

G.I.-30 SEPT. 1976

GEOCRES No. 400-4

DIST. 1 REGION _____

W.P. No. 43-66-18/21

CONT. No. 75-27

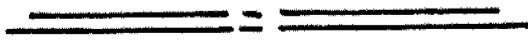
W. O. No. _____

STR. SITE No. 14-372

HWY. No. 402

LOCATION Hwy 402 & Telfer
Channel

No of PAGES -



OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

MEMORANDUM

40 O-4

TO: Mr. A. P. Watt, (2)
Regional Structural Planning Eng.,
Southwestern Region,
London, Ontario.

FROM: Foundations Office,
Design Services Branch,
West Bldg., Downsview.

ATTENTION: Mr. S. Jants,
Structural Planning Technician.

DATE: February 21, 1973.

OUR FILE REF. IN REPLY TO

FEB 28 1973

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
The Proposed Bridge Site 14-372
Hwy. 402 and Telfer Channel Diversion
Approx. 0.5 Mi. East of Telfer Rd.
District #1, Chatham
W.O. 72-11141 -- W.P. 43-66-18, 21
CONT. 75-27

40 O-4
GEOLOGICAL No.

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ao
Attch.
cc: E. J. Orr
B. R. Davis
A. Rutka
A. Wittenberg
F. C. Brown
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh

Foundations Files
Documents

TABLE OF CONTENTS

1. INTRODUCTION.
 2. DESCRIPTION OF SITE.
 3. FIELD WORK AND LABORATORY INVESTIGATIONS.
 4. SUBSOIL CONDITIONS.
 - 4.1) General.
 - 4.2) Sandy Silt, Some Clay, Traces of Gravel.
 - 4.3) Clayey Silt, Some Sand and Traces of Gravel.
 - 4.4) Silty Clay, Some Sand, Traces of Gravel.
 - 4.5) Bedrock.
 5. GROUNDWATER CONDITIONS.
 6. DISCUSSION AND RECOMMENDATIONS.
 - 6.1) General.
 - 6.2) Foundations.
 - a) Spread Footings.
 - b) Pile Foundations.
 - 6.3) Channel Slopes.
 7. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION REPORT
For
The Proposed Bridge Site 14-372
Hwy. 402 and Telfer Channel Diversion
Approx. 0.5 Mi. East of Telfer Rd.
District #1, Chatham
W.O. 72-11141 -- W.P. 43-66-18, 21

1. INTRODUCTION:

A foundation investigation was undertaken for the proposed Hwy. 402 and Telfer Channel Diversion Bridges. There are two proposals for each of the bridges; a single-span and a triple-span, two-lane structure. A request was received from Mr. S. Jants, Structural Planning Technician for the Southwestern Region, dated January 22, 1973. The field investigation was completed before this date as a machine was in the area having completed three other jobs in the vicinity. A laboratory investigation of the subsoil samples was undertaken on completion of the job. Presented in this report are the results of the investigation, together with recommendations concerning the structure foundation.

2. DESCRIPTION OF SITE:

The general area around the site is very flat. The site is situated partly on Greenwood Golf Club and an adjoining farmer's field.

Geologically, the site is part of the physiographic region known as the St. Clair Clay Plain. The region is one of little relief with a deep deposit of clay. Most of Lambton County is essentially till plains smoothed by shallow deposits of lacustrine clay which settled in the depressions while the knolls were being lowered by wave action.

3. FIELD WORK AND LABORATORY INVESTIGATIONS:

The field work consisted of eight sampled boreholes and thirteen dynamic cone tests, three of the cone tests being adjacent to the boreholes. The drilling was done by a Bombardier mounted C.M.E. equipped with hollow stem augers. The bedrock was cored using a BX core barrel. Split-spoon samples were taken at regular intervals and standard penetration tests were conducted in driving the split spoon. Thin walled 2-inch I.D. Shelby tubes were advanced into the soil either hydraulically or manually to obtain undisturbed samples. Where possible in situ shear strength was measured using a standard M.T.C. field vane.

Soil samples were identified in the field and again upon arrival in the laboratory. Laboratory tests to determine moisture content, grain size, and Atterberg Limits were carried out on representative samples.

The groundwater levels across the site were determined by recording the water levels in the open boreholes over the period of the investigation.

All field and laboratory test results are recorded on the accompanying Record of Borehole sheets. The locations and elevations of the boreholes as well as two stratigraphical profiles are shown on Dwg. #72-11141A at the end of this report. The surveying of the site was carried out by personnel from the Southwestern Region Engineering Surveys Section.

4. SUBSOIL CONDITIONS:

4.1) General:

The subsoil consists of four different deposits. As the job was partly in a farmer's field the first layer encountered was a 1 to 1.5 ft. layer of topsoil. Following this, depending on the borehole, came a layer of sandy silt, some clay, traces of

gravel then clayey silt, some sand, traces of gravel. The final subsoil before the bedrock was silty clay, some sand, traces of gravel. A summary of the main layers is given below.

4.2) Sandy Silt, Some Clay, Traces of Gravel:

This layer was encountered in five of the eight boreholes and sometimes was found directly beneath the topsoil and sometimes following a layer of clayey silt. The sandy silt varied in thickness from 2 to 3.5 feet and ranged between elevations 582 and 596. Standard penetration "N" values varied between 29 and 71 blows per foot corresponding to a compact to very dense relative density. Laboratory grain size analyses yield the following results.

