FOUNDATION INVESTIGATION REPORT
For
Proposed South Trunk Sewer
From Heart Lake Road to North of Britannia Road
Hwy. 401-403-410 Complex
Town of Mississauga, County of Peel
District #6 (Toronto)
W.O. 73-110~~14~~ - W.P. 127-66-~~34~~ 53

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1. *INTRODUCTION:*

In conjunction with the construction program of Hwy. 401 and Hwy. 403, it is proposed to install a new trunk sewer along the south side of Hwy. 401 from Little Etobicoke Creek westerly to 401/410/403 interchange and then along proposed Hwy. 410 northerly to some 500 feet north of existing Britannia Road. The Foundations Office was requested to carry out a subsurface investigation for this trunk sewer. The request was initiated by the Regional Systems Design Office, Central Region. The detail of the proposed sewer system were submitted by Foundation of Canada Engineering Corporation Ltd. (Plan No. 3983-1T-100). Subsequently, an investigation was carried out by this Office to determine the subsoil, bedrock and groundwater conditions at the site.

It is understood that the proposed south trunk sewer will be constructed under two contracts. This report will deal with the western portion of the proposed trunk sewer, from Station 139+00 (near existing Heart Lake Road) to Station 98+60. The eastern portion of this trunk sewer was covered in a separate foundation report W.O. 73-11008 submitted on July 6, 1973.

2. *DESCRIPTION OF THE SITE AND GEOLOGY:*

The site under investigation is bounded by the following:

East	-	Heart Lake Road
South	-	Some 500 feet south of Hwy. 401
West	-	Half a mile east of First Line E
North	-	Britannia Road

The site is located in the Town of Mississauga, County of Peel. The ground surface in the general area varies from elevation 570 to elevation 600 and is generally sloping in a south-easterly direction. The land is primarily used for farming purposes.

Physiographically, the site is situated in the region known as the "Peel Plain." The characteristic deposit in the vicinity of the area under investigation, is composed of a cohesive glacial till whose thickness is quite variable. In this region, the Credit River, Oakville and Etobicoke Creeks have cut deep valleys into the overburden. There is, therefore, no large undrained depression, swamp or bog in this area, although in many of the interstream areas drainage is still imperfect.

The overburden is underlain by grey shale bedrock of the Meaford-Dundas formation, Ordovician Period.

3. *FIELD AND LABORATORY WORK:*

Nine sampled boreholes were put down during the course of field investigation. The borings were advanced by a continuous flight auger machine (commercially known as C.M.E. 45) adapted for soil sampling purposes.

Samples of the overburden were obtained in a 2" O.D. split-spoon sampler at required depths. The sampler was hammered into the soil with a driving energy of 350 ft.-lb. per blow, in accordance with the specifications for Standard Penetration Test. Bedrock was proven in all of the boring locations by obtaining BXL size rock core samples.

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Groundwater level observations were carried out, during the period of the investigation, in the open boreholes.

The soil, bedrock and groundwater conditions encountered at the boring locations, are presented in the Record of Borehole sheets. The location and elevation of the various boreholes were surveyed in the field by Construction Personnel from District #6 (Toronto). The elevations in this report are referred to a Geodetic datum. Boring locations and elevations, together with an estimated stratigraphical profile along the proposed sewer line are shown on Drawing Nos. 73-11014A & B.

All samples were subjected to careful visual examination in the field and subsequetnly in the laboratory. Following this examination, laboratory tests were carried out on selected representative samples to determine the physical properties of the various soil types encountered; namely,

Natural Moisture Contents
Atterberg Limits
Grain-Size Distribution

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

4. *SUBSOIL AND BEDROCK CONDITIONS:*

4.1) *General:*

The overburden across the site is composed of a heterogeneous mixture of hard clayey silt to silty clay, sand and gravel (glacial till). The thickness of this cohesive glacial till stratum varies from 4 to 11 feet. The overburden is underlain by shale bedrock.

The stratigraphical sequence encountered in the borings is plotted on the Record of Borehole sheets. Stratigraphical profile has been inferred from this data and shown on Drawings No. 73-11014A & B. The subsoil and bedrock encountered from ground surface downward, are presented in the following subsections.

