried out for the construction of Hwy 69 (NBL and SBL) on a new alignment, at a maximum offset of 130m to the west, from the existing Hwy 69 alignment. The investigation was carried out at the request of Northern Region Planning and Design Section.

SITE DESCRIPTION

The site for the proposed Highway 69 (new alignment) over three swamps is located about 22 km north of Port Severn, from Muskoka Road 38 northerly to the Musquash River. Between the swamps there are rock outcrops covered with shrubs and trees. At the time of this investigation, the site was frozen and covered with snow.

Physiographically the site is located in the Algonquin Highlands. This region takes in much of the area underlain by granite and other hard Precambrian rocks. Overall it is broadly dome shaped. Locally, the relief is rough, rounded knobs and ridges. There are frequent outcrops of bare rock but they do not amount to more than 5 per cent of the total area. The soils are generally shallow but thickness over the bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. As an exception several areas have deeper till and few rock outcrops, and the surface of the till is smoothed and moulded with occasional drumlins appearing (Reference: Chapman and Putnam, 'The physiography of Southern Ontario; 3rd Edition, 1984).

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 97 03 24 and 97 04 02. Totals of fourteen boreholes (BH 5 and BH 7 through BH 19) were advanced for the subsurface investigation. Dynamic cone penetration was carried out in Borehole 5. The boreholes were advanced using a track-mounted auger machines equipped with 82mm ID hollow stem augers.

Samples were recovered by means of a 50mm OD split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586). In general, samples were retrieved at 0.75m within the peat and then 1.5m intervals below the peat.

The boreholes were staked out by the Northern Region Surveys and Plans Section of the MTO. Locations and elevations were also provided by the Surveys and Plans Section.

The Laboratory testing program for the representative samples consisted of:

-- Grain Size Analyses
-- Natural Moisture Content Determinations, and
-- Atterberg Limit Tests

The results of the laboratory tests are plotted on the Record of Borehole sheets, attached.

Groundwater was observed during drilling of the boreholes and immediately after completion of the field work.

SUBSURFACE CONDITIONS

Based on the information obtained in fourteen boreholes, the subsurface conditions are quite variable across the sites with large changes in thickness of peat and silty clay and deep depressions in the bedrock surface. In some locations, the bedrock is exposed at the ground surface and in some areas, there is no presence of peat. In general, the peat and silty clay are underlain by silty sand to sand and gravel or directly overlie the bedrock.

For reference to swamp locations and numbers, please refer to the attached Figures No:1 and 2. We have identified the swamp areas as follows:

Swamp 2:	This is the southern swamp among the three new proposed swamp crossings. The area is located near station 17+500 and 17+570, north of MR 32. This area looks like a pond.
Swamp 3:	The small middle swamp within the three new proposed swamp crossings, near station 17+880 and 17+920.
Swamp 4:	The large northern swamp among the three new swamp crossings, located between stations 17+980 and 18+268.

The Records of Borehole Sheets (attached) illustrate the subsurface conditions at the borehole locations. The locations of the boreholes are shown on Figures No:1 and 2. Following are the detailed descriptions of the soil strata encountered at each swamp:

Swamp Crossing # 2

At this location, two boreholes (BH5 and BH7) were drilled. An attempt to put a third borehole was unsuccessful due to melting ice conditions. The swamp was covered with water and the water depth ranged from 1.1 to 1.2m. The water elevation was 190.5m. Following are the details of the soil encountered at this location:

Peat

At Swamp No. 2, the two boreholes revealed the presence of peat ranging in thickness from 1.0m (BH 5) to 2.3m (BH 7). The peat was fibrous and of dark brown colour. The top elevation of the peat was about 189.4m (BH7). The N-values ranged from 0 to 1 blow per 0.3m penetration. The moisture content of the peat at this location ranged from 115 to 436 percent.

Silty Clay

The peat was underlain by 3.3m (BH5) to 9.8m (BH7) thick deposit of silty clay. The top elevation of this deposit was 187.1m (BH 7) and 188.3m (BH 5). The N-values recorded was 0 to 2 blows per 0.3m penetration. The consistency of this deposit was very soft to firm having an undrained shear strength ranging from 13 kPa to 31 kPa with and average shear strength of 15 kPa.

Typical properties of the silty clay material, as determined by laboratory tests of representative samples from the boreholes, are summarized as follows:

	Range (%)
Water Content (W)	52 - 77
Plastic Limit (W_P)	18 - 20
Liquid Limit (W_L)	39 - 43

Silty Sand

This non cohesive deposit was encountered only in Borehole 5. The top elevation of this deposit was 185.0m. This deposit was 1.8m thick. The N-value of 10 blows per 0.3m penetration suggested this deposit to be compact.

Sand & Gravel

This non cohesive deposit was only encountered in BH 7. The top elevation of this deposit was at 177.3m and the thickness was more than 2m. Full thickness of this deposit was explored. A N-value of 6 blows per 0.3m penetration suggested this deposit to be loose.

Swamp Crossing # 3

Two boreholes (BH8 and BH 9) were put down in this area. Following are the details of the soil encountered at this location:

Peat

At Swamp No. 3, the peat was 2.6m thick. The peat was fibrous and of dark brown colour. The top elevation of the peat was about 192.4m (BH9). The N-values ranged from 0 to 1 blow per 0.3m penetration. The moisture content of the peat at this location ranged from 278 to 387 percent.

Silty Clay

The peat was underlain by 3.5m to 6.1m thick deposit of silty clay. The top elevation of this deposit was at about 189.8m (BH 9). The N-values recorded was 0 to 1 blow per 0.3m. The consistency of this deposit was soft to firm having an undrained shear strength ranging from 12 kPa to 34 kPa with an average shear strength of 20 kPa.

Typical properties of the silty clay material, as determined by laboratory tests of representative samples from the boreholes, are summarized as follows:

	Range (%)
Water Content (W)	72 - 83
Plastic Limit (W_P)	20 - 22
Liquid Limit (W_L)	49 - 50

Silty Sand

This non cohesive deposit was encountered only in Borehole 9. The top elevation of this deposit was 183.7m. This deposit was 1.5m thick. A N-value of 9 blows per 0.3m penetration suggested this deposit to be loose.

Swamp Crossing # 4

Ten boreholes BH 10 to BH 19 were put down in this area. A total of five boreholes (BH10 to BH 14) at the southbound lane location, two boreholes (BH15 and BH 16) in the median area and three boreholes (BH17 to BH 19) in the area of the northbound lane were drilled. The thickness of the silty clay to clay is somewhat lesser in the area of the northbound lanes in the range of 1.9m to 4.6m thick with no surficial peat encountered in the boreholes. The overall undrained shear strength of the clay ranges from a low of 10 kPa to as high as 38 kPa. The higher strengths are in the lower portion of the deposit. The silty clay is underlain by silty sand to sand and gravel. In general, the water level is very close to the surface. Following are the details of the soil encountered at this location:

Peat

At Swamp No. 4, Peat is present mainly on the west side of the proposed Hwy 69 centerline and its thickness ranged from 1.5m to 5.3m. The peat was fibrous and of dark brown colour. The top elevation of the peat ranged from 192.4m (BH10) and 192.8m (BH16). The thickness of the peat ranged from 1.5m (BH 10) to 5.3m (BH 11). The N-values ranged from 0 to 1 blow per 0.3m penetration. The moisture content of the peat at this location ranged from 373 to 859 percent.

Silty Clay

This cohesive deposit was encountered in all boreholes except BH 10 and was underlying the peat. The top elevation of this deposit was at 187.2m (BH 11) to 193.4m (BH 17). The thickness of this deposit ranged from 1.9m (BH 19) to 9.4m (BH 13). The N-values recorded was 1 to 4 blows per 0.3m with an average of 1 blow/0.3m. The consistency of this deposit was very soft to firm having an undrained shear strength ranging from 10 kPa to 38 kPa with an average shear strength of 15 kPa.

Typical properties of the silty clay material, as determined by laboratory tests of representative samples from the boreholes, are summarized as follows:

	Range (%)
Water Content (W)	26 - 194
Plastic Limit (W_P)	12 - 22
Liquid Limit (W_L)	27 - 55

Silty Sand

This non cohesive deposit was encountered in Boreholes 11, 14, 16, 17 and 19. The top elevation of this deposit ranged from 179.5m (BH16) to 191.3 (BH19). The thickness of this deposit ranged from 0.5m (BH19) to 4.0m (BH17). The N-values ranged from 0 to 40 blows/15cm suggesting this deposit to be very loose to dense.

Groundwater Conditions

Groundwater was encountered in all boreholes except BH 10, 15, 17 and 18. In general groundwater was at the ground surface. At some locations the groundwater was encountered within one metre below the ground surface. It should be noted that groundwater is subject to seasonal fluctuation.

DISCUSSION AND RECOMMENDATIONS

General

The foundation investigation was carried out to investigate at three new proposed swamp crossings north of Muskoka Road 32 between stations 17+500 and 18+268 for the new alignment of Hwy 69. We were also asked to comment on raising the grade of existing Hwy 69 between stations 17+200 and 17+300, south of Muskoka Road 32, to correct a substandard sag. For reference, we have identified the swamp areas as follows:

Swamp 1:	This is the low area on the existing Hwy 69 between stations 17+200 and 17+300, south of MR 32.
Swamp 2:	This is the southern swamp among the three new proposed swamp crossings. The area is located near station 17+500 and 17+570, north of MR 32. This area looks like a pond.
Swamp 3:	The small middle swamp within the three new proposed swamp crossings, near station 17+880 and 17+920.
Swamp 4:	The large northern swamp among the three new swamp crossings, located between stations 17+980 and 18+268.

Proposed New Alignment

Swamp Area No. 2

At this location the western half of the embankment will be constructed over the existing pond. The height of the embankment will be 2.0m to 2.3m. Based on the slope analysis the peat and the underlying silty clay to clay material cannot support the proposed embankment. Also, it is not expected that the rock fill will displace all of the soft material on its own. To construct the embankment as proposed, removal of the soft material will be required. Following are our recommendations:

1. The construction of the highway over the pond will be difficult, expensive and will require post construction maintenance due to long term settlement. We recommend that the existing alignment should not be changed to avoid construction into the pond.

2. If the highway is to be constructed at the proposed alignment, then completely remove the peat and soft to firm cohesive material above the bedrock or above the non cohesive material. The maximum depth of excavation will be 13.2m. Excavation to such depth is beyond the limit of conventional equipment. Special equipment will be required to do the excavation.

3. If excavation of all the peat and soft to firm cohesive material, as recommended above is not possible, then excavate to a maximum practical depth (6m or more) and use blasting to displace the rest of the cohesive material. Since at Swamp 2, the clay deposit is in a dish shape it may be difficult to displace the cohesive material using blasting. However, a blasting expert may be able to comment on this. In any partial excavation and displacement approach (displacement by blasting) there is always a possibility that soft material will be trapped under the embankment and will cause post construction settlement. However, such settlement will be smaller, than if the material is not excavated or displaced at all.

We again strongly suggest that the proposed alignment should be changed to avoid the construction problem.

Swamp Area No. 3 and 4

In the area of Swamp 3 and Swamp 4, mainly the western half of the proposed embankment will fall within the swamp area. The embankment will be 3m to 3.5m high at Swamp 3 and 3m to 4.5m high at Swamp 4. At Swamp 4, the eastern half of the embankment will be constructed on an area that is underlain by soft to firm silty clay to clay up to 4.6m below the ground surface. Following are our recommendations:

1. The construction of the highway over the swamp underlain by soft to firm clay up to 13.3m deep will be difficult, expensive and will require post construction maintenance due to long term settlement. We recommend that the existing alignment should not be changed.

2. To avoid large post construction settlement, completely remove the peat and soft to firm cohesive material above the bedrock or above the non cohesive material. The maximum depth of excavation at Swamp 3 and 4 will be 8.7m and 13.3m respectively. Excavation to such depth is beyond the limit of conventional equipment. Special equipment will be required to do the excavation.

3. The embankment may be constructed by partially excavating peat or soft material up to 6m and then back filling with rock fill. However, there will be on going settlement problem and ongoing maintenance of the highway will be required. If this option is chosen then excavate and remove the peat and soft material within 6m below the existing grade and then construct the embankment with rock fill. The rock fill will displace some material. Apply a surcharge load of 1.5m thick small size rock fill to accelerate the consolidation process. Leave the surcharge load for as long as possible but for a minimum period of six month.