Gravel	1	-	5%
Sand	23	-	48%
Silt	36	-	48%
Clay	11	-	28%

Natural moisture content ranged between 8 and 12.5%. A typical grain-size curve envelope is included in the Appendix as Fig. 1.

4.3) Clayey Silt, Some Sand and Traces of Gravel:

The clayey silt was encountered beneath the topsoil but in some boreholes followed the sandy silt. This deposit was found to a maximum depth of 55 ft. corresponding to elevation 544. The average thickness of this deposit ranged between 25 and 55 ft. Standard penetration "N" values within this layer varied between 9 and 44 blows per foot.

Laboratory grain size analyses yielded the following results:

Gravel	0	-	3%
Sand	11	-	29%
Silt	44	-	86%
Clay	0	-	43%

The following physical properties were obtained from field and laboratory tests.

Natural Moisture Content (%)	10.5 - 32
Liquid Limit (%)	25 - 37
Plastic Limit (%)	15 - 20
Bulk Density (p.c.f.)	125.7 - 131.5
<u>Undrained Shear Strength</u>	
Field Vane Test (p.s.f.)	950 - >2000

The undrained shear strength of the overall deposit is estimated to be firm to stiff. A typical grain-size envelope is included in the Appendix as Fig. 2.

4.4) Silty Clay, Some Sand, Traces of Gravel:

Following the clayey silt is a deep deposit of silty clay, some sand, traces of gravel, some 73 to 92 feet in depth. This deposit is between elevation 544 and 470 and extends to a maximum depth of 128 ft. Standard penetration "N" values range between 15 and 44 blows per foot. Laboratory grain size analyses yielded the following distributions.

Gravel	0 - 2%
Sand	6 - 13%
Silt	43 - 49%
Clay	38 - 46%

The following physical properties were obtained from laboratory tests of the subsoil samples.

Natural Moisture Content (%)	19.5 - 32.5
Liquid Limit (%)	35 - 42
Plastic Limit (%)	19 - 22
Bulk Density (p.c.f.)	119 - 130
<u>Undrained Shear Strength</u>	
Field Vane Test (p.s.f.)	750 - >2000

Based on the foregoing the consistency of the deposit is estimated to be firm to hard. A typical grain-size envelope is included in the Appendix as Fig. 3.

4.5) Bedrock:

A brief description of the bedrock has been given by Mr. K. W. Ingham, Geologist, for the borehole drilled to bedrock at this site, together with the appropriate bedrock elevation.

Hole No. 12	Bedrock at 472.0
472.0 - 477.5	Interbedded medium grey shaley limestone and light grey limestone; fine grained, generally thin to medium bedded.

5. GROUNDWATER CONDITIONS:

The following groundwater levels were observed in the following B.H.'s during the field investigation.

B.H. #2	Elevation 577.2
B.H. #9	Elevation 567.7
B.H. #12	Elevation 587.0

These levels may not be representative of the actual groundwater levels due to the relatively impermeable nature of the subsoil and the short duration of the field work.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

There are two proposals for this site, a single span (84') structure and a three span (53' - 53' - 53') structure. The proposal consists of twin structures to carry Hwy. 402 over Telfer Channel Diversion. The profile grade of Hwy. 402 at this point is about elevation 599, approximately 2 to 3 ft. above the existing ground level. The base of the channel will be at elevation 575.

The subsoil at this site consists mainly of a deep deposit of clayey silt and silty clay. The upper 9 to 12 ft. is a very stiff to hard desiccated surface crust. Below the crust the undrained shear strength of the material decreases until a minimum value of about 800 p.s.f. is reached, then increases again with depth, with some random variation.

6.2) Foundations:

a) Spread Footings:

If the structure is built on spread footing, the following design criteria are suggested.

Eastbound Structure

For the single-span structure both abutment footings may be placed at or below elevation 571 with a safe net pressure of 1.5 t.s.f.

For the three-span structure the abutments may be placed at elevation 590 and the piers at or below elevation 571, both with a safe net pressure of 1.5 t.s.f.

Westbound Structure

For the single-span structure both abutments may be placed at or below elevation 571 with a safe net pressure of 1.5 t.s.f.

For the three-span structure the abutments may be placed at elevation 590 with a safe net pressure of 1.5 t.s.f. Both piers may be placed at or below elevation 571 with a safe net pressure of 1.5 t.s.f.

As the subsoil is susceptible to softening on contact with water, it is recommended that the footing excavations be protected by a concrete working slab, immediately on exposure.

Settlement calculations indicate that the footings for these structures will settle in the range of 1.5 to 2.0 inches. It is recommended that the structure either single span or triple span be built to accommodate a 1.0 inch differential settlement between adjacent footings.

The foundations should be protected against scour. The depth of scour may be obtained from the Hydrology Office.

b) Pile Foundations:

As an alternative the structures for both proposals may be founded on timber piles. These piles should be driven to

the elevation necessary to achieve the required pile capacity. It is recommended that the piles be treated if they are not completely below the groundwater level. In determining the safe capacity of a timber pile, the following equation may be used.

$$Q = 0.5 L \text{ (Tons)}$$

where Q = safe capacity of one pile

L = embedded length in original ground (ft.)

Maximum settlements for the pile groups were calculated to be in the order of 1.5 inches. It is recommended that the structure be built to accommodate a 1.0 inch differential settlement between abutments and piers.