4.2) Heterogeneous Mixture of Clayey Silt, to Silty Clay, Sand and Gravel (Glacial Till):

The glacial till is composed of a heterogeneous mixture of clayey silt to silty clay, sand and gravel. This stratum was encountered in all boring locations. The thickness of this stratum varies between 4 (B.H. #15) to 11 (B.H. #11) feet. Grain size distribution testing was carried out for the samples of this glacial till stratum. The results are presented in the Record of Borehole sheets.

Results of Atterberg Limit Tests, performed on samples recovered in this stratum were plotted on the Record of Borehole sheets. They are also tabulated below:

	Range	*(Average)*
Liquid Limit (W_L) %	33 - 43	(39)
Plastic Limit (W_p) %	17 - 23	(20)
Natural Moisture Content (W) %	14 - 19	(18)

Standard Penetration testing was carried out within this stratum and the results were plotted on the Record of Borehole sheets. The "N" values vary from 37 blows/foot near the ground surface generally increasing with depth to 100 blows per 3 inches. It is estimated that the consistency of this cohesive material is generally hard.

4.3) Bedrock:

Bedrock was proven at all of the boring locations by obtaining up to 64 feet of BXL size rock core samples. The rock samples were carefully examined by Mr. K. W. Ingham, Geologist. Mr. Ingham presented the results of his bedrock description, as well as an interpretation of geological conditions existing at this site, in a memo to this Office, dated June 29, 1973. A copy of this memo is enclosed in the Appendix of this report.

The bedrock encountered at the boreholes is a dark grey thin bedded shale with minor thin limestone bands. The

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upper portion of the bedrock is generally in a weathered condition. The thickness of this weathered zone ranges from 3 to 10 feet.

The bedrock surface was found to vary between elevations 561 and 595.

5. *GROUNDWATER CONDITIONS:*

Groundwater level observations have been carried out during and after the period of the investigation by recording the water level in the open boreholes. The observations are recorded on the Record of Borehole sheets and summarized on Drawings No. 73-11014A & B. The results of the measurements in the open boreholes indicate that the groundwater level, ranges from ground surface to 5 feet below existing ground surface, corresponding to elevation between 563 (B.H. #100) and 595 (B.H. #16).

6. *DISCUSSION AND RECOMMENDATIONS:*

6.1) *General:*

It is proposed to install a 5,500 foot storm trunk sewer in conjunction with the construction program of Hwy. 401 & Hwy. 403 in the Town of Mississauga, County of Peel. As mentioned previously, this report will deal with the 4000-foot-long portion of the sewer between Heart Lake Road and Britannia Road. The diameter of this portion of the sewer will range from 8 to 9 feet.

The invert of the sewer, which is shown on Drawings No. 73-11014A & B will range from elevation 526 (at Heart Lake Road) to elevation 558 at the north end of the sewer. At this grade it will be located from 28 to 68 feet below the existing ground surface.

The predominant stratum across the site is a deposit of cohesive glacial till, up to 11 feet in thickness. It is underlain by shale bedrock.

The invert of the sewer will be located within the shale bedrock.

It is understood that between Station 105+20 to Station 139+00, the sewer will be installed using rock tunnelling procedures. From Station 98+60 to Station 105+20, it is believed that a cut and cover method will be used.

6.2) Sewer Constructed by Open Cut Methods (Station 98+60 to Station 105+20):

The sewer excavations will be carried out through the cohesive glacial till stratum into the shale bedrock. The maximum depth of excavation will be of the order of 32 feet. Temporary cuts of this height will be inherently stable with respect to a deep-seated rotational type of failure provided that the cuts are constructed with 1:1 slopes within the overburden and weathered shale bedrock. If, due to space restrictions, slopes steeper than that specified or vertical cuts are desired in the overburden and weathered shale bedrock, the excavation should be properly sheeted and braced.

The prevailing groundwater level, as recorded during the course of field investigation is, in general, well above the invert elevations of the trunk sewer. In view of the impervious nature of the glacial till stratum, groundwater seepage into the excavation will be negligible in quantity. It is believed that this can be handled by employing standard techniques, such as pumping from sumps.