For the proposed new alignment at the three swamp crossings, there will be construction difficulties in achieving the above recommendations. Also, no matter what construction method is used there will be a long term settlement problem that will require ongoing maintenance.

Existing Highway Grade Raise

Swamp Area No 1

At this location, the existing highway was constructed over a swamp. There has been on going settlement at this location and the highway has been repaired several times by adding more material. This shows that there is still peat or soft material under the highway. We understand that berms were also added on the east and west sides of the highway to correct the problem but settlement is still occurring. We understand that the sag at this portion of the highway is substandard and it is proposed to raise the grade by 1.8m or higher. Initially we suggested not to raise the grade because any grade raise in this area would cause substantial settlement or failure. However, we understand that it is proposed that after the southbound lane is constructed, all the traffic will be diverted over the southbound lane and the existing highway will be excavated and reconstructed.

Due to adjacent new southbound lane there will be a limit to the excavation depth so that the stability of the new southbound lane is not effected. Also, due to ongoing settlement and repair by putting more material in this area we think that the granular fill in this area will be quite thick. In view of the limited depth of excavation due to adjacent southbound lane we expect that the excavation will be within granular material. If we excavate about 3.2m of fill material with unit weight 18 kN/m3 and replace it with slag then we can raise the grade to 1.8m above the existing grade without adding any extra load at this location. We have come up with an equation so that you can calculate how much grade can be raised. Assuming the excavation at the existing highway will be within granular or rock fill material of unit weight 18 kN/m3, and assuming the backfilling and the grade raise will be carried out by using lightweight fill (unit weight 11.5 kN/m3), the depth of excavation and the height of the grade raise can be calculated by the following equations without any load increment:

Depth of excavation = 1.77 X Proposed height of the fill above the present grade

Proposed height of the fill above present grade = 0.56 X Depth of excavation

Therefore, if it is proposed to raise the grade by 1.8m then 3.2m excavation will be required to remove the existing granular material provided the entire fill material is slag. However, if the granular material is only 1.8m thick then after the granular material is removed and backfilled with slag, the allowable grade raise will be 1.0m only. The regional geotechnical section shall verify the thickness of fill material in that area.

Since the peat or any soft material from this area cannot be completely removed due to limitation to the excavation depth, the highway will still experience ongoing settlement and will require maintenance. If the weight of the road is reduced by excavating more granular material, replacing it with lightweight material and reducing the proposed grade height, then post construction maintenance may be minimized.

The excavation to reconstruct the existing highway should be carried out in strips as detailed in Foundation Report W.P. 217-89-00 (A) dated May 9, 1994 for the Southbound lane construction. The recommendation for the southbound lane construction over the swamp will be as detailed in our Foundation report W.P. 217-89-00 (A) dated May 09, 1994.

MISCELLANEOUS

The field work for this project was carried out under the supervision of K.S.Q. Ahmad, Foundation Engineer. The equipment used was owned and operated by Canadian Soil Drilling Inc.

The report was written by K.S.Q. Ahmad, Foundation Engineer. The report was reviewed and approved by T.C. Kim, Senior Foundation Engineer.

LICENSED PROFESSIONAL ENGINEER
S. Q. AHMAD
PROVINCE OF ONTARIO

for Taechul Kim
K.S.Q. Ahmad, P. Eng.
Foundation Engineer

LICENSED PROFESSIONAL ENGINEER
T.-C. KIM
PROVINCE OF ONTARIO

Taechul Kim
T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX

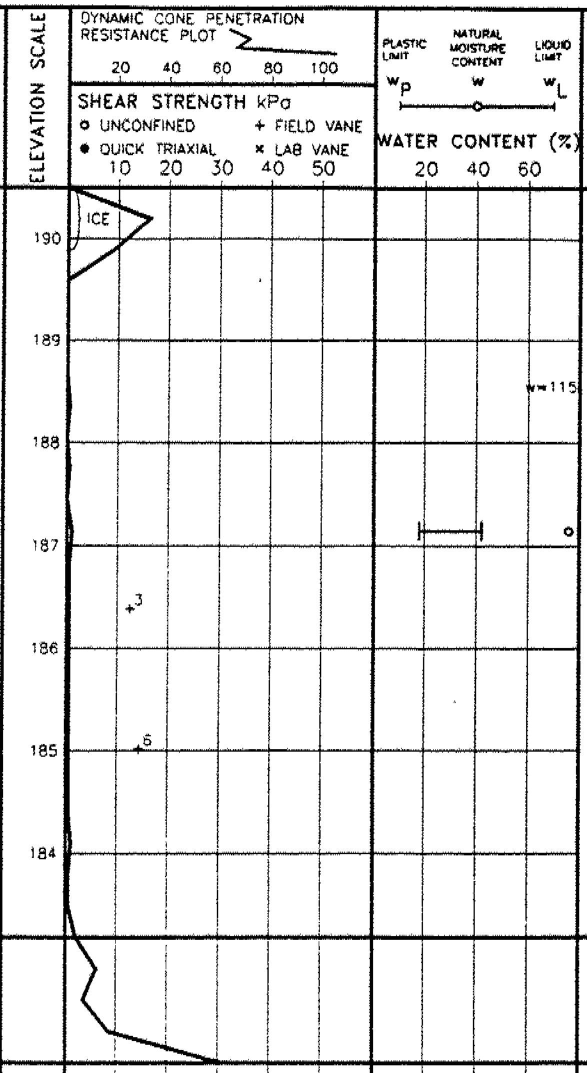
Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 5

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 17+525; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger/ Cone Test
COMPILED BY KA
DATUM Geodetic
DATE 1997 04 01
CHECKED BY TK

SOIL PROFILE			SAMPLES					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.5	Pond Surface							
0.0 189.9	Ice							
0.6 189.3	Water							
1.2 188.3	Peat Fibrous, Dark Brown		1	SS	1			
2.2 185.0	Silty Clay Light Grey to Reddish Grey Very Soft to Soft		2 3 4	SS SS SS	1 1 0			
5.5 183.2	Silty Sand, Some Gravel Grey, Compact		5	SS	10			20 44 (36)
7.3 182.0	End of Borehole Auger Refusal – Probable Bedrock							
8.5	End of Cone Test Cone Refusal– Probable Bedrock Note: Cone Test was carried out at a distance of 1.5m from the Borehole							



+3, +5 : Numbers refer to Sensitivity

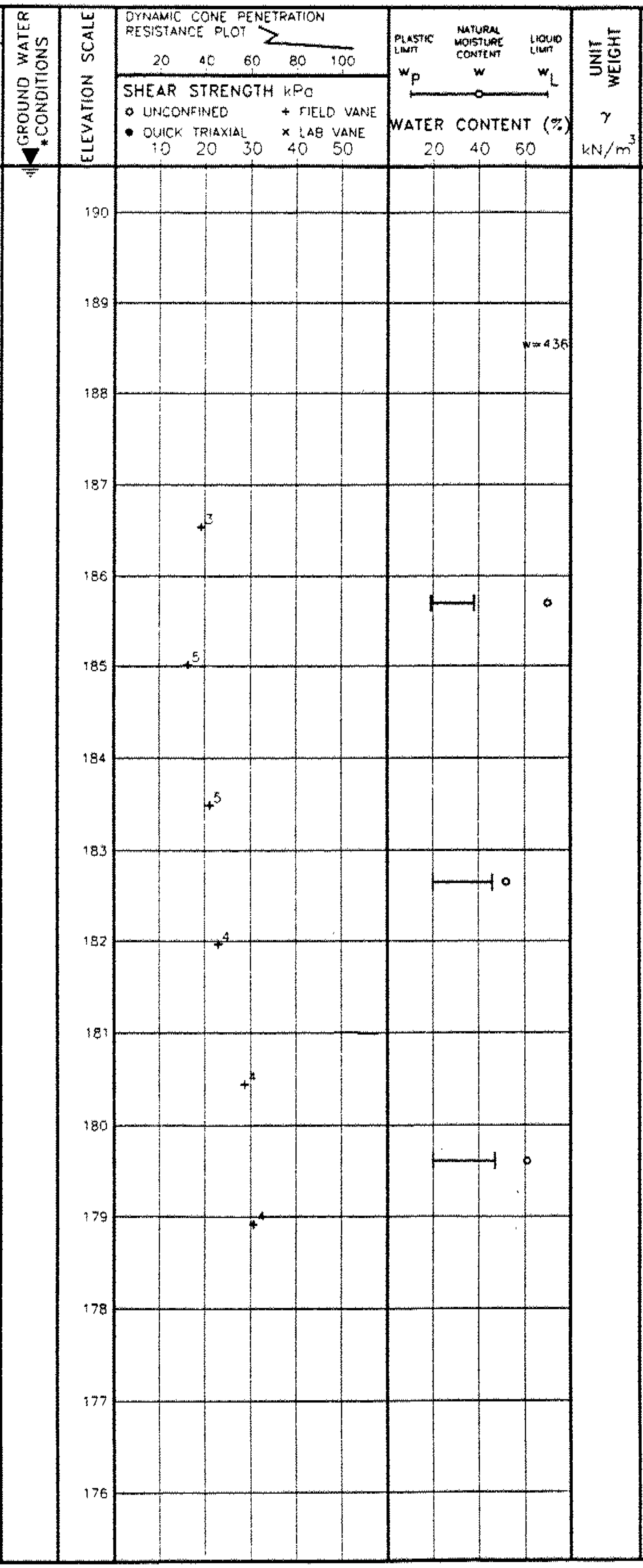
$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 17+550; o/s 14m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 04 02
CHECKED BY TK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.5	Pond Surface				
0.0 190.1	Ice				
0.4 189.4	Water				
1.1	Peat Fibrous, Dark Brown	1	SS	0	
		2	SS	1	
187.1		3	SS	0	
3.4	Silty Clay Light Grey to Reddish Brown Soft to Firm	4	SS	0	
		5	SS	0	
		6	SS	1	
		7	SS	2	
		8	SS	2	
177.3		9	SS	1	
13.2	Sand and Gravel Grey, Loose to Compact	10	SS	6	49 37 (14)
175.3					
15.2	End of Borehole				



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

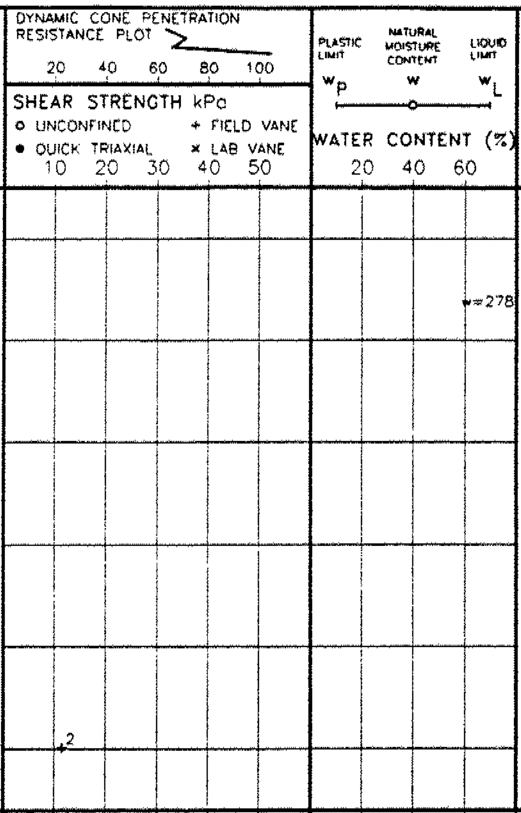
$15\overset{20}{\underset{10}{\diamond}}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 17+922; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 04 01
CHECKED BY TK

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.5	Ground Surface										
0.0	Peat Fibrous, Dark Brown					▼	192				
			1	SS	1				w=278		
			2	SS	0		191				
189.9 2.6	Silty Clay Grey, wet Very Soft						190				
			3	SS	0		189				
			4	SS	1		188				
							187	+2			
186.4 6.1	End of Borehole Auger Refusal, Probable Bedrock										