As a second alternative the structure may be supported on steel H-piles driven to bedrock utilizing the maximum allowable design load for the particular steel section used.

All footings and/or pile caps should be protected against frost action by at least 4 feet of earth cover.

No major dewatering problems are anticipated because of the relative impermeable nature of the subsoil.

6.3) Channel Slopes:

It is recommended that the proposed channel be constructed with 2:1 slopes and be protected against scour action in the vicinity of the new structure.

7. MISCELLANEOUS:

The field work was carried out from December 12, 1972, to January 10, 1973, and was supervised by Mr. P. Korgemagi, Project Foundations Engineer.

The equipment used was owned and operated by P.V.K. and Sons Drilling Ltd., Burford, Ontario.

This report was written by Mr. P. Korgemagi and reviewed by Mr. K. G. Selby, Supervising Foundations Engineer.

P. Korgemagi
P. Korgemagi, P. Eng.



K. G. Selby
K. G. Selby, P. Eng.

PK/ao
Feb. 19/73

APPENDIX I

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 72-11141

LOCATION Sta. 206+06 o/s 35' LT. of Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18,21

BORING DATE December 21, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *PK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT w_L			BULK DENSITY γ	REMARKS				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS/FOOT	25	50	75	100	125	PLASTIC LIMIT w_p	WATER CONTENT w			WATER CONTENT %	P.C.F.	GR.	SA.
597.1	Ground Level																			
0.0	Clayey Silt Some sand & Traces of Gravel (probable)																			
10.9	End of Cone Test																			

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 72-11141

LOCATION Sta. 206 + 06 o/s 77' LT. & Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18,21

BORING DATE January 8, 1973

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT %				
597.2	Ground Level														
0.0	Top Soil														
1.5	Clayey Silt Some sand & Traces of Gravel		1	SS	14	590									
589.7															
7.5	Sandy silt with clay V. Dense Traces Gravel		2	SS	71	590									1 23 48 28
586.2															
11.0	Brown		3	SS	23	580									
16.5	Grey		4	SS	20										
572.2	Stiff to Hard		5	SS	17	570									
25.0															
	Silty Clay Some Sand Traces of Gravel		6	TW	PH	570								128.5	
	Very Stiff		7	SS	19	560									2 11 49 38
			8	TW	PH	560								128.5	
551.7	End of Borehole		9	SS	15	560									
45.5															

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 72-11141

LOCATION Sta. 206+44 o/s 35' LT. of Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18,21

BORING DATE December 21, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		25	50	75	100	125	W_P	W		
597.5	Ground Level														
0.0	Clayey Silt Some Sand & Traces of Gravel (probable)														
589.5						590									
8.0	End of Cone Test														

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 5

JOB 72-11141

LOCATION Sta. 206+60 o/s 35' LT. of Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18,21

BORING DATE January 5, 1973

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — W _L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		25	50	75	100	125	PLASTIC LIMIT — W _P	WATER CONTENT — W			γ
						SHEAR STRENGTH P.S.F.				W _P — W — W _L		WATER CONTENT %		P.C.F.	GR.SA.SI.CL	
597.3	Ground Level															
0.0																
	Clayey Silt Some Sand Traces of Gravel															
21.0																
	Probably Same															
547.4																
49.9	End of Cone Test															

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 6

JOB 72-11141

LOCATION Sta. 206+60 o/s 77' LT. of Hwy. 402

ORIGINATED BY PK.

W.P. 43-66-18,21

BORING DATE January 9, 1973

COMPILED BY PK.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT W_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	BLOWS / FOOT	PLASTIC LIMIT W_P	WATER CONTENT W			
									W_P	W	W_L	P.C.F. GR. SA. SI. CL.
597.3	Ground Level											
0.0	Top Soil											
1.5			1	SS	36	Dry Hole						
589.8												
587.3	Sandy Silt clay some Very Dense gravel		2	SS	56	590						4 32 44 2
10.0	Brown											
12.0			3	SS	22							
	Clayey Silt		4	SS	12	580						0 17 47 3
	Some Sand											
	Traces of Gravel		5	TW	PH						130.5	
			6	SS	14	570						
	Stiff to Hard		7	TW	PH						130.5	
	Grey		8	SS	15	560						
			9	SS	20							3 12 47 3
548.3												
49.0	Silty Clay		10	SS	16	540						w/L. Not DETERMINED
	Some Sand											
	Traces of Gravel		11	SS	15	530						
	Very Stiff to Hard											
523.3			12	SS	38							
74.0	End of Borehole											

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 8

JOB 72-11141

LOCATION Sta. 207+12 o/s 77' LT. of Hwy. 402

ORIGINATED BY PK.

W.P. 43-66-18,21

BORING DATE January 5, 1972

COMPILED BY PK.