It is recommended that the sewer bedding adhere to standards currently being used by the Ministry, specifically for class 'B-3' or 'B-4' for unyielding foundation (Standard No. DD-823), and be placed in a dry trench. In addition, particular attention should be paid to the compaction and shaping of the bedding material. Backfill for the sewer excavations should comply with Standard No. DD-813-B currently used by the Ministry.

6.3) Sewer Construction by Tunnelling Through Bedrock (Station 105+20 to Station 139+00):

Between the aforementioned stations the proposed sewer will be located within the sound shale bedrock. It is understood

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that this section of the sewer will be constructed by tunnelling through the shale bedrock.

For bridging purposes, a minimum of 10 feet of sound rock cover is required. In order to provide adequate bridging support for the sewer tunnel at the proposed Britannia Road, it is recommended that the tunnelling should be carried out prior to the roadway cuts in this area. For estimating purposes it may be assumed that about 10% overbreak could occur in a sewer of this diameter.

The groundwater level recorded during the field investigation is up to 58 feet above the proposed sewer invert. Since the tunnel will be situated within the shale bedrock, water under pressure may enter the tunnel through the fractures and fissures in the shale. Therefore, necessary measures to overcome this problem must be taken.

It is believed that tunnelling may be accomplished either by conventional drill and blast methods, or by the use of tunnelling machines.

At this stage, the design detail of the tunnel liner and related information is not available, therefore, it is extremely difficult to give specific recommendations. However, this Office will provide necessary information once the specific details become available.

7. *MISCELLANEOUS:*

The field work performed between May 1 and 16, 1973, was carried out under the supervision of Messrs. V. Korlu and C.S. Poon, Project Foundations Engineers.

The drilling equipment used was owned and operated by Dominion Soil Investigation Ltd. (Toronto).

This report was prepared by Mr. C. S. Poon, Project

Foundations Engineer, and was reviewed by Mr. M. Devata, Supervising Foundations Engineer.

REGISTERED PROFESSIONAL ENGINEER
C.S.L. POON
PROVINCE OF ONTARIO

C. S. Poon, P. Eng.

M. Devata, P. Eng.

CSP/ao
Aug. 1, 1973

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 11

JOB 73-11014
W.P. 127-66-34
DATUM Geodetic

LOCATION Co-ords. 15,856,878N & 959,592E
BORING DATE May 1, 1973
BOREHOLE TYPE Auger and BXL Rock Core

ORIGINATED BY J.B.
COMPILED BY C.S.P.
CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	WATER CONTENT %	REMARKS
572.2	Ground level						
0.0	Heterogeneous mixture of silty clay, sand and gravel (Glacial till) Brown-grey Hard				570		W.L. Elev.568.7 June 1973
		1	SS	39			
		2	SS	56		o	
561.2 / 11.0	Weathered						
558.5 / 13.7	BEDROCK— Shale with occasional limestone bands up to 2" thick				560		
		3	BXL RC	96% Rec			
		4	BXL RC	100% Rec	550		
		5	BXL RC	96% Rec			
		6	BXL RC	100% Rec			
		7	BXL RC	90% Rec	540		
		8	BXL RC	100% Rec			
		9	BXL RC	100% Rec	530		
		10	BXL RC	100% Rec			
520.7	Dark grey Sound						
51.5	End of Borehole				520		

Chart headings: SOIL PROFILE; STRAT. PLOT; SAMPLES; DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; LIQUID LIMIT —W_L PLASTIC LIMIT —W_P WATER CONTENT —W; WATER CONTENT % 10 20 30; BULK DENSITY γ P.C.F.; GR SA SI CL

20 15 ◇ 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE Nº 12

FOUNDATIONS OFFICE

JOB 73-11014 — LOCATION Co-ords. 15,856,794N & 959,293E — ORIGINATED BY C.S.P.

W.P. 127-66-34 — BORING DATE May 4, 1973 — COMPILED BY C.S.P.