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

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

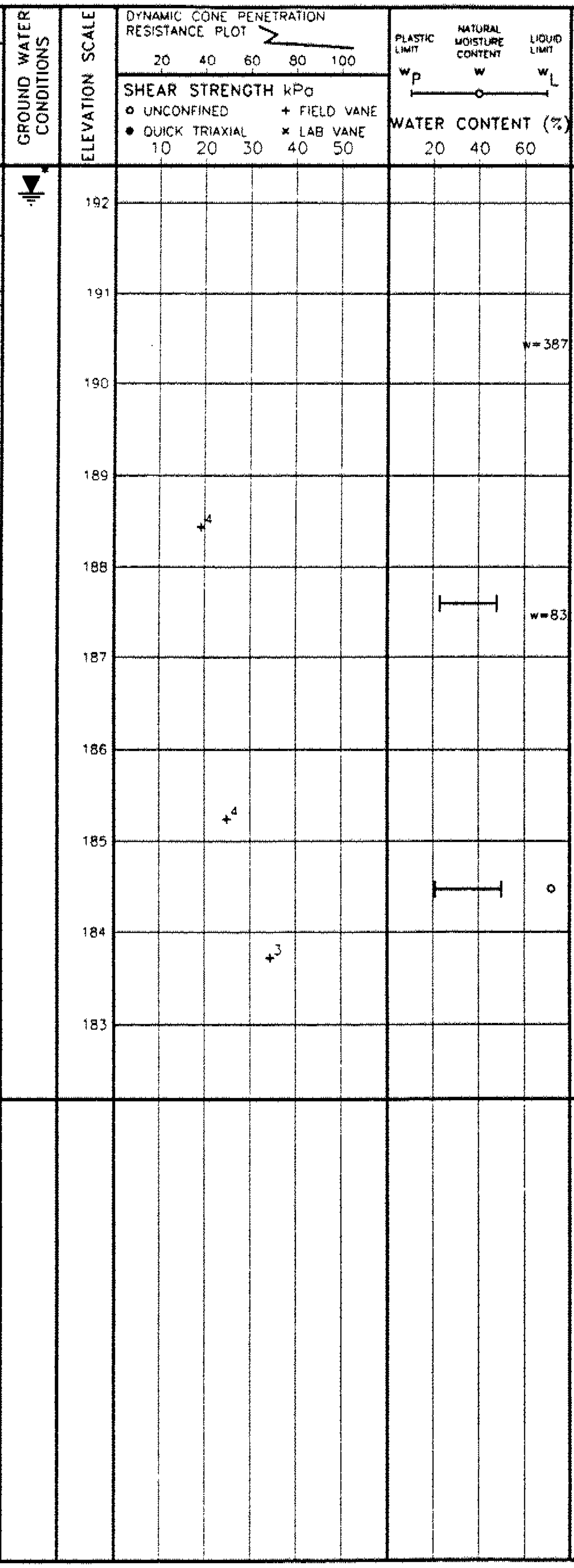
RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 689-93-00
LOCATION Sta. 17+900 Centreline, New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 04 01
CHECKED BY TK

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.4	Ground Surface				
0.0	Peat Fibrous, Dark Brown	1	SS	1	
		2	SS	0	
189.8 2.6	Silty Clay to Clay Grey, Wet Soft to Firm	3	SS	1	
		4	TW	PM	0 0 42 58
		5	SS	1	
		6	SS	1	1 1 49 49
183.7 8.7	Silty Sand, Trace Clay Grey, Wet Loose	7	SS	9	2 43 48 7
182.2 10.2	End of Borehole Auger Refusal Probable Bedrock				



UNIT WEIGHT γ kN/m³

+3, ×5 : Numbers refer to Sensitivity

$$\begin{array}{ccc} & 20 & \\ 15 & \diamond & 5 \\ & 10 & \end{array}$$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 17+983; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA

DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA

DATUM Geodetic
DATE 1997 03 27
CHECKED BY TK

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 10 20 30 40 50	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
192.4	Ground Surface										
0.0	Peat Fibrous, Dark Brown					*	192				
190.9							191				
1.5	End of Borehole Auger Refual Probable Bedrock * Water Level, Not Established										

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

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

Ministry of Transportation
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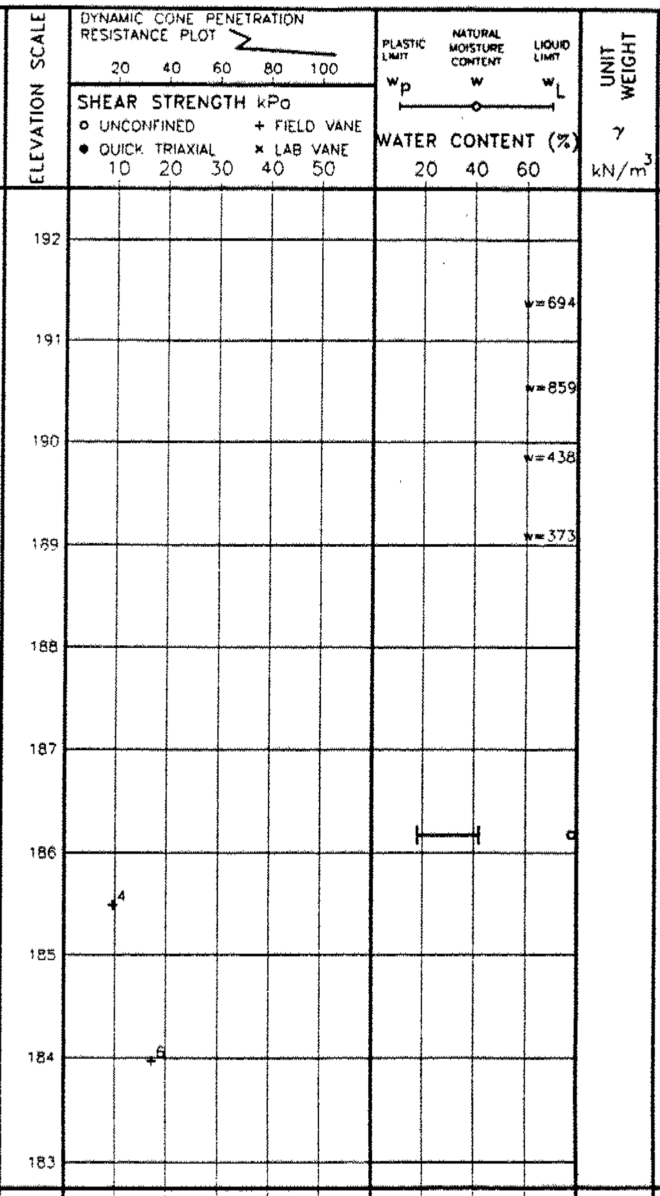
Foundation Design

RECORD OF BOREHOLE No 11 1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+046; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 26
CHECKED BY TK

SOIL PROFILE		SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
192.5	Ground Surface								
0.0	Peat Fibrous, Dark Brown				▼				
		1	SS	1					
		2	SS	0					
		3	SS	1					
		4	SS	1					
187.2		5	SS	0					
5.3	Silty Clay Grey, Wet Very Soft to Soft								
		6	SS	0					
		7	SS	0					
183.8									
8.7	Sandy Silt, Some Gravel Trace Clay, Grey	8	SS	40	/15cm	13	29	(58)	
182.7									
9.8	End of Borehole Auger Refusal Probable Bedrock								



+3, ×5 : Numbers refer to Sensitivity

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

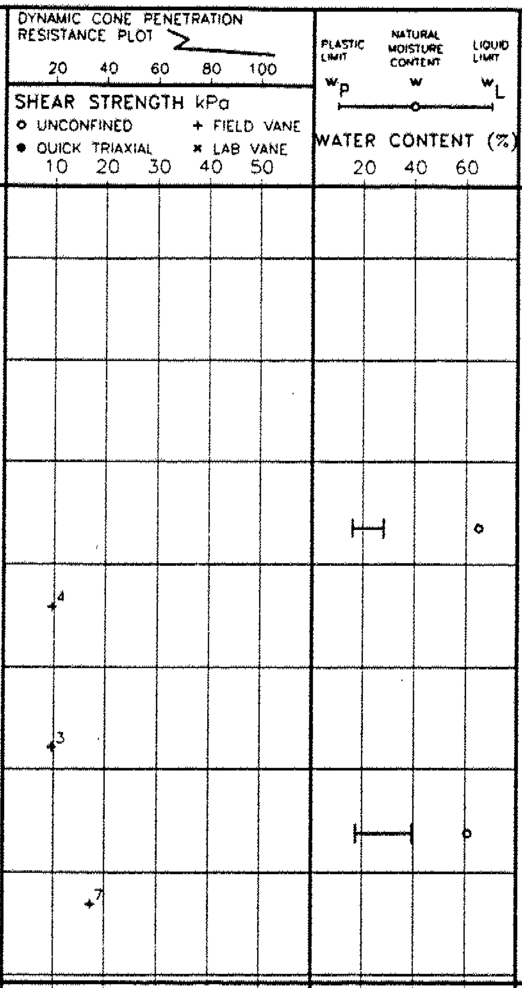
Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 12

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+124; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 26
CHECKED BY TK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES				
192.7	Ground Surface							
0.0	Peat Fibrous, Dark Brown				▼*	192		
		1	SS	1				
		2	SS	1		191		
190.2 2.5	Silty Clay Grey, Wet Very Soft to Soft					190		
		3	SS	1		189		
		4	SS	0		188		
						187		
		5	TW	PM				0 1 56 43
						186		
184.9		6	SS	68	/15cm	185		
7.8	End of Borehole Hammer Bouncing Probable Bedrock							



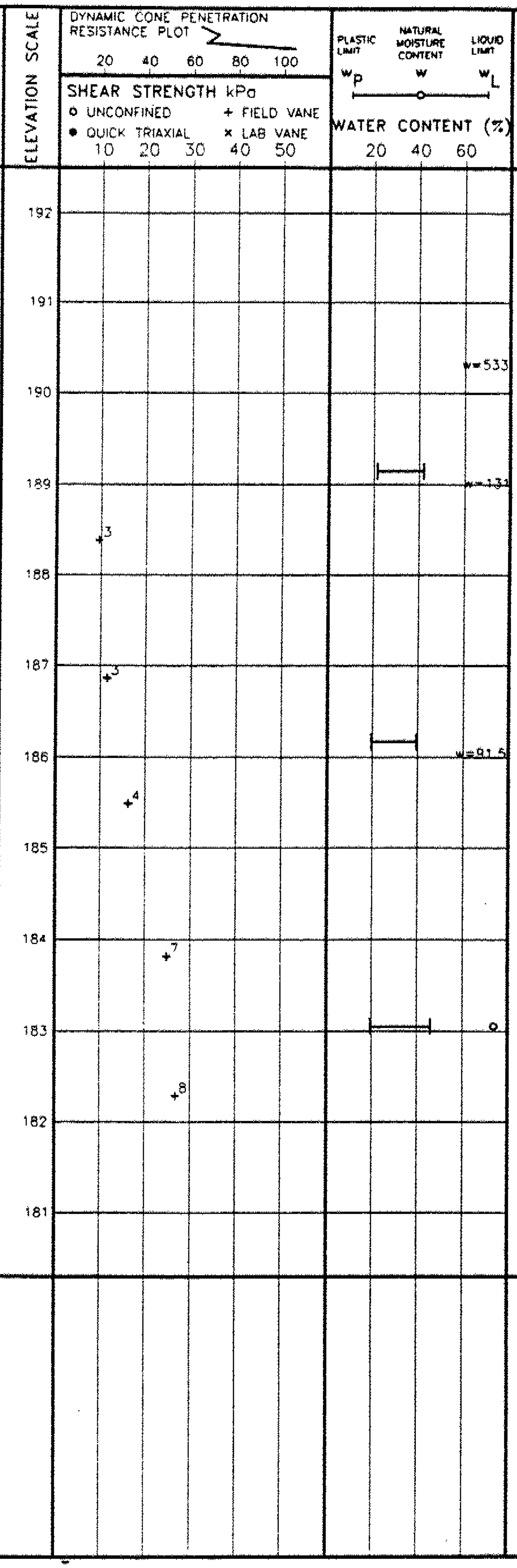
$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 13 1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+192; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 25
CHECKED BY TK

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS
192.5	Ground Surface				
0.0	Peat Fibrous, Dark Brown	1	SS	1	▼
		2	SS	0	
189.7 2.8	Silty Clay Grey, Wet Very Soft to Soft	3	SS	0	
		4	SS	0	
		5	SS	1	
		6	SS	1	
		7	SS	1	
		8	SS	1	
180.3 12.2	End of Borehole Auger Refusal Probable Bedrock				