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY [Signature]

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT —WL PLASTIC LIMIT —Wp WATER CONTENT —W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FOOT	25	50	75	100	125	Wp	W		
597.0	Ground Level														
0.0	Clayey Silt Some Sand Traces of Gravel														
20.0	Probably Same														
555.0															
42.0	End of Cone Test														

20
15 5 % STRAIN AT FAILURE
10

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 9

JOB 72-11141

LOCATION Sta. 207+28 o/s 35' LT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18, 21

BORING DATE December 14th to 15th, 1972

COMPILED BY P.K.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT w_L			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS/FOOT	SHEAR STRENGTH P.S.F.		WATER CONTENT %					
							1000	2000							
597.7	Ground Level														
0.0	Top Soil														
			1	SS	32										
			2	SS	34										
			3	SS	37	590									2 29 48 2
10.0	Brown		4	SS	19										
585.7	Silty sand some clay		5	SS	47										5 48 36 1
12.0	Dense Traces of Gravel		6	SS	11	580									
582.7	Grey		7	SS	12										
15.0	Clayey Silt some sand Traces of Gravel		8	TW	PH	570									
	Stiff to Hard		9	SS	20										
			10	TW	PH	560									
			11	SS	14	550									5 16 44 3
551.7			12	SS	10	540									
46.0	Silty Clay Some Sand Traces of Gravel		13	SS	19	530									
	Stiff to Hard		14	SS	39										
523.7															
74.0	End of Borehole														

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 11

JOB 72-11141

LOCATION Sta. 207+65 o/s. 35' LT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18, 21

BORING DATE December 18, 1972

COMPILED BY P.K.

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_l			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		25	50	75	100	125	PLASTIC LIMIT — w_p	WATER CONTENT — w			
						SHEAR STRENGTH P.S.F.					w_p	w	w_l			
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT %					
596.3	Ground Level															
0.0	Clayey Silt some sand Traces of Gravel (probable)															
586.4						590										
9.9	End of Borehole															

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 12

JOB 72-111h1

LOCATION Sta. 207 + 65 o/s 77' Lt. Ø Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18, 21

BORING DATE Dec. 12 to 14, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow stem auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.		W _p	W	W _L		
597.0	Ground Level												
0.0	Topsoil												
1.0	Sandy silt, some sand												
593.0	traces gravel. Dense		1	SS	36								2 32 42 21
4.0	Brown		2	SS	44								
	Clayey silt, some sand.		3	SS	41								
9.5	traces gravel		4	SS	26								
			5	SS	15								2 19 46 33
	Grey		6	SS	13								
	Stiff to Hard		7	TW	PH						128.0		
			8	SS	14								
562.0			9	SS	25								
35.0	Silty clay, some sand, traces of gravel.		10	TW	PH						127.0		
			11	SS	20								1 12 49 38
	Grey		12	SS	19								
	Stiff to Hard		13	TW	PH						119		
			14	SS	14								
			15	SS	25								
			16	TW	PH						123		
			17	SS	31								1 13 43 43
			18	SS	40								

Continued

20
15 5 % STRAIN AT FAILURE
10

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 12 Contineud

JOB 72-11141

LOCATION Sta. 207 + 65 o/s 77' Lt. Ø Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18, 21

BORING DATE Dec. 12 to 14, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow stem auger

CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT W_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS/FOOT	SHEAR STRENGTH P.S.F.		PLASTIC LIMIT W_p	WATER CONTENT W			
							○ UNCONFINED	+ FIELD VANE	W_p	W	W_L	P.C.F.	GR.SA.SI.CL.	
							● QUICK TRIAXIAL	x LAB VANE						
							1000	2000	10	20	30			
472.0	Silty clay, some sand, traces of gravel.	[Hatched]	19	SS	28	490								
	Grey Stiff to Hard	[Hatched]				480								
125.0	Shaley Limestone Bedrock	[Pattern]	20	RC BX	96%	470								
465.4	Sound	[Pattern]												
131.6	End of Borehole													

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 13

JOB 72-11141

LOCATION Sta. 206+06 n/s 36' RT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18, 21

BORING DATE December 21, 1972

COMPILED BY P.K.

DATUM Gendetic

BOREHOLE TYPE Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		25	50	75	100	125	W _P	W	W _L			P.C.F.	GR.	SA.
598.3	Ground Level																		
0.0	Clayey Silt some sand Traces of Gravel (probable)																		
589.3						590													
9.0	End of Cone Test																		

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 14 Continued

JOB 72-11141

LOCATION Sta. 206+06 o/s 78' RT. of Hwy. 402

ORIGINATED BY _____

W.P. 43-66-18,21

BORING DATE January 3rd to 4th, 1972

COMPILED BY _____

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY _____

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FOOT	25	50	75	100	125	W_P	W			W_L
						SHEAR STRENGTH P.S.F.					WATER CONTENT %					
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE					10 20 30					
						1000 2000										
	A Silty Clay Some Sand Traces of Gravel Grey Stiff to Hard					490										
			17	SS	44		480									
470.1			18	SS	100	471"										
128.4	End of Borehole															

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 15

JOB 72-11141

LOCATION Sta. 206+44 n/s 36' RT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18, 21

BORING DATE January 10, 1973

COMPILED BY P.K.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		BULK DENSITY	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	W _p	W _L			WATER CONTENT %	
598.0	Ground Level						1000 2000							
0.0	Top Soil													
1.5	Brown Grey Clayey Silt Some Sand Traces of Gravel Stiff to Hard		1	SS	18	Dry Hole						W.L. Not Determined		
			2	SS	38	590								
11.5			3	SS	11								2 16 48 3	
			4	SS	9	580								
			5	TW	PH							129		
			6	SS	10	570								
			7	TW	PH							125		
			8	SS	16	560							1 13 48 3	
			9	SS	18									
									> 2000					
549.0			Silty Clay Some Sand Traces of Gravel Grey Very Stiff		10	SS	22							
49.0					11	SS	19	540						
	12	SS			19	530								
524.0														
74.0	End of Borehole													

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 17

JOB 72-11141

LOCATION Sta. 206+60 o/s 36' RT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18, 21

BORING DATE December 20, 1972

COMPILED BY P.K.