DATUM Geodetic — BOREHOLE TYPE Auger and BXL Rock Core — CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
577.5	Ground level									
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till) (With cobbles below elevation 574) Brown Hard		1	SS	100/4"					▼ W.L. Elev. 575.0 June 1973
568.0						570				
9.5 / 565.5	Weathered		2	BXL RC	25% Rec					
12.0	BEDROCK - shale with occasional thin limestone bands Dark-grey Sound		3	BXL RC	97% Rec					
561.0 / 16.5	End of Borehole					560				

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 13

JOB 73-11014 — LOCATION Co-ords. 15,856,690N & 958,823E — ORIGINATED BY C.S.P.

W.P. 127-66-34 — BORING DATE May 7-8, 1973 — COMPILED BY C.S.P.

DATUM Geodetic — BOREHOLE TYPE Auger and BXL Rock Core — CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	REMARKS
590.8	Ground level				
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)(with cobbles below elev587) Hard	1	BXL RC	70% Rec	W.L. Elev586.8 June 1973
585.3 / 5.5		2	BXL RC	55% Rec	
		3	BXL RC	73% Rec	
575.3 / 15.5	Weathered	4	BXL RC	56% Rec	
		5	BXL RC	97% Rec	
	BEDROCK — Shale with occasional bands of limestone up to 5" thick	6	BXL RC	96% Rec	
		7	BXL RC	98% Rec	
		8	BXL RC	96% Rec	
		9	BXL RC	100% Rec	
		10	BXL RC	98% Rec	
534.3	Dark grey Sound	11	BXL RC	96% Rec	
56.5	End of Borehole				

Other column headings: STRAT. PLOT; ELEV. SCALE (590, 580, 570, 560, 550, 540, 530); DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE); LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %; BULK DENSITY γ P.C.F.; GR.SA.SI.CL.

20 / 15 5 / 10 % STRAIN AT FAILURE

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RECORD OF BOREHOLE Nº 14

JOB 73-11014
W.P. 127-66-34
DATUM Geodetic

LOCATION Co-ords. 15,856,597N & 958,420E
BORING DATE May 9, 1973
BOREHOLE TYPE Auger and BXL Rock Core

ORIGINATED BY C.S.P.
COMPILED BY C.S.P.
CHECKED BY S.R.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
593.8	Ground level									
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)(with cobbles below elev. 590) Hard					590				W.L. Elev. 590.3 June 1973
585.8 / 8.0	BEDROCK - Shale with minor limestone bands Dark grey Moderately weathered		1	BXL RC	60% Rec					
580.3 / 13.5	End of Borehole					580				

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 15

JOB 73-11014 — LOCATION Co-ords. 15,856,515N & 958,074E — ORIGINATED BY C.S.P.

W.P. 127-66-34 — BORING DATE May 9-11, 1973 — COMPILED BY C.S.P.

DATUM Geodetic — BOREHOLE TYPE Auger and BXL Rock Core — CHECKED BY S.P.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
596.4	Ground level									
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)(with cobbles below elev. 592) Hard		1	SS	100/4"					W.L. Elev. 594.4 June 1973
590.1			2	BXL RC	30% Rec	590				
6.3 / 587.2	Weathered		3	BXL RC	96% Rec					
9.2			4	BXL RC	97% Rec	580				
			5	BXL RC	100% Rec					
	BEDROCK — Shale with occasional limestone layers up to 8" thick		6	BXL RC	100% Rec	570				
			7	BXL RC	100% Rec					
			8	BXL RC	84% Rec	560				
			9	BXL RC	96% Rec					
			10	BXL RC	100% Rec	550				
			11	BXL RC	95% Rec					
			12	BXL RC	98% Rec	540				
			13	BXL RC	96% Rec					
528.9	Dark grey Sound		14	BXL RC	97% Rec	530				
67.5	End of Borehole					520				

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE №16

JOB 73-11014 | LOCATION Co-ords. 15,856,895N & 957,360E | ORIGINATED BY V.K.

W.P. 127-66-34 | BORING DATE May 16, 1973 | COMPILED BY C.S.P.