UNIT WEIGHT γ kN/m³

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

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

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

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RECORD OF BOREHOLE No 14

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+268; o/s 35m Lt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 25
CHECKED BY TK

SOIL PROFILE			SAMPLES				
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
193.0	Ground Surface						
0.0	Clayey Silt with Sand Brown, Very Soft		1	SS	2	▼	192
191.6 1.4	Silty Clay to Clay Grey, Wet Very Soft		2	SS	1		191
			3	SS	1		190
189.0 4.0	Silty Sand Brown, Wet, Compact		4	SS	9		189 188
187.4 5.6	End of Borehole Auger Refusal Probable Bedrock						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

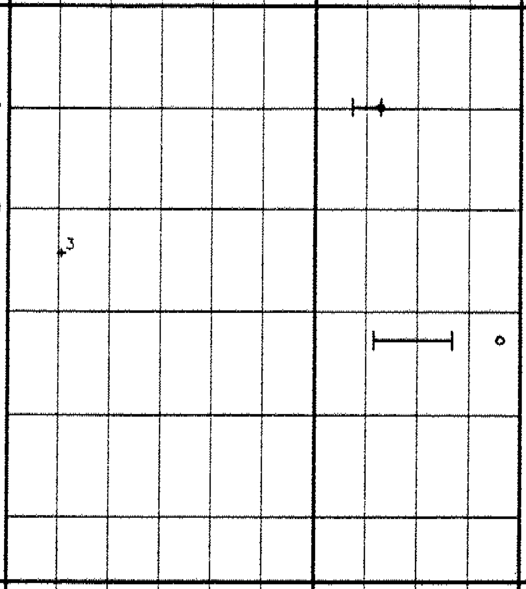
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
10 20 30 40 50

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m^3

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



+3, ×5 : Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
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RECORD OF BOREHOLE No 15 1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+065; Centreline, New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 26
CHECKED BY TK

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 10 20 30 40 50	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
192.7	Ground Surface										
0.0						*					
	Trace Organics						192				
			1	SS	2						
	Silty Clay to Clay Grey, Soft to Firm		2	SS	5		191				
190.4			3	SS	10	/5cm					
2.3	End of Borehole Hammer Bouncing Probable Bedrock * W.L. did not establish										

+3, ×5 : Numbers refer to Sensitivity

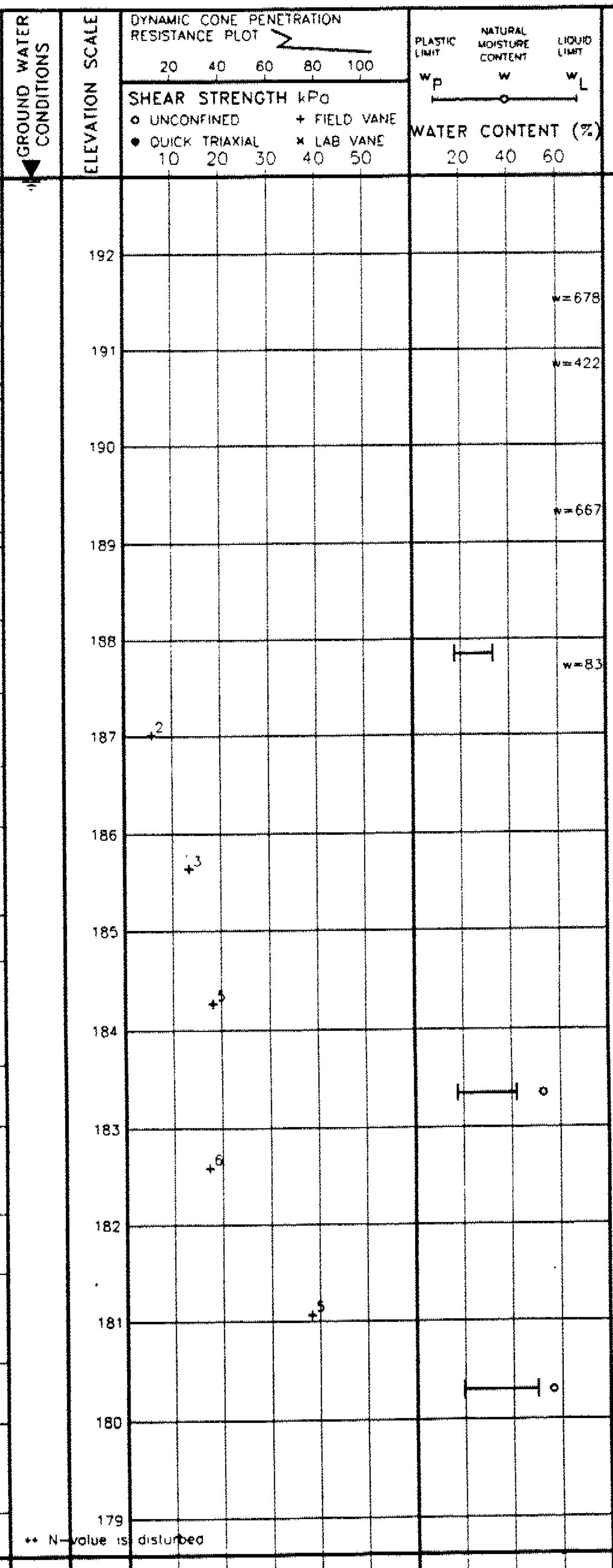
20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 16

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+150; Centreline New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger/Cone Test
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 24
CHECKED BY TK

SOIL PROFILE			SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GR SA SI CL
192.8	Ground Surface					
0.0	Peat Fibrous, Dark Brown		1	SS	1	
			2	SS	1	
			3	SS	1	
			4	SS	1	
188.3			5	SS	1	
4.5	Silty Clay to Clay Grey, Wet Very Soft to Firm		6	SS	0	
			7	SS	1	
			8	SS	0	
			9	SS	1	
	Very Soft to Soft Firm		10	SS	1	
179.5			11	SS	1	
13.3	Silty Sand Grey, Wet					
178.6			12	SS	3 **	3 77 (20)
14.2	End of Borehole Dynamic Cone test was carried out below elevation 178.6m Cone stopped at elev. 176.1m at Probable Bedrock					



** N-value is disturbed

UNIT WEIGHT γ kN/m³

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

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

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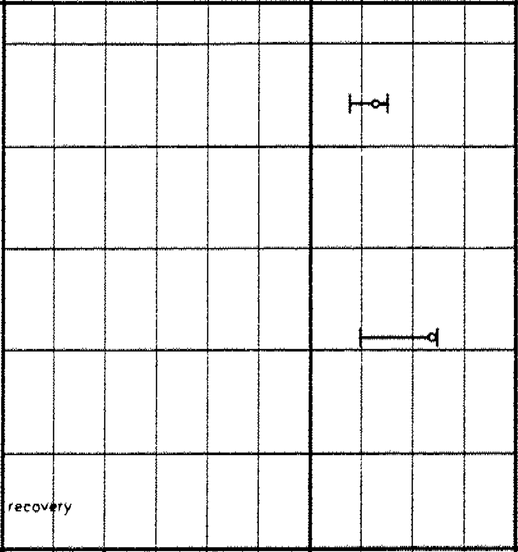
RECORD OF BOREHOLE No 17

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+019; o/s 35m Rt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 27
CHECKED BY TK

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 10 20 30 40 50	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.4	Ground Surface										
0.0	Clayey Silt to Silty Clay Brown to Grey Soft to Firm					*	193				
			1	SS	6		192				
			2	SS	8						
			3	SS	4		191				
			4	SS	2		190				
189.4											
4.0	Probable Silty Sand						189				
			** 5	SS	0		** No	recovery			
188.1											
5.3	End of Borehole Hammer Bouncing Probable Bedrock * W.L. did not establish										



+3, ×5 : Numbers refer to Sensitivity

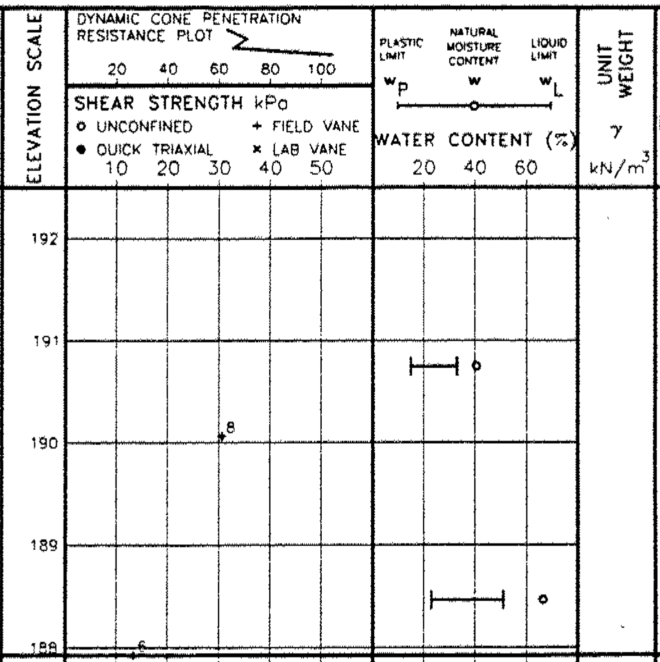
20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 18

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+100; o/s 35m Rt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 27
CHECKED BY TK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES		
192.5	Ground Surface					
0.0					*	
	A piece of wood	1	SS	3		
		2	SS	2		
	Silty Clay to Clay Grey Very Soft to Firm					
		3	TW	PM		0 1 30 69
187.9						
4.6	End of Borehole Auger Refusal, Hammer Bouncing Probable Bedrock ** W.L. did not establish					



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

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

RECORD OF BOREHOLE No 19

1 OF 1 METRIC

W.P. 689-93-00
LOCATION Sta. 18+174; o/s 35m Rt. New Align. Hwy 69
ORIGINATED BY KA
DIST 52 HWY 69
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY KA
DATUM Geodetic
DATE 1997 03 25
CHECKED BY TK

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 10 20 30 40 50	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
193.2	Ground Surface										
0.0	Clayey Silt to Silty Clay Brown, Soft to Firm					▼					
			1	SS	4						
							192		w=194		
191.3			2	SS	24						
1.9	Silty Sand, Grey, Compact										
190.8			3	SS	60	/15cm	191				
2.4	End of Borehole Hammer Bouncing Probable Bedrock										