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	BLOWS / FOOT					PLASTIC LIMIT — w_p	WATER CONTENT — w			γ
							25	50	75	100	125	WATER CONTENT %				
												w_p	w	w_L		
							SHEAR STRENGTH P.S.F.									
							○ UNCONFINED + FIELD VANE									
							● QUICK TRIAXIAL × LAB VANE									
598.2	Ground Level															
0.0																
	Clayey Silt Some sand Traces of Gravel (probable)					590										
580.2																
18.0	End of Cone Test															

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 18

JOB 72-11141

LOCATION Sta. 206+60 o/s 78' RT. of Hwy. 402

ORIGINATED BY PK.

W.P. 43-66-18, 21

BORING DATE December 21, 1972

COMPILED BY PK.

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *PK.*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT % w_p w w_L	BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT							
598.8	Ground Level											
0.0	Clayey Silt some sand Traces of Gravel											
21.0	Probably Same											
553.9												
44.9	End of Cone Test											

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 20

JOB 72-11141

LOCATION Sta. 207+12 o/s 78' RT. of Hwy. 402

ORIGINATED BY P.K.

W.P. 43-66-18,21

BORING DATE December 19, 1972

COMPILED BY P.K.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *SK*

SOIL PROFILE		STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125 SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W W _P — W — W _L WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS					
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	BLOWS/FOOT										
596.8	Ground Level														
0.0	Brown		1	SS	19	Dry Hole				3 25 47 2					
			2	SS	42						590				W.L. NOT DETERMINED
			3	SS	32										
11.0	Clayey Silt Some Sand Traces of Gravel Grey Stiff to Hard		4	SS	10	+				131.5 0 14 46 40					
			5	TW	PH						580				
			6	SS	11										
			7	TW	PH						570				
			8	SS	13										
			9	TW	PH						560				
			10	SS	20										
551.8			Silty Clay Some Sand Traces of Gravel Grey Very Stiff to Hard		11						TW	PH	+		
45.0	12	SS			18	540									
	13	SS			29										
			14	SS	35	530				130.0					
517.8						520				0 8 47 45					
79.0	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 21

JOB 72-11141 LOCATION Sta. 207+28 n/s 36' RT. of Hwy. 402 ORIGINATED BY PK.
 W.P. 43-66-18,21 BORING DATE December 20, 1972 COMPILED BY PK.
 DATUM Geodetic BOREHOLE TYPE Cone Test CHECKED BY SK.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w w_p — w — w_L WATER CONTENT %	BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
597.2	Ground Level									P.C.F. GR. SA. SI. CL.
0.0	Clayey Silt Some Sand Traces of Gravel (probable)					590				
						580				
						570				
569.2 28.0	End of Cone Test									

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 23

JOB 72-11141

LOCATION Sta. 207+65 o/s 36' RT of Hwy. 402

ORIGINATED BY PK

W.P. 43-66-18,21

BORING DATE December 18, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *PK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ	REMARKS				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		25	50	75	100	125	W_P	W			W_L	P.C.F.	GR.	SA.
597.6	Ground Level																		
0.0	Clayey Silt Some Sand & Traces Of Gravel (probable)																		
590																			
580																			
576.6	End of Cone Test																		
21.0																			

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 24

JOB 72-11141

LOCATION Sta. 207+65 o/s 78' RT. of Hwy. 402

ORIGINATED BY PK.

W.P. 43-66-18,21

BORING DATE December 20, 1972

COMPILED BY PK.