DATUM Geodetic | BOREHOLE TYPE Auger and BXL Rock Core | CHECKED BY S.P.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS
599.9	Ground level						
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)						
595.4 / 4.5	Limestone Weathered		1	BXL RC	67% Rec		W.L. Elev. 595.5 June 1973
591.9 / 8.0	Shale Weathered		2	BXL RC	67% Rec	590	
588.7 / 11.2	BEDROCK — SHALE with occasional to frequent layers (up to 6") of limestone		3	BXL RC	84% Rec		
			4	BXL RC	100% Rec	580	
			5	BXL RC	100% Rec		
			6	BXL RC	100% Rec		
			7	BXL RC	100% Rec	570	
			8	BXL RC	100% Rec		
			9	BXL RC	100% Rec	560	
			10	BXL RC	100% Rec		
	Dark grey Sound		11	BXL RC	80% Rec	550	
			12	BXL RC	86% Rec		
			13	BXL RC	60% Rec		
541.4 / 58.5	End of Borehole					540	

Column headings also include: DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE); LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT %; BULK DENSITY γ P.C.F.; GR SA SI CL

20 / 15 ✧ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 17

JOB 73-11014 | LOCATION Co-ords. 15,857,245N & 956,874E | ORIGINATED BY V.K.

W.P. 127-66-34 | BORING DATE May 16, 1973 | COMPILED BY C.S.P.

DATUM Geodetic | BOREHOLE TYPE Auger and BXL Rock Core | CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
590.0	Ground level									
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)									▼W.L. Elev. 587.5 June 1973
			1	BXL RC	33% Rec					
581.3 / 8.7	Interbedded - limestone and shale, weathered					580				
577.7 / 11.3	BEDROCK - SHALE Occasional limestone layers (up to 7" in thickness)		2	BXL RC	100% Rec					
			3	BXL RC	100% Rec					
	Dark grey Sound		4	BXL RC	100% Rec	570				
567.5 / 22.5	End of Borehole									
						560				

20 / 15 ✧ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 18

JOB 73-11014 | LOCATION Co-ords. 15,857,388N & 956,614E | ORIGINATED BY V.K.

W.P. 127-66-34 | BORING DATE May 14, 1973 | COMPILED BY C.S.P.

DATUM Geodetic | BOREHOLE TYPE Auger and BXL Rock Core | CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT % (10 20 30)	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
585.6	Ground level									
0.0	Heterogeneous mixture of clayey silt, sand and gravel (Glacial till)		1	SS	100/3"			Wp–W–WL plotted (approx. 12–18–30)		W.L. Elev. 585.6 June 1973
581.6 / 4.0	SHALE		2	BXL RC	100% Rec	580				
			3	BXL RC	67% Rec					
	Weathered		4	BXL RC	67% Rec					
572.6 / 13.0	BEDROCK — SHALE		5	BXL RC	67% Rec					
	Occasional weathered zones		6	BXL RC	100% Rec	570				
			7	BXL RC	92% Rec					
	Occasional limestone layers (up to 6" in thickness)		8	BXL RC	100% Rec	560				
			9	BXL RC	100% Rec					
			10	BXL RC	73% Rec	550				
			11	BXL RC	83% Rec					
	Dark grey		12	BXL RC	96% Rec	540				
533.1			13	BXL RC	96% Rec					
52.5	End of Borehole					530				

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 100

JOB 73-11014 | LOCATION Co-ords. 15,856,946N & 959,758E | ORIGINATED BY C.S.P.

W.P. 127-66-34 | BORING DATE May 11-12, 1973 | COMPILED BY C.S.P.

DATUM Geodetic | BOREHOLE TYPE Auger and BXL Rock Core | CHECKED BY S.R.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % 15 30 45	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
567.6	Ground level									
0.0	Heterogeneous mixture of silty clay, sand and gravel (Glacial till)		1	SS	37					5,3,52,40 WL @ 563.6
560.8	Brown-grey Hard		2	SS	100/3"	560				
6.8			3	BXLRC	85% Rec					
	Weathered		4	BXL RC	75% Rec					
555.6 / 12.0			5	BXL RC	100% Rec					
			6	BXL RC	92% Rec	550				
	Shale bedrock with occasional limestone bands (maximum 3" thick)		7	BXL RC	96% Rec					
			8	BXL RC	100% Rec	540				
			9	BXL RC	97% Rec					
			10	BXL RC	97% Rec	530				
			11	BXL RC	100% Rec					
			12	BXL RC	98% Rec	520				
511.1	Dark grey Sound		13	BXL RC	100% Rec					
56.5	End of Borehole					510				

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. M. Devata,
Sup. Foundation Engineer.