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

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

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

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

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

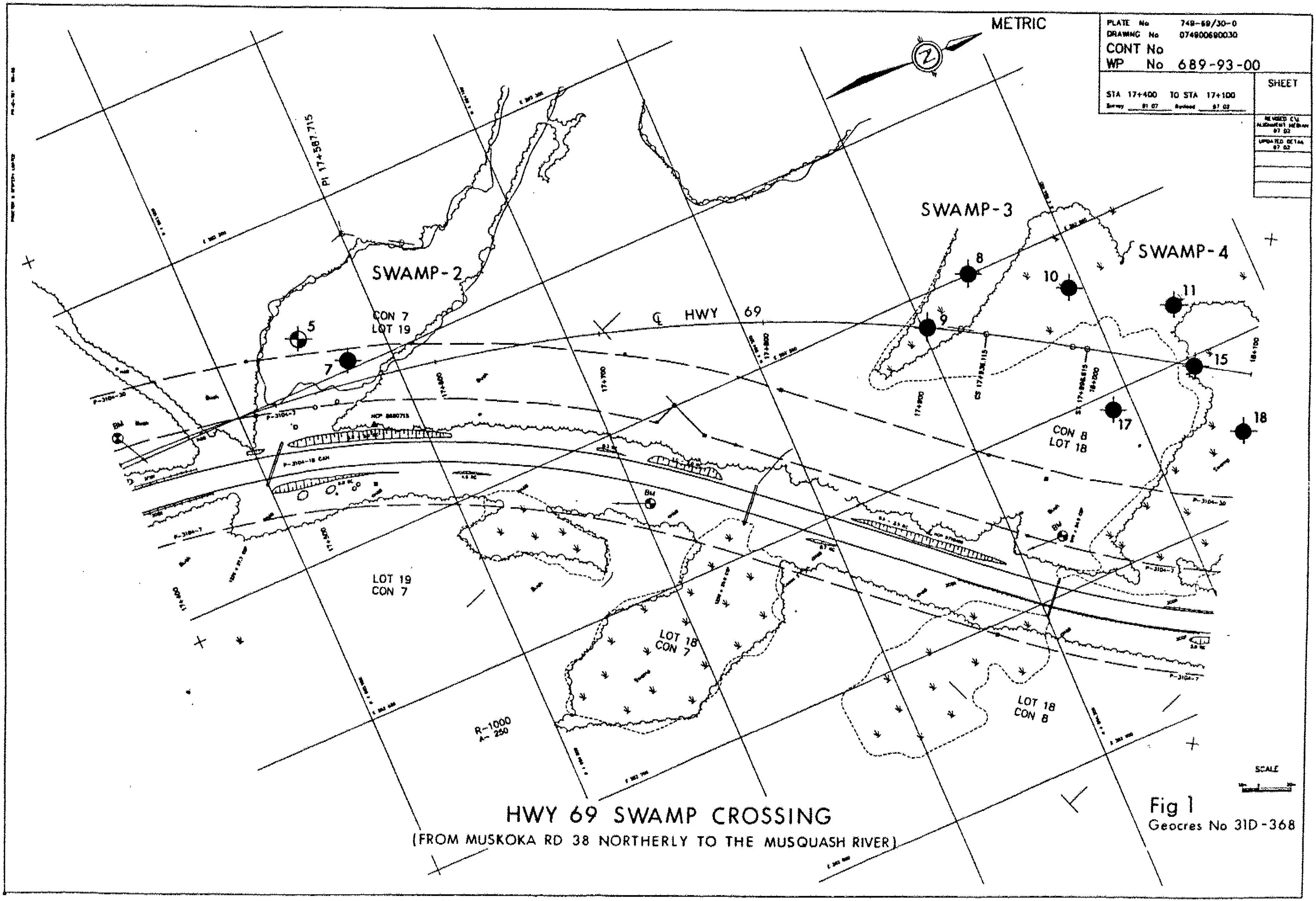


PLATE No 749-69/30-0
DRAWING No 074900690030
CONT No
WP No 689-93-00
STA 17+400 TO STA 17+100
Survey 91 07 Revised 97 02
SHEET
REVISED C/L ALIGNMENT MEDIAN 97 02
UPDATED DETAIL 97 02

HWY 69 SWAMP CROSSING
(FROM MUSKOKA RD 38 NORTHERLY TO THE MUSQUASH RIVER)

Fig 1
Geocres No 31D-368

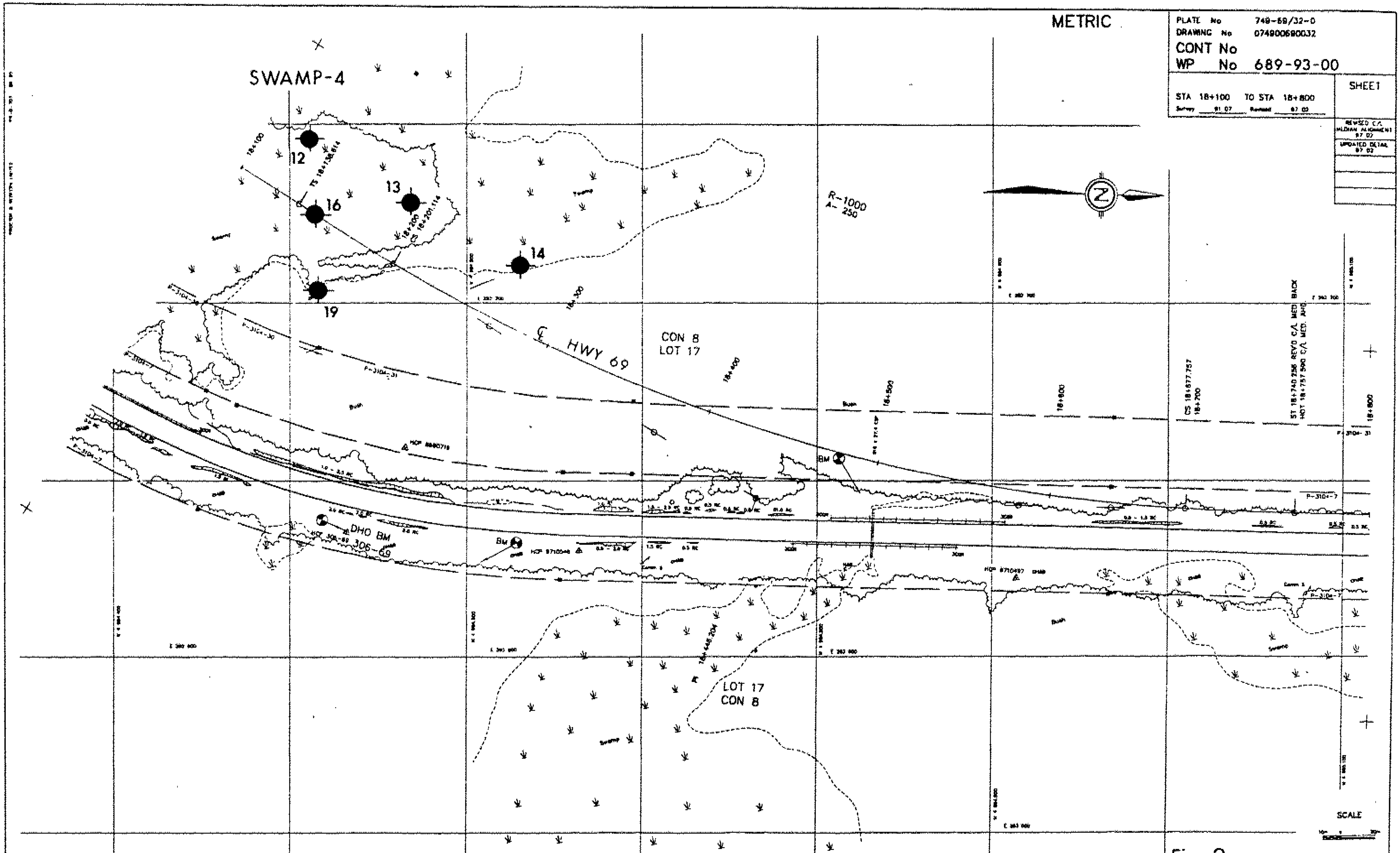
PLATE No 749-69/32-0
DRAWING No 074900690032
CONT No
WP No 689-93-00

STA 18+100 TO STA 18+800
Survey 91 07 Revised 97 02

SHEET

REVISED C/L
MEDIAN ALIGNMENT
97 07

UPDATED DETAIL
97 02



HWY 69 SWAMP CROSSING

(FROM MUSKOKA RD 38 NORTHERLY TO THE MUSQUASH RIVER)

Fig 2
Geocres No 31D-368

From: Ken Ahmad
To: MTONR.NORTHBAY.SmithDa
Subject: Swamp #1, WP 689-93-00, Hwy 69 From Muskoka Road 38 Northerly 4.3 km -Reply

Dale:

We cannot use the same recommendations given for one project to the other. Condition at Swamp 1 (soil condition, location) is different from other three swamp locations. At Swamp 1 recommendation was given to remove peat only. However, at other three swamps, recommendations are given for the removal of peat and soft material above the bedrock or competent soil. At Swamp No 1, rock fill will be placed on cohesive deposit. These are two different cases. For Swamp 1, Please follow the recommendations given in the report W.P. 217-89-00 (A), Geocres 31E-115, dated May 09, 1994.

For the strip excavation, the strips should be 'perpendicular to the centreline' and not 'parallel to the centreline'. There is a typo on Sketch No. 1, it should read "Perpendicular to the Centreline"

We are not familiar with the Special Provision of the lightweight material you have sent. Also, this is not the latest NSSP. Our office had developed NSSP for lightweight material based on in situ tests and distributed to all regions. Please look for the latest NSSP for lightweight material in any recent contract documents. The latest NSSP requires that the blast furnace slag should be compacted with special equipment.

Thanks

Ken Ahmad

>>> Dale Smith 12/17/97 03:53pm >>>

Hi Tae,

A Foundation Investigation and Design Report concerning the above swamp crossing was issued by your office on May 9, 1994 (GEOCRES 31E-115). The recommendation was for full excavation in strips, replacement with rock fill. No surcharge recommendation.

Golder Associates subsequently a report for the treatment of 3 other swamp crossings (swamps 2, 3, and 4) on this job, and recommended full excavation and replacement with rock fill, surcharged for minimum 4 months with 2 m of Granular B. This report is dated September 1997.

My question is... do you have any concerns with a similar surcharge of the swamp #1?

Also, to clear up a little confusion, should the strip excavation proceed parallel to the highway centreline, or perpendicular? See sketch no. 1 of GEOCRES 31E-115.

And finally, this job will also involve the use of lightweight material (slag) in accordance with your correspondence of May 1997. Attached is an NSSP downloaded from CPS. Could you please take a look at it and correct if necessary?

The technical review for this project was today, and the timeline for completion of the package is tight, therefore an early response would be appreciated.

Thanks,
Dale.

CC: MTONR.NORTHBAY.Lecoarer, MTONR.NORTHBAY.McDougal, ...

Ontario

memorandum

To: Paul Lecoarer, P. Eng
Senior Project Engineer
Planning and Design Section
Northern Region

1997 05 16

From: Pavements and Foundation Section
Room 315, Central Building
Downsview, Ontario

Re: Preliminary Recommendations
Highway 69 Swamp Crossings
From Muskoka Rd 38 Northerly to the Musquash River
W.P. 689-93-00
Highway # 69, District 52, Huntsville

This is further to our memo of April 23, 1997 and our meeting with you on May 1, 1997 in your office to discuss this project. The meeting was attended by Paul Lecoarer, Jim McDougall, Evan Clinch, Tae Kim and Ken Ahmad.

General

The foundation investigation was carried out to investigate at three new proposed swamp crossings north of Muskoka Road 32 between stations 17+500 and 18+268 for the new alignment of Hwy 69. We were also asked to comment on raising the grade of existing Hwy 69 between stations 17+200 and 17+300, south of Muskoka Road 32, to correct a substandard sag. For reference, we have identified the swamp areas as follows:

Swamp 1: This is the low area on the existing Hwy 69 between stations 17+200 and 17+300, south of MR 32.

Swamp 2: This is the southern swamp among the three new proposed swamp crossing. The area is located in the vicinity of station 17+500 and 17+570, north of MR 32. This area looks like a pond.

Swamp 3: The small middle swamp within the three new proposed swamp crossings, in the vicinity of station 17+880 and 17+920.

Swamp 4: The large northern swamp among the three new swamp crossings, located between stations 17+980 and 18+268.

Soil Condition

In Swamp 2, two boreholes BH 5 and BH 7 were drilled. A third borehole BH 6 could not be drilled as the ice broke and the drilling machine got trapped in the pond. The ice thickness in the pond was 0.4m to 0.6m. The water was 1.1 to 1.2m deep. The boreholes encountered peat up to 2.3m thick. The peat was underlain by very soft to firm silty clay to clay. The thickness of the silty clay deposit ranged from 3.3m to 9.8m. The Standard Penetration tests N-values within the peat and silty clay material generally ranged from no resistance to 1 blow per 0.3m penetration. Undrained shear strength within silty clay to clay deposit ranged from 12kPa to 32 kPa. Average undrained shear strength in the silty clay to clay within the upper five metres was 15 kPa. The silty clay was underlain by non cohesive silty sand to sand and gravel material. The thickness of silty sand in BH5 was 1.8m. In BH 7 full thickness of the sand and gravel could not be determined. The borehole advanced 2m in this material before it was terminated. The N-value within silty sand to sand & gravel deposit ranged from 6 blows to 10 blows per 0.3m penetration indicating this deposit to be loose to compact.

In Swamp 3, two boreholes BH 8 and BH 9 were drilled. In this swamp the boreholes encountered 2.6m thick peat deposit. The peat was underlain by silty clay to clay raging in thickness from 3.5m to 6.1m. The Standard Penetration N-values within the peat and silty clay material generally ranged from no resistance to 1 blow per 0.3m penetration. The undrained shear strength within the silty clay to clay deposit ranged from 12 kPa to 34 kPa. Average undrained shear strength in the silty clay to clay was 20 kPa. The silty clay was either underlain by non cohesive silty sand to sand and gravel layer or overlying probable bedrock.