DATUM Geodetic

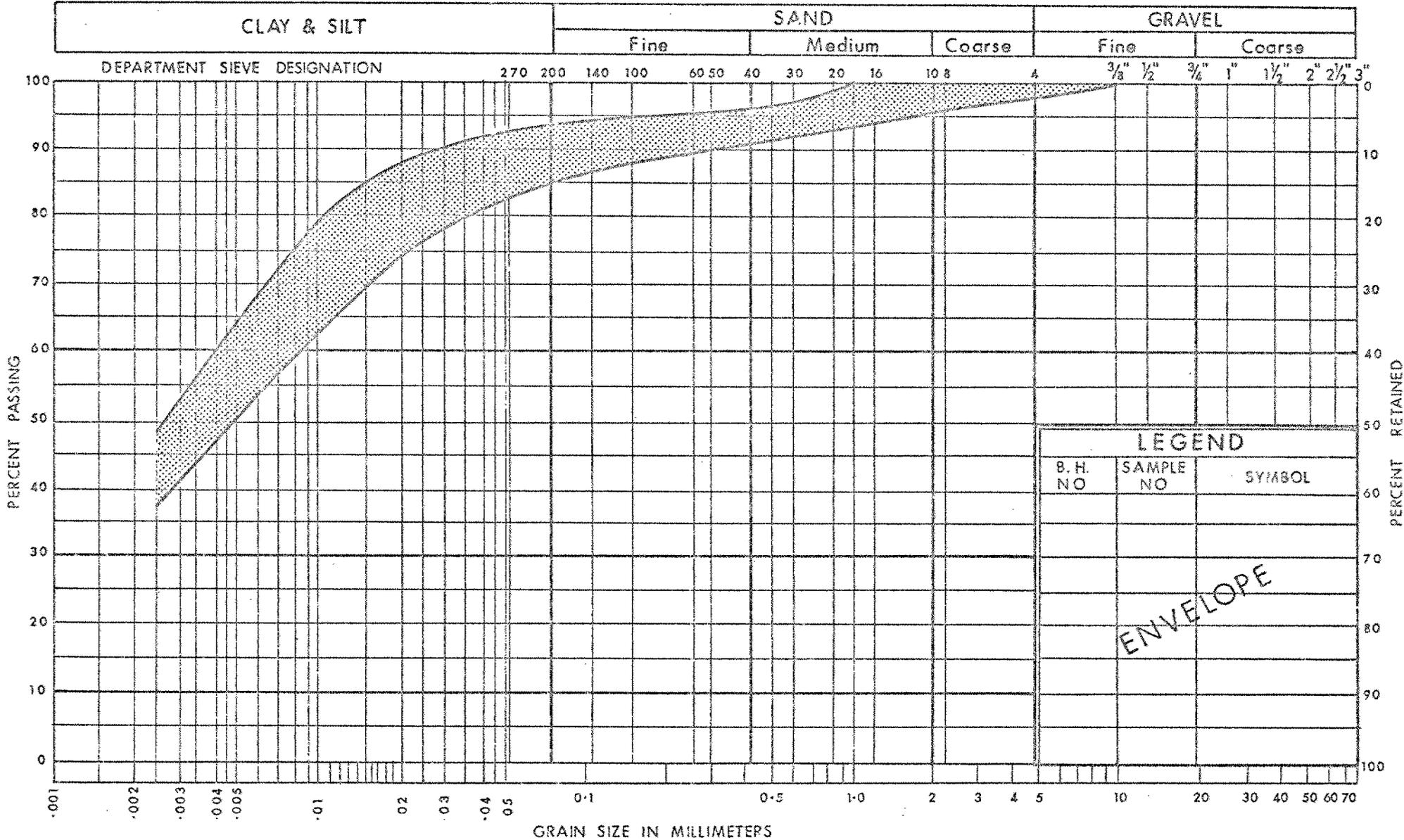
BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		25	50	75	100	125	WATER CONTENT % Wp — W — WL				
597.1	Ground Level															
0.0	Brown Sandy Silt Compact Grey Clayey Silt Some Sand Traces of Gravel Stiff to very Stiff	[Strat. Plot]	1	SS	33										P.C.F. GR. SA. SI. CL. W.L. NOT DETERMINED. 3 37 42 18 2 11 45 4 127.0 129.5 0 11 46 4	
592.1			2	SS	29											
5.0			3	SS	37											
590.1			4	SS	16											
7.0			5	SS	10											
9.0			6	SS	10											
			7	TW	PH											
			8	SS	13											
			9	TW	PH											
			10	SS	24											
553.1					11	SS	20									
44.0	End of Borehole															

OFFICE REPORT SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
SILTY CLAY
SOME SAND TRACES OF GRAVEL

W.P. No. 43-66-18 & 21
JOB No. 72-11141
FIG. NO. 3

FD-90 (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'-STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS :-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTSOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