FROM: K. W. Ingham

ATTENTION:

DATE: June 29, 1973

OUR FILE REF.

IN REPLY TO

SUBJECT: Foundation Investigation 73-11014;
Highways 401 and 410, Storm Sewers

A brief description is given below for 9 boreholes drilled to bedrock at this site, together with the appropriate bedrock elevation.

Hole No. 11 — Bedrock at 561.2

11.0 - 13.7	Shale; medium grey, thin to platy bedded, badly weathered.
13.7 - 14.1	Limestone; light to medium grey, fine grained, slightly silty.
14.1 - 22.0	Shale; dark grey, thin to medium bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, also limestone with thin beds of shale 18.8 to 19.9 ft., moderately weathered throughout with occasional badly weathered sections up to 0.5 ft. in thickness.
22.0 - 51.5	Shale; dark grey, medium bedded, occasional limestone layers 0.1 to 0.3 ft. in thickness.

Hole No. 12 — Bedrock at 568.0

9.5 - 10.0	Shale; medium grey, thin to platy bedded, badly weathered.
10.0 - 16.5	Shale; dark grey, thin bedded, minor thin limestone layers, limestone 15.5 - 15.9 ft.

Hole No. 13	Bedrock at 585.3
5.5 - 15.5	Shale; dark grey, thin to platy bedded, occasional limestone layers 0.1 to 0.4 ft. in thickness, badly weathered throughout.
15.5 - 16.7	Limestone; light to medium grey, fine grained, thin to medium bedded, occasional thin shale interbeds.
16.7 - 44.5	Shale; dark grey, thin to platy bedded, occasional limestone layers 0.1 to 0.4 ft. in thickness, moderately weathered with frequent badly weathered sections throughout.
44.5 - 48.0	Limestone; light to medium grey, fine grained, thin to medium bedded, thin moderately weathered shale interbeds.
48.0 - 56.5	Shale; dark grey, thin to platy bedded, occasional limestone layers 0.1 to 0.3 ft. in thickness, moderately weathered throughout.

Hole No. 14	Bedrock at 585.8
8.0 - 13.0	Shale; medium grey, thin to platy bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, moderately weathered throughout.
13.0 - 13.5	Limestone; light grey, fine grained.

Hole No. 15	Bedrock at 592.4
4.0 - 6.3	Till changing to weathered shale.
6.3 - 9.2	Interbedded layers of limestone 0.1 to 0.3 ft. in thickness and thin bedded bands of badly weathered shale.
9.2 - 11.2	Shale; dark grey, thin bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, moderately weathered throughout.
11.2 - 12.0	Limestone; light grey, fine grained, thin to medium bedded.

Hole No. 15 - Continued

12.0 - 22.4	Shale; dark grey, thin bedded, occasional limestone layers 0.2 to 0.4 ft. in thickness, moderately weathered throughout.
22.4 - 23.8	Limestone; medium grey, fine grained, medium bedded, occasional thin moderately weathered shale bands.
23.8 - 67.5	Shale; dark grey, medium bedded, occasional limestone layers 0.2 to 0.5 ft. in thickness.

Hole No. 16 — Bedrock at 595.4

4.5 - 8.0	Limestone; light grey, fine grained, medium bedded, sandy, frequent sections of badly weathered shale.
8.0 - 11.2	Shale; dark grey, thin to platy bedded, moderately weathered with occasional badly weathered sections.
11.2 - 11.7	Limestone; dark grey, fine grained, shaly.
11.7 - 20.0	Shale; dark grey, thin bedded, occasional limestone layers 0.1 to 0.3 ft. in thickness, moderately weathered layers throughout.
20.0 - 20.5	Limestone; medium grey, fine grained.
20.5 - 22.0	Interbedded dark grey shale and light to medium grey limestone, thin bedded.
22.0 - 22.7	Limestone; light grey, fine grained.
22.7 - 27.0	Shale; dark grey, thin to medium bedded, occasional to frequent limestone layers 0.1 to 0.3 ft. in thickness.
27.0 - 58.5	Shale; dark grey, medium bedded, occasional limestone layers 0.2 to 0.4 ft. in thickness.