In Swamp 4, ten boreholes BH 10 through BH 19 were put down. Peat was mainly encountered on the west side of the proposed Hwy 69 centreline. The thickness of peat ranged from approximately 1.5m to 5.3m thick. The peat was generally underlain by very soft to firm silty clay to clay ranging in thickness from 3.4m to 9.4m. The maximum depth of soft to firm silty clay to clay was 13.3m below ground surface and that was mainly on the northwest side of the swamp. The Standard Penetration N-values within the peat and silty clay material generally ranged from no resistance to 1 blow per 0.3m penetration. However, in area beyond the swamp boundary (north and east sides of the swamp), the N-values within the silty clay to clay deposit generally ranged from 1 to 8 blows per 0.3m penetration. Average undrained shear strength in the silty clay to clay was 15 kPa. The silty clay was either underlain by non cohesive silty sand to sand and gravel layer or overlying probable bedrock.

DISCUSSION AND RECOMMENDATIONS:

Proposed New Alignment:

Swamp Area No. 2

2.3m.

At this location the western half of the embankment will be constructed over the existing pond. The height of the embankment is not finalized. However, it is expected that it may be as high as 4m. Based on the slope analysis the peat and the underlying silty clay to clay material cannot support the proposed embankment. Also, it is not expected that the rockfill will displace all of the soft material on its own. To construct the embankment as proposed, removal of the soft material will be required. Following are our recommendations:

1. The construction of highway over the pond will be difficult, expensive and will require post construction maintenance due to long term settlement. We recommend that the existing alignment should not be chainged to avoid construction into the pond.

2. If the highway is to be constructed at the proposed alignment, then completely remove the peat and soft to firm cohesive material above the bedrock or above the non cohesive material. The maximum depth of excavation will be 13.2m. Excavation to such depth is beyond the limit of conventional equipment. Special equipment will be required to do the excavation.

3. If excavation of all the peat and soft to firm cohesive material, as recommended above is not possible, then excavate to a maximum practical depth (6m or more) and use blasting to displace the rest of the cohesive material. Since at Swamp 2, the clay deposit is in a dish shape it may be difficult to displace the cohesive material using blasting. However, a blasting expert may be able to comment on this. In any partial excavation and displacement approach (displacement by blasting) there is always a possibility that soft material will be trapped under the embankment and will cause post construction settlement. However, such settlement will be smaller than if the material is not excavated or displaced at all.

We again strongly suggest that the proposed alignment should be changed to avoid construction problem. We suggest that the Region retain a consultant for detail blasting design. We will be pleased to assist in hiring a Consultant, provide necessary information for design, and will be involved in liaison with the Consultant and design review.

Swamp 3 : 3-5m high embankment.
Swamp 4 : 3.0-4.0m high embankment.
3m ,

Swamp Area No. 3 and 4

In the area of Swamp 3 and Swamp 4, mainly the western half of the embankment falls within the swamp area. The embankment will be up to 7m high. At Swamp 4, the eastern half of the embankment will be constructed on an area that is underlain by soft to firm silty clay to clay up to 4.6m below the ground surface. Following are our recommendations:

1. The construction of highway over the swamp underlain by soft to firm clay up to 13.3m deep will be difficult, expensive and will require post construction maintenance due to long term settlement. We recommend that the existing alignment should not be chainged. Also, the height of the embankment up to 7m at the north end of Swamp 4 is enormous and should be lowered.

2. To avoid large post construction settlement, completely remove the peat and soft to firm cohesive material above the bedrock or above the non cohesive material. The maximum depth of excavation at Swamp 3 and 4 will be 8.7m and 13.3m respectively. Excavation to such depth is beyond the limit of conventional equipment. Special equipment will be required to do the excavation.

3. The embankment may be constructed by partially excavating peat or soft material up to 6m and then back filling with rockfill. However, there will be on going settlement problem and ongoing maintenance of the highway will be required. If this option is chosen then excavate and remove the peat and soft material within 6m below the existing grade and then construct the embankment with rockfill. The rockfill will displace some of the material. Apply a surcharge load of 1.5m thick small size rockfill to accelerate the consolidation process. Leave the surcharge load for as long as possible but for a minimum period of six month.

For the proposed new alignment at the three swamp crossings, there will be construction difficulties in achieving the above recommendations. Also, no matter what construction method is used there will be a long term settlement problem that will require ongoing maintenance.

Existing Highway Grade Raise

Swamp Area No 1

At this location, the existing highway was constructed over a swamp. There has been on going settlement at this location and the highway has been repaired several times by adding more material. This indicates that there is still peat or soft material under the highway. We understand that berms were also added on the east and west sides of the highway to correct the problem but settlement is still occurring. We understand that the sag at this portion of the highway is substandard and it is proposed to raise the grade by 1.8m or higher. Initially we suggested not to raise the grade because any grade raise in this area would cause substantial settlement or failure. However, we understand that it is proposed that after the southbound lane is constructed, all the traffic will be diverted over the southbound lane and the existing highway will be excavated and reconstructed.

Due to adjacent new southbound lane there will be a limit to the excavation depth so that the stability of the new southbound lane is not affected. Also, due to ongoing settlement and repair by putting more material in this area we think that the granular fill in this area will be quite thick. In view of the limited depth of excavation due to adjacent southbound lane we expect that the excavation will be within granular material. If we excavate about 3.2m of fill material with unit weight 18 kN/m3 and replace it with slag then we can raise the grade to 1.8m above the existing grade without adding any extra load at this location. We have come up with a equation so that you can calculate how much grade can be raised. Assuming the excavation at the existing highway will be within granular or rockfill material of unit weight 18 kN/m3 and assuming the backfilling and the grade raise will be carried out by using lightweight fill (unit weight 11.5 kN/m3) the depth of excavation and the height of grade raise can be calculated by the following equations without any load increment:

Depth of excavation = 1.77 X Proposed height of fill above present grade

Proposed height of fill above present grade = 0.56 X Depth of excavation

Therefore, if it is proposed to raise the grade by 1.8m then 3.2m excavation will be required to remove the existing granular material provided the entire fill material is slag. However, if the granular material is only 1.8m thick then after the granular material is removed and backfilled with slag, the allowable grade raise will be 1.0m only. The regional geotechnical section shall verify the thickness of fill material in that area.

Since the peat or any soft material from this area cannot be completely removed due to limitation to the excavation depth, the highway will still experience ongoing settlement and will require maintenance. If the weight of the road is reduced by excavating more granular material, replacing it with lightweight material and reducing the proposed grade height, then post construction maintenance may be minimized.

> The excavation to reconstruct the existing highway should be carried out in strips as detailed in Foundation Report W.P. 217-89-00 (A) dated May 9, 1994 for the Southbound lane construction. The recommendation for the southbound lane construction over the swamp will be as detailed in our Foundation report W.P. 217-89-00 (A) dated May 09, 1994.

The final report will be provided as soon as the lab test results are available and the borehole location plans are ready.

Due to staffing constraints and new procedure for hiring consultants, the minimum delivery time for a Foundation Report should be 4 months if done in house and 6 months if given to a consultant. We suggest that strategic plan should be developed for additional crossing at Hwy 69. We will assist you in the process.

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

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

cc:

E. Clinch
J. McDougall
T. Kazmierowski

Golder Associates Ltd.

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Mississauga, Ontario, Canada L5N 5S3
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Fax (905) 567-6561

Golder Associates

July 14, 1997

971-1160

Cole, Sherman & Associates Ltd.
75 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N9

Attention: Mr. Bram H. Hurd, P.Eng.
Senior Associate

RE: SWAMP CROSSINGS, HWY. 69
FROM MUSKOKA RD. #38 TO THE MUSQUASH RIVER
W.P. 689-93-00
DISTRICT 52, HUNTSVILLE

Dear Sirs:

Golder Associates Ltd. has been requested by Cole, Sherman & Associates Ltd., at the direction of the Ministry of Transportation, Ontario to provide a review of options available for the embankments over the swampy areas for the above mentioned project. It was agreed that the work should be carried out in two stages.

The first stage would comprise of the following tasks:

- Review existing data
- Meeting with Pavement and Foundation Section Engineers
- Meeting with Terrafix technical staff
- Prepare a preliminary letter reviewing a range of viable options and outlining the details for the Stage II work to develop a final report with recommendations for the option selected by the design team

This letter outlines the options available and a brief description of each option with the respective advantages and disadvantages.

SITE DETAILS AND HISTORY

There are four areas where embankment construction for the Hwy. 69 over swamps are required for this project. The Ministry's references for these swamp crossings are as follows:

- ***Swamp Crossing Area No. 1***

At this location, the existing highway #69 merges with the proposed Hwy. 69 alignment and the existing Hwy. 69 two lanes, will be designated as northbound lanes (N.B.L.). The design will require a 1.8 m grade raise over the existing grade. Recommendations pertaining to the proposed higher grade are given in a memo dated May 5, 1997 to Planning and Design Section, Northern Region, MTO from the Ministry's Pavements and Foundation Section.

The new Hwy. #69 requires the construction of southbound lanes (S.B.L.) where these two lanes crosses a swamp area between Sta. 17+200 and Sta. 17+300 (centreline of proposed Hwy. 69). The recommendations for the southbound lane construction over the swamp was provided in a Foundation report W.P. 217-89-00(a) dated May 9, 1997.

- ***Swamp Crossing Area No. 2***

This area is located in the vicinity of Sta. 17+500 and Sta. 17+570 (centreline Hwy. #69) and at this location, the alignment is completely new. The area is located north of Muskoka Rd. #32 and is covered with 1.1 to 1.2 m of water giving the appearance of a pond. The Ministry's Foundation Section carried out two boreholes (BH #5 and BH#7), however, an attempt, to put a third borehole was unsuccessful due to melting ice conditions.

At this location, the proposed northbound lanes (N.B.L.) will be in a cut section and whereas, the southbound lanes (S.B.L.) will be crossing the swampy area.

- ***Swamp Crossing Area No. 3***

This swamp lies between Sta. 17+880 and Sta. 17+920 (centreline Hwy. 69). In this area, the western half of the proposed Hwy #69 will require embankments over the swamp. It appears that the swampy area does not encroach the northbound lanes. However, at this location, the embankments for the northbound lanes will be over the soft to firm silty clay deposits. The Ministry's Foundation Section carried out two boreholes (BH#8 and BH#9) but not one in the vicinity of the northbound lanes.

- ***Swamp Crossing Area No. 4***

This is the largest swamp crossing and it is located between Sta. 17+980 and Sta. 18+268 (centreline Hwy. 69). At this location, the western half (southbound lanes) will be situated in the swamp area whereas the eastern portion of Hwy. #69 (northbound lanes) will be underlain with soft to firm silty clay. The Ministry's Pavement and Foundation section carried out ten boreholes (BH #8 to BH#19).

SUBSURFACE CONDITIONS

The data obtained from the Ministry's geotechnical investigation is summarized in the following Table 1.

TABLE 1
RESULTS OF FOUNDATION INVESTIGATION DATA SUMMARY

Location	Reference Borehole Nos.	Depth of Water (m)	Depth of Peat (m)	Depth of Clay (m)	Undrained Shear Strength of Clay kPa	Sensitivity of Clay	Depth to Hard Bottom
Swamp Area 1	2-1 to 2-10	-	4.3 to 7	1.5 to 10.4	7 to 28	2 to 6	7.5 to 17.4
Swamp Area 2	5 and 7	1.1 to 1.2	1.0 to 2.5	3.3 to 9.8	12 to 32	3 to 6	5.5 to 13.2
Swamp Area 3	8 and 9		2.6	3.5 to 6.1	12 to 34	2 to 4	6.1 to 8.7
Swamp Area 4 S.B.L.	10 to 14 (both inclusive)		1.5 to 5.3	2.6 to 9.4	10 to 28	3 to 8	1.5 to 12.2
Centreline Median	15 and 16		0 to 4.5	2.3 to 8.8	6 to 38	3 to 6	2.3 to 13.3
N.B.L.	17, 18 & 19		No peat	1.9 to 4.6	15 to 30	6 to 8	1.9 to 4.6

Water level is generally at the ground surface at all boreholes except BH #5 and #7, where the ground is covered with 1.1 to 1.2 m of water.

The soil conditions at the site consisted of peat overlying very soft to firm silty clay to clay over silty sand or bedrock. In certain locations, the peat was not present and the silty clay to clay was found immediately below the ground surface.