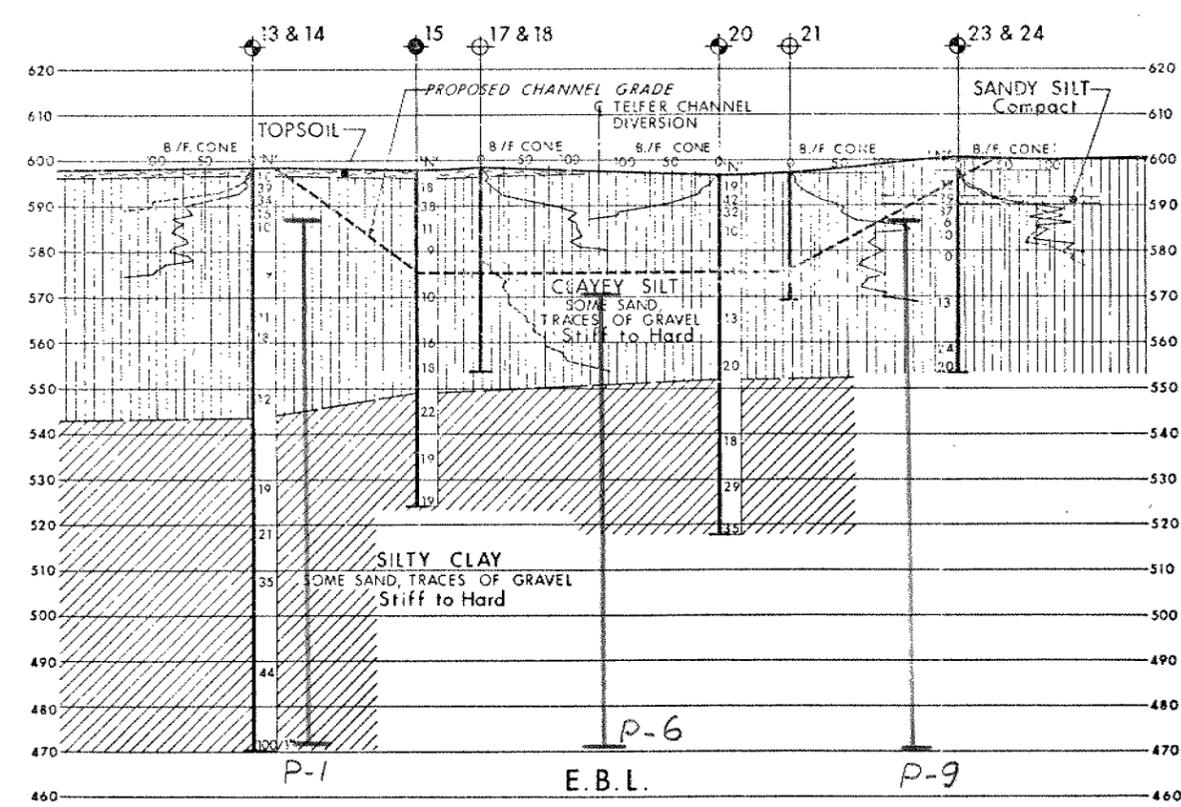
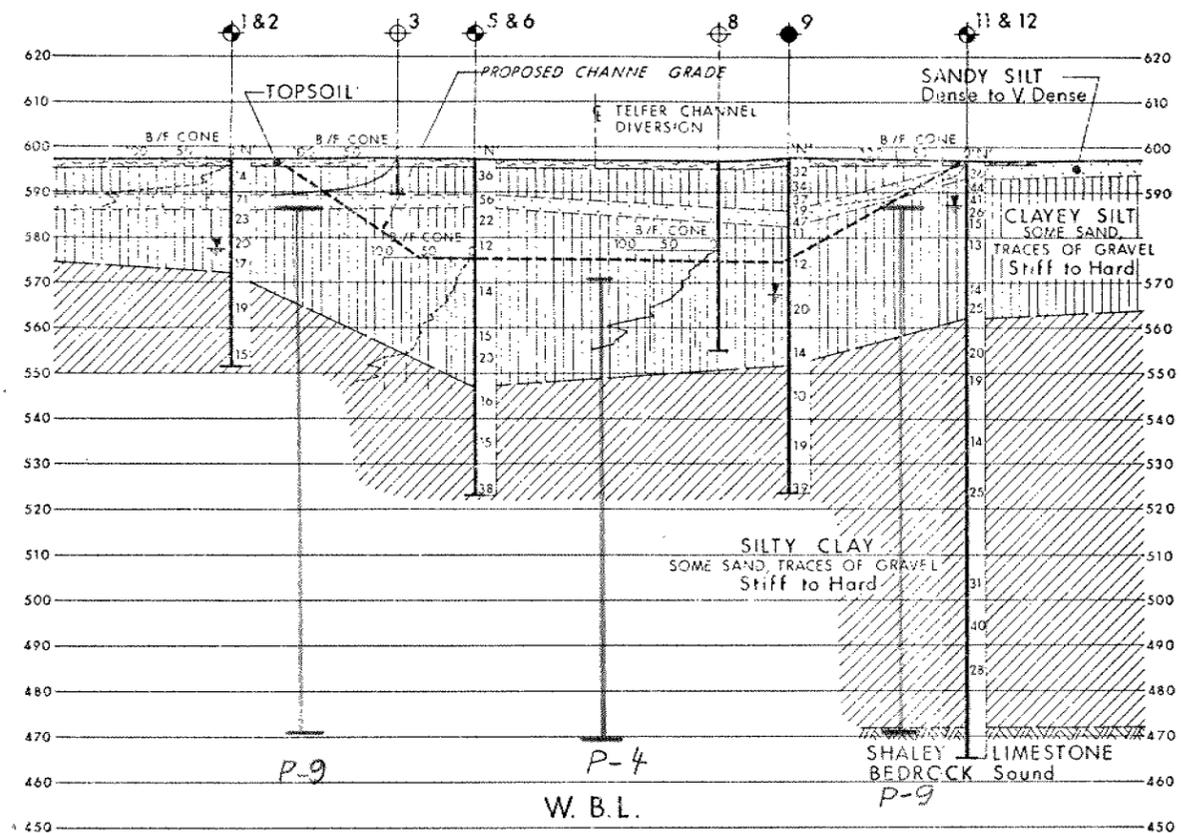
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