Hole No. 17	Bedrock at 585.0
5.0 - 10.5	Interbedded limestone and badly weathered shale, thin to medium bedded.
10.5 - 11.3	Limestone; light grey, fine grained, medium bedded.
11.3 - 14.2	Shale; dark grey, thin to platy bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, moderately to badly weathered throughout.
14.2 - 15.0	Limestone; light grey, thin to medium bedded, occasional thin dark grey shale seams.
15.0 - 22.5	Shale; dark grey, thin bedded, occasional limestone layers 0.1 to 0.3 ft. in thickness, moderately weathered sections throughout.

Hole No. 18	Bedrock at 580.6
5.0 - 6.4	Limestone; light grey, fine grained, medium bedded, thin badly weathered shale interbeds.
6.4 - 13.0	Shale; dark grey, thin to platy bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, badly weathered throughout.
13.0 - 21.5	Shale; dark grey, thin bedded, moderately weathered throughout, some badly weathered zones, limestone 13.6 - 14.0 ft. and 18.5 - 19.0 ft.
21.5 - 42.7	Shale; dark grey, medium bedded, occasional limestone layers 0.1 to 0.4 ft. in thickness.
42.7 - 43.5	Limestone; light grey, fine grained, medium bedded, slightly silty.
43.5 - 51.0	Shale; dark grey, medium bedded, occasional limestone layers 0.1 to 0.3 ft. in thickness.

Hole No. 18 - Continued

51.0 - 51.9	Limestone; light grey, fine grained, medium bedded, slightly silty.
51.9 - 52.5	Interbedded limestone and shale.

Hole No. 100 Bedrock at 561.1

6.5 - 9.7	Shale; dark grey, thin to platy bedded, moderately to badly weathered, occasional thin layers of limestone.
9.7 - 12.7	Interbedded limestone and shale; light grey limestone in beds 0.1 to 0.7 ft. in thickness, layers of moderately to badly weathered shale 0.1 to 0.3 ft. in thickness.
12.7 - 16.1	Shale; dark grey, thin bedded, occasional limestone layers 0.1 to 0.2 ft. in thickness, moderately weathered throughout.
16.1 - 38.0	Shale; dark grey, medium bedded, minor thin layers of limestone and shaly limestone.
38.0 - 53.3	Shale; dark grey, medium bedded, occasional layers of limestone 0.1 to 0.3 ft. in thickness.
53.3 - 56.5	Limestone; light to medium grey, fine grained, medium bedded, occasional thin layers of shale and shaly limestone.

K. W. Ingham,
Geologist.

KWI:mv

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 :-

CONSISTENCY	c LB./SQ. FT.	DENSENESS	'N' BLOWS / FT.
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 "		

FD-9b (Rev. Jan.73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL 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' and ϕ') IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	(c_u and ϕ_u) IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	$= 3{\cdot}1416$
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 (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