- ***Peat***

Organic peat was encountered below the ground surface to a maximum depth of 5.3 m below existing ground surface. This fibrous peat was dark brown to black.

- ***Silty Clay to Clay***

Underlying the peat or immediately below the ground surface, a cohesive very soft to firm silty clay to clay was encountered. The undrained shear strength is as low as 5 kPa in the upper portion and generally increasing with depth to a maximum value of 34 kPa at the lower portion of the deposit with sensitivity ranging from 2 to 8.

DESIGN OPTIONS

The centreline of the new Highway 69 alignment traverses peat bogs or rock outcrops and in this particular project, four swamp crossings are to be designed, designated as swamp 1, 2, 3 and 4 as described elsewhere. A number of factors influence the selection of the most appropriate alternative for the swamp crossings underlain by extensive very soft to firm cohesive silty clay to clay deposits. Constraints associated with project schedules, costs and technical reasons will influence the most appropriate alternative. In the Phase I study, viable options for the swamp crossings are discussed. These are as follows:

- Geosynthetic reinforced embankment over peat, and or very soft to firm silty clay to clay with surcharge.
- Displacement method of embankment construction by blasting techniques over weak areas.
- Full depth excavation of peat and compressible clay deposits backfill with blast rock.
- Pile foundation supported trestle to cross the weak areas.
- Long term, unreinforced, staged construction with surcharge.
- Partial excavation and displacement with surcharge.

A brief description of each option concept is described as follows:

Option 1 - Geosynthetic reinforced embankment over peat, and or soft to firm silty clay to clay

In this method, the foundation system is a structurally stabilized soil system in which a sufficient prism of geogrid reinforced soil creates a foundation capable of supporting heavy loads over organic and/or inorganic subsoils of marginal bearing capacity. The reinforcing system can be constructed as follows:

i) Trees and shrubs are cleared leaving the root mat and vegetative surface undisturbed.
ii) A layer of stiff biaxial geogrid is placed directly on the surface of the swamp parallel to the highway centreline. The biaxial geogrid is used to help create a construction platform by distributing loads over a larger surface area. In areas where the free standing water exceeds one metre in depth, it may be necessary to use a raft to assist in the installation. Alternatively, the pond area could be drained.

iii) Immediately over the biaxial geogrid, the first layer of uniaxial geogrid is installed perpendicular to the centreline. The uniaxial geogrids provide the primary reinforcing for the long term stability of the embankment.
iv) One metre of blast rock fill is end dumped and spread in one lift over the two layers of geogrid. This results in a stable construction platform capable of supporting construction equipment and the main central embankment.
v) The central embankment is then constructed with fill and alternating layers of primary geogrid reinforcing as required.
vi) If necessary, a surcharge of 1.0 to 1.5 m may be placed on top of the central embankment to help accelerate consolidation.
vii) If necessary, wick drains may be installed in the areas of clay deposits of extensive thickness to accelerate consolidations of the deep deposits of clay.

According to available information, geosynthetic reinforcement can be placed underwater by anchoring to the original ground surface. In places where surface conditions are soft, a geogrid working mat is necessary to facilitate construction equipment to the designated area. Locally available blast rock can be used for embankment construction and also for surcharge requirements.

The final design should ensure the internal and external stability of the proposed embankment. Furthermore, drainage, consolidation and settlements are to be addressed in the final design.

Option 2 - Displacement Method of Embankment Construction Over Weak Soils (Peat and/or very soft to firm silty clay to clay) by Blasting Techniques

This method of construction requires a very detailed assessment of the properties of the peaty soils and also the properties of the underlying clay deposit. In addition, a review of the thickness of the compressible deposits in relation to the height of the embankment, is necessary.

In North American highway construction, the following methods for displacing organic and/or inorganic soils with explosives have been used:

a) Toe shooting
b) Underfill blasting
c) Ditching
d) Relief method

For this particular project a review of underfill blasting will be appropriate. The underfill blasting is carried out as follows:

i) The vegetative mat is thoroughly broken up by blasting.
ii) The fill is placed and the explosives are pushed through the fill well into the peat and clay to the depth of displacement. For greater depths of displacement of peat and clayey deposits, explosive setting of the compressive layers by blasting in stages.
iii) To achieve maximum displacement and minimize the possible entrapment of soft pockets below the fill, it is essential to restrict the mud waves formed, by progressive removal through the use of draglines, by dredging or eroding the mud waves with high pressure water jets.
iv) The effective use of explosives is to place them in the lower thirds of the soft deposits and allow the mud wave to form ahead of the embankment; the fill is surcharged at the nose and the explosive then fired. Mud wave blasting could be carried out at intervals of forward advance of the fill equal to the fill height.

This method of construction has been used successfully in Ontario for Rainy Lake causeway construction and also elsewhere in Canada. If this option is adopted a detailed examination of the soil properties, the extent of the weak deposits with longitudinal and transverse profiles including blasting techniques and staging requirements are necessary.

Option 3 - Full Depth Excavation of Peat and Very Soft to Firm Silty Clay to Clay with Replacement of Blast Rock

This method of construction has been used in Ontario over the past for excavating weak organic and/or inorganic soils for full depth excavation. The excavation is then replaced with blast rock. In this type of construction, the avoidance of undermining the adjacent ground is essential to ensure the safety of the heavy excavation equipment. Sequence and staging of excavation and backfilling has to be examined to develop special information to the contractor. Stability has to be ensured at all times and disposal sites have to be investigated. The availability of equipment and its cost effectiveness has to be investigated if this option is chosen.

Option 4 - Pile Foundation Supported Trestle Over the Weak Deposits

This method is also a viable option since pile could be driven to an end bearing stratum such as dense sand or bedrock. At these crossings, end bearing stratum exists within a maximum depth of 13 m ±. Piles could be designed to the maximum selected structural capacity of the pile section. Timber and steel 'H' piles are to be considered for a trestle type of structure.

Option 5 - Long term, Unreinforced Embankment, Stagged Construction with Surcharge

This method of construction is not a new concept but requires considerable time for construction to dissipate porewater pressure and thus consolidate the underlying weak soils. Since scheduling is set, this concept may not be a suitable option for this particular project.

Option 6 - Partial Excavation/Displacement of Weak Peaty Soil and Clay, and Backfilling with Blast Rock plus Surcharge

In this method of construction, peat and soft clay deposits will be excavated to a reasonable depth and also the weaker clay soil is displaced by end dumping with blast rock. In addition, surcharge is required to accelerate settlements. Stability and settlements have to be investigated. Long term maintenance of the highway has to be considered. Disposal of excavated material has to be investigated.

A table (Table 2) provides the advantages and disadvantages of the above options. The final choice of the option could be developed based on the details provided in this letter together with other considerations by the design team.

TABLE 2
VIABLE OPTIONS AND ITS ADVANTAGES AND DISADVANTAGES

Option No.	Advantages	Disadvantages
1 Geosynthetic Reinforced Embankment	1) No environmental impacts since peat and clay soils are left in place. 2) Peat compresses quickly and develops as a strong base mat. 3) Proven performance for a Hwy. 69 project by MTO in 1992. 4) Materials and skills are available in Ontario. 5) Requires only embankment and surcharge material.	1) Side berms may be required. 2) Requires surcharge to be left in place for 4 to 6 months. 3) Excavation of the upper portion or embankment is necessary to place subbase materials. 4) Requires skilled staff to supervise installation.
2 Displacement by Blasting	1) Proven successful method (Ref. Rainy Lake causeway).	1) Requires a very competent blasting contractor with the guidance of a geotechnical expert. 2) Possible entrapment of soft zones below the fill.

Option No.	Advantages	Disadvantages
		3) Requires work to be carried out on 24 hour basis to facilitate displacement in remolded condition. 4) Mud wave material may require some removal.
3 Full Depth Excavation and Backfilling	1) No surcharge is necessary. 2) Surplus blasted rock could be used for backfilling.	1) Requires heavy equipment to reach the base of the clay. 2) Slow and may be costly. 3) Require disposal sites and hauling equipment for excavated material. 4) Require good construction supervision to ensure all the weak material is removed and hard bottom is reached prior to backfilling. 5) Large quantities of material is needed to backfill the excavation.
4 Pile Supported Trestle	1) Design could be developed without any difficulties. 2) No post construction settlements.	1) Construction requires time. 2) May not be economical. 3) Requires structural superstructure. 4) Pile driving equipment required for the installation of piles.
5 Long Term Staged Construction	1) Requires small quantities of fill for embankment / surcharge.	1) Very slow and requires instrumentation to monitor porewater pressures at all stages of construction. 2) Long term maintenance required to accommodate post construction settlements.
6 Partial Excavation and Backfilling	1) Excavation by standard equipment to partial depth (peat and some soft clay). 2) Requires less quantities of blast rock compared to full depth excavation.	1) Full displacement of clay is not achieved. 2) Post construction settlements and maintenance. 3) Berms may be required to ensure stability during construction. 4) Surcharge may be needed to reduce post construction settlements.

We trust this letter provides sufficient information with regard to viable options for the construction of embankments underlain by soft organic, and/or inorganic soils. A geosynthetic reinforced embankment (Option #1) appears to be a viable option for this project, as well as Option #2 and #3. Should you require any clarification, or any questions, please contact us.

Yours very truly,

GOLDER ASSOCIATES LTD.

M.S. Devata, P.Eng.
Consultant

F.J. Heffernan, P.Eng.
Consultant

MSD/FJH/dh

71160GL1.DOC

Ontario

memorandum

To:	Evan Clinch Pavement Design and Evaluation Officer Geotechnical Section Northern Region	1997 04 23
From:	Pavements and Foundation Section Room 315, Central Building Downsview, Ontario	
Re:	Preliminary Comments Swamp Crossings Highway 69, From Muskoka Rd 38 Northerly to the Musquash River W.P. 689-93-00 Highway # 69, District 52, Huntsville	

The fieldwork for the above project is complete. The lab tests are in progress. We have produced borehole logs and cross sections. Further calculations and analyses will determine feasibility of the proposal, embankment height and width of any berms.

In the mean time, this memo will provide you information on the soil condition and our comment on the feasibility of the project. The preliminary recommendation will be provided to you shortly. The final report will be provided once the lab test results are completed and the PDR drawings from your office is available (with correct stations marked on it).

Within the limit of this investigation the new alignment of Hwy 69 will cross three swamp areas. For the purposes of discussion and reference we have identified these areas as follows:

Swamp Area 1:	The area is located on the south side within the limits of this project in the vicinity of station 17+500. This area looks like a pond. Perhaps there is a beaver dam as well.
Swamp Area 2.	The small swamp area in the middle, in the vicinity of station 17+900.
Swamp Area 3:	The large swamp area located between stations 17+980 and 18+268. This area is located on the north side within the limits of this project.

In swamp Area 1, two boreholes were put down (BH5 and BH7). A third borehole BH6 could not be drilled in this area as the ice broke and the drilling machine got trapped in the pond. The boreholes encountered peat up to 2.3m thick. The peat was underlain by very soft to firm silty clay to clay. The thickness of the silty clay deposit ranged from 3.3m to 9.8m. The Standard Penetration N-values within the peat and silty clay material generally ranged from no resistance to 1 blow per 0.3m penetration. The silty clay was underlain by non cohesive silty sand to sand and gravel. With the proposed new alignment, the toe of the embankment will be 35m west into the pond (swamp). This area is not feasible for the proposed embankment. We recommend that the present alignment of the highway at this location should not be changed.

In swamp Areas 2 and 3, the boreholes encountered peat ranging from approximately 2.5m to 5.5m thick. The peat was underlain by very soft to firm silty clay to clay. The Standard Penetration N-values within the peat and silty clay material generally ranged from no resistance to 1 blow per 0.3m penetration. The silty clay was either underlain by non cohesive silty sand to sand and gravel layer or overlying probable bedrock. In Area 3 peat was mainly concentrated on the west side of the proposed centreline. In these areas excavation will be required to remove the peat in order to construct the embankment over the silty clay. However, wide mid height berms will be required to provide adequate factor of safety against slope failure. We are doing slope stability analyses to determine the width of the berms. In addition, geogrid may also be required to construct the embankment over the swamp. To design the embankment over geogrid, we may have to retain a local company Terrafix for their services who have design similar projects on Hwy 69. The preliminary recommendations will be provided to you shortly.

If the PDR drawings area ready, please provide us at your earliest so that we can plot our boreholes on them for our final report.