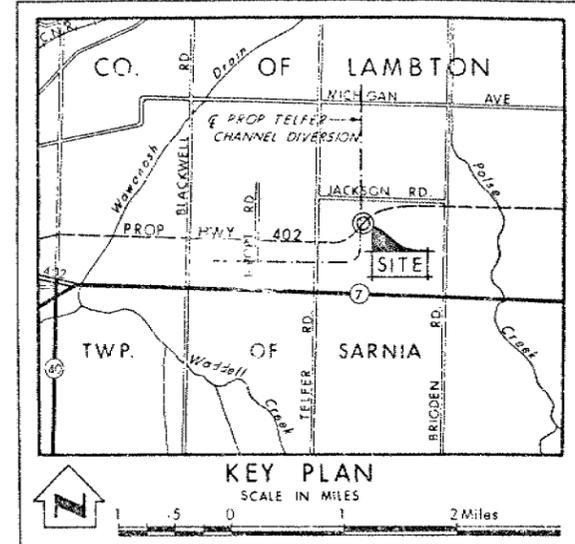
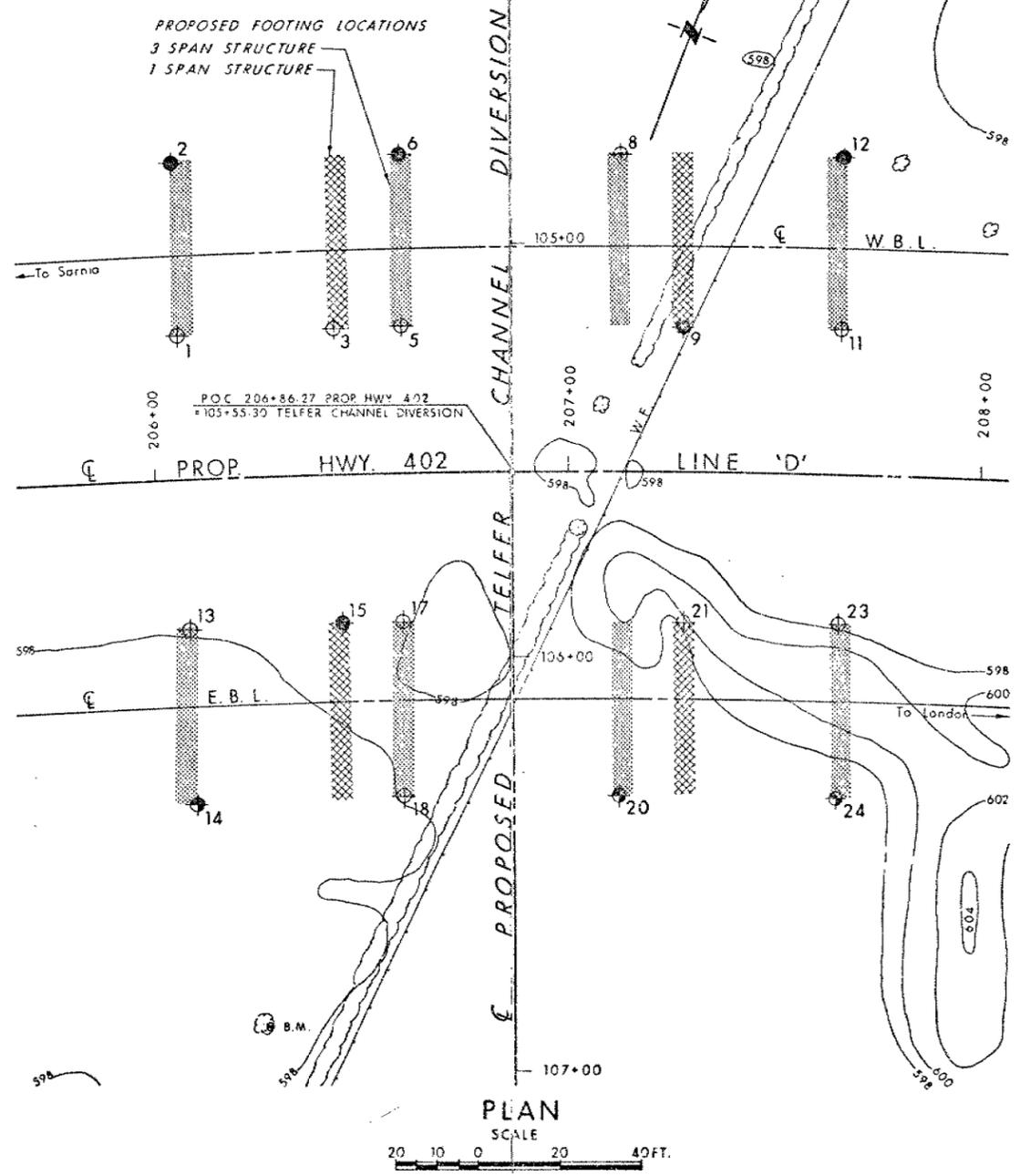
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



PROFILES
SCALE
20 10 0 20 40 FT.

NOTE:
WATER LEVELS NOT DETERMINED
IN BORE HOLES 6, 14, 15, 20 & 24



LEGEND

- Bore Hole
- ⊕ Cone Penetration Test
- ⊕ Bore Hole & Cone Test
- ⊕ Water Levels established at time of field investigation Jan. 1973

NO.	ELEVATION	STATION	OFFSET
1	597.1	206+06	35' LT.
2	597.2	206+06	77' LT.
3	597.5	206+44	35' LT.
5	597.3	206+60	35' LT.
6	597.3	206+60	77' LT.
8	597.0	207+12	77' LT.
9	597.7	207+28	35' LT.
11	596.3	207+65	35' LT.
12	597.0	207+65	77' LT.
13	598.3	206+06	36' RT.
14	598.5	206+06	78' RT.
15	598.0	206+44	36' RT.
17	598.2	206+60	36' RT.
18	598.8	206+60	78' RT.
20	596.8	207+12	78' RT.
21	597.2	207+28	36' RT.
23	597.6	207+65	36' RT.
24	597.1	207+65	78' RT.

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

NO.	DATE	BY	DESCRIPTION



MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

TELFER CHANNEL DIVERSION

HIGHWAY NO. PROP. 402 LINE 'D' DIST. NO. 1
CO. LAMBTON
TWP. SARNIA LOT 8 & 9 CON. VII

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD P.K.	CHECKED	WP NO. 43-66-18 & 21	DRAWING NO.
DRAWN	CHECKED	W.O. NO. 72-1114	72-1114A
DATE Feb 12, 1973	SITE NO. 14-372	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		

REF NO E-5341-1