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

For

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

cc: P. Lecoarer

memorandum

Ontario

To: T. Kim, P. Eng.
Sr. Foundation Engineer

From: Geotechnical Section,
Northern Region

Date: 10 February 1997

Phone: 1-705-497-5478

Subject:

WP 689-93-00
Highway 69, From Muskoka Road 38,
Northerly To the Musquash River.
District 52, Huntsville.

As I understand it, you and Lynda Boyd discussed having the field investigations carried out, and recommendations made for some of the swamp crossings on this project. As part of the work your consultant normally provides, we would also like to have them provide the soils data that the Planning and Design Section require for quantities determination and for environmental reasons. Project details are included in this memo.

Four swamp areas require investigation. Three are on new alignment, and one is on the existing highway. This section of Highway 69 is to be upgraded to a four lane facility. The locations of the swamp areas are:

EXISTING HIGHWAY (Proposed North Bound Lanes)

Planning and Design propose raising the grade line of the existing fill between Station 17±100 and Station 17± 200 by an additional 3.0 m to correct a substandard sag.

There is a settlement problem at this location This fill has been settling since the road was constructed. The last work done at the site was carried out under Contract 89-71. A Foundations Report, which contained recommendations to stabilize the fill, was issued for that contract. Some additional settlement has occurred since that work was done. A Foundations Report for the proposed south bound lanes adjacent to this existing fill, has been issued.

NEW ALIGNMENT

There are three swamp areas that are on new alignment. Planning and Designed have stated that the fills over the swamps will be 6.0 m high. Both the proposed north bound and south bound lanes will require investigation. The locations of the swamp areas are:

Sation	to	Station
17±450		17±520
17±800		17±850
17±900		18±230

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FEB 12 1997
FOUNDATION DESIGN SECTION

A plan showing the locations of these swamp areas is attached. The highlighted line on the plan is the new centreline of median. The plan shows a north and a south bound lane to the east of the new alignment. Only the most easterly lanes presently exist. The centreline of median has been staked in the field. The centreline of the lanes are at an 18.75 m offset to the median alignment. The proposed cross-section is: 3.0 m outside shoulder, 1.5 m median shoulder, and 7.5 m wide lanes.

The soils information gathered in the field is important not only from a Geotechnical point of view, but is also important information for the Planning & Design Section. Sufficient information not only need be gathered to produce a Soils/Foundations Design but also must provide Planning & Design with enough data to calculate accurate construction quantities, and to enable them to address Environmental concerns. The following sections describe the information that must be gathered for Planning and Design use, together with the format that this data should be presented. Please pass this information on to the consultant that will be hired to carry out the investigation work for the swamp areas.

SOILS INVESTIGATION AND PRESENTATION REQUIREMENTS

1. PREAMBLE

Details for the placement and depth of boreholes, soils sampling, the preparation of boreholes logs, and other related information are outlined here. THIS INFORMATION SHOULD BE CONSIDERED AS THE MINIMUM REQUIREMENTS. Additional borings may be required to suit special conditions.

2. IDENTIFICATION OF SOIL TYPES

The soils encountered on this project shall be identified and classified using the Ministry of Transportation Soils Classification System. A copy of the MTC Soil Classification Manual is contained in the Ministry of Transportation Pavement Design and Rehabilitation Manual. Abbreviations used in the Log of Boreholes shall conform to Ontario Provincial Standard Drawing (OPSD) 100.06. A copy of OPSD 100.06 is attached to this document.

3. BOREHOLE LOCATION AND DEPTH REQUIREMENTS

Boreholes should be placed at even stations as much as possible. Extra borings are also required where an obvious change in the soil conditions occurs between stations.

Cross-Sectional Soils Information must also be provided. Boreholes shall be placed at the centreline, and to the left and/or right of the centreline, at the frequencies listed in the following.

a) Borehole Intervals Along Centreline

Fills	- 50 m - Fills of 300 mm or less in height are to be treated as cuts.
Cuts	- 25 m in earth - 20 m in rock - At the transition points - 10 m past the transition point in bedrock areas.
Muskeg and Soft Soils	- 25 m

b) Offset Intervals For Cross-sections

Fills - One section in the deepest part of the fill, minimum.

Cuts - 50 m in earth
20 m in rock

Muskeg and Soft Soils
- 50 m if uniform conditions are encountered
- 25 m if non-uniform conditions exist

Note: In areas where bedrock is present and there is a cut on one side of the Highway only, place borings on the fill side to match the borehole intervals on the cut side.

c) Offset Distances From Centreline

Fills - At toe of slope, assuming a 2:1 fill slope

Cuts
- At back of ditch line
- 5.0 m beyond ditch line in bedrock areas where overburden is 1.0 m or greater

Muskeg and Soft Soils
- 8.0 m, where the fill height is 2.0 m or less
- 8.0 m, plus the height of fill, where fill is greater than 2.0 m

d) Depth of Boreholes

Fills - Equal to height of fill, a minimum of 1.2 m, unless bedrock or refusal is encountered

Cuts - 1.5 m below profile grade line, unless bedrock or refusal is encountered.

Muskeg and Soft Soils. - Bottom of organic and/or soft materials and to firm bottom.

Notes:

I) In some areas boreholes can reach depths greater than six metres, particularly in swamp areas. Be sure you have adequate drilling equipment.

II) The difference in elevation of the original ground at the offset location and the original ground at centreline must be taken into account when drilling the offset holes. In cuts the test holes at the offset locations must be advanced to 1.5 m below the proposed profile grade at centreline. In fills the test holes drilled at the offset locations must be equal in depth to the difference in elevation of the proposed profile grade at centreline and the original ground at the offset location.

4. PREDICTION OF SOIL ERODIBILITY

The susceptibility to surface erosion shall be predicted for each soil type encountered on the project. The erosion potential of the soils shall be categorized using the Wischmeier Nomograph, and the "K" Factor shall be recorded on the Borehole Notes. Details concerning the use of the Wischmeier Nomograph are given on page 117 of the Pavement Design and Rehabilitation Manual. A copy of the Wischmeier Nomograph is provided on page 118 of that manual.

To use the nomograph, the percentages of silt, sand, and organics contained in the earth materials must be known. When using the Wischmeier Nomograph, Silt is defined as soil particles between 2 µm and 75 µm. Sand is defined as soil particles that are between 75 µm and 2.00 mm in size.

5. SUSCEPTIBILITY TO FROST HEAVING

The Frost Susceptibility of each soil type that is found on the project shall be evaluated, and shall be identified on the Borehole Log. The soil is classed as High (HSFH), Medium (MSFH) or Low (LSFH) susceptibility to frost heaving, based on the percentage of soil particles between 5 µm and 75 µm. The classification for each soil type is established by use of the following table.

CLASS	% of Particles 5 µm - 75 µm
HSFH	55 - 100
MSFH	40 - 55
LSFH	0 - 40

6. BOREHOLE NOTES

Borehole Logs will form part of the final Contract Documents. It is important that the Township, the Work Project Number, the Highway Number, the Job Location, and lane (NBL or SBL) are recorded on the Borehole Notes.

When recording the additional borehole data gathered for Planning and Design purposes, the following format must be used.

a) Abbreviations used shall conform with the OPSD 100 series. Abbreviations for boring and test data shall conform to OPSD 100.06 only. Use only the abbreviations that are listed, do not make up new and/or alter abbreviations.

b) A field estimate of the moisture content for all materials identified on a borehole log is required. A soil shall be designated as Dry, Moist or Wet. These calls are related to the Optimum Moisture Content for that particular soil type as listed here:

Dry - Moisture content well below optimum
Moist - Moisture content at or near optimum
Wet - Moisture content well above optimum

c) Test hole depths shall be measured in millimetres and metres only. The depths from 0 to 999 millimetres shall be measured in millimetres to 10 mm. Depths from 1.00 m and deeper shall be measured in metres to the nearest 0.01 m. Do not show units on the Bore Hole Logs.

d) The Chainage at the location where the borehole was excavated, the Offset Distance of the hole from the Centreline of the lane, and an estimate of the Ground Elevation at borehole location must be noted on the Borehole Logs.

The term "Datum" is defined as the original ground elevation at the proposed centreline of construction. The elevation of the offset hole locations shall be related to the OG elevation at centreline for the lane being investigated and shall be recorded as Datum plus or Datum minus the appropriate height.

An example of the manner in which to recorded the hole location, offset and the relative ground elevation is:

15+000 10.0 Rt C/L D+1.20

or 15+000 10.0 Lt C/L D-450

Although using the abbreviation **'D'** to mean **DATUM** is in conflict with OPSD - 100 series, this one exception is the accepted practice in the Northern Region.

e) When a boring is not advanced to the required depth the reason for abandoning the hole must be recorded. The term "No Further Progress" (NFP) is written on the field notes with the reason that drilling was stopped. Reasons for a NFP call include sloughing of the test hole or encountering boulders, bedrock or any other object that halts the drilling. The depth and reason for the NFP call is recorded in the Field Notes as shown in the following example.

10+000 C/L

0	-	100	F Sa Tps
100	-	500	F Sa Moist
		500	NFP BR

As well as in the boreholes that are abandoned before the proper depth is reached a NFP identification shall be given when sounding swamps or if bedrock or boulders are encountered at the prescribed borehole depth.

If possible, Planning and Design would like to have the recommendations and field data for these swamp areas by April 15th. unrealistic

Thank you for your attention to this matter.

Evan Clinch
Pavement Design and
Evaluation Officer

cc: P. Lecoarer
File
(\swamps.new)

ABBREVIATIONS FOR BORING AND TEST DATA

Accep	Acceptable
Agg	Aggregate
Amor	Amorphous
Asph	Asphalt
BR	Bedrock
Blk	Black
Bl	Blue
BH	Borehole
Bld (y)	Boulder (y)
Blds	Boulders
BU	Break Up
Br	Brown
CF	Channel Face
Cl	Clay
Co	Coarse
Cob	Cobbles
Comp	Compact
Conc	Concrete
Contam	Contaminated
Cord	Corduroy
Cr	Crushed
Dk	Dark
Decomp	Decomposed
D	Dense
E	Earth
Fib	Fibrous
w	Field Moisture Content
F	Fine
Fr Wat	Free Water
FB	Frost Boil
FH	Frost Heave
Gran	Granular
Gr	Gravel (y)
Grn	Green
Gry	Grey
H	Heavy
Hi	Highly
HP	High Plasticity
HM	Hot Mix
Lt	Light
Liq	Liquid
W_L	Liquid Limit
Lo	Loam
L	Loose
Mrl	Marl
Matl	Material
Max	Maximum
MDD	Maximum Dry Density
MWD	Maximum Wet Density
Med	Medium
MP	Medium Plasticity
Mod	Moderate
Mott	Mottled
Mul	Mulch
NFP	No Further Progress
NFP (Blds)	No Further Progress (Boulders)
Num	Numerous
OCC	Occasional
Wopt	Optimum Moisture Content
Ora	Orange
Org	Organic
Org M	Organic Matter
Ob	Overburden
Pavt	Pavement
Pedo	Pedological
Pen Mac	Penetration Macadam
W_P	Plastic Limit
I_P	Plasticity Index
Psty	Polystyrene
Poss	Possible
PST	Prime & Surface Treatment
Quant	Quantity
Reinf	Reinforced
RSS	Remoulded Shear Strength
RF	Rock Fill
Sa	Sand
Sat	Saturated
SH	Shale
St	Sensitivity
SSM	Select Subgrade Material
Sh Rk	Shot Rock
Si (y)	Silt (y)
Sl (y)	Slight (ly)
SP	Slight Plastic
Stn (y)	Stone (y)
D_R	Relative Density
Stks	Streaks
Surf	Surface
Temp	Temperature
TH	Test Hole
TP	Test Pit
Tps	Topsoil
Tr	Trace
USS	Undisturbed Shear Strength
Unreif	Unreinforced
Varv	Varved
VF	Very Fine
WT	Water Table
Weath	Weathered
W	With
Wd (y)	Wood (y)
Yel	Yellow

SUSCEPTIBILITY TO FROST HEAVING

HSFH - High
MSFH - Medium
LSFH - Low

ONTARIO PROVINCIAL STANDARD DRAWING

Date 1996 07 18 Rev

Date

ABBREVIATIONS

GEOTECHNICAL

OPSD - 100.06