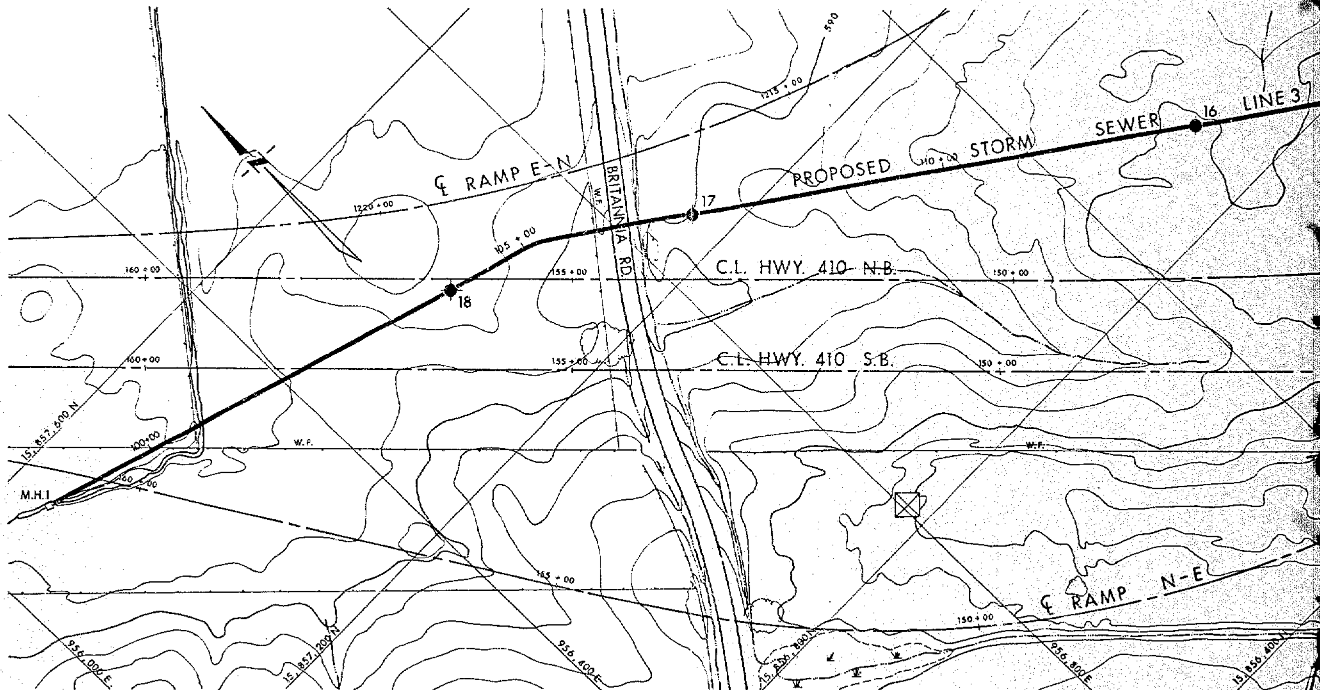
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

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

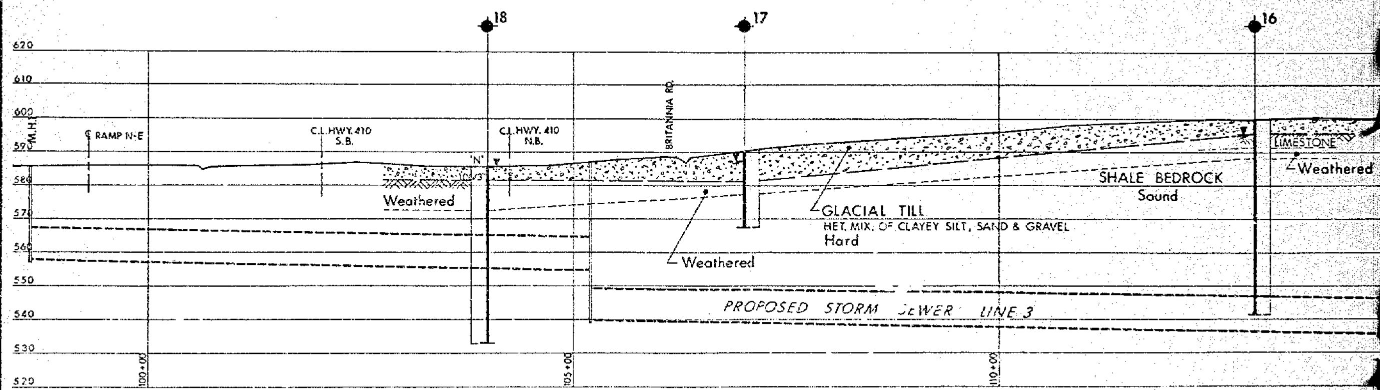
SLOPES

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



PLAN

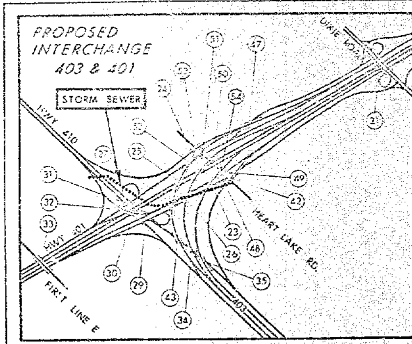
80 40 0 SCALE 80 160 FT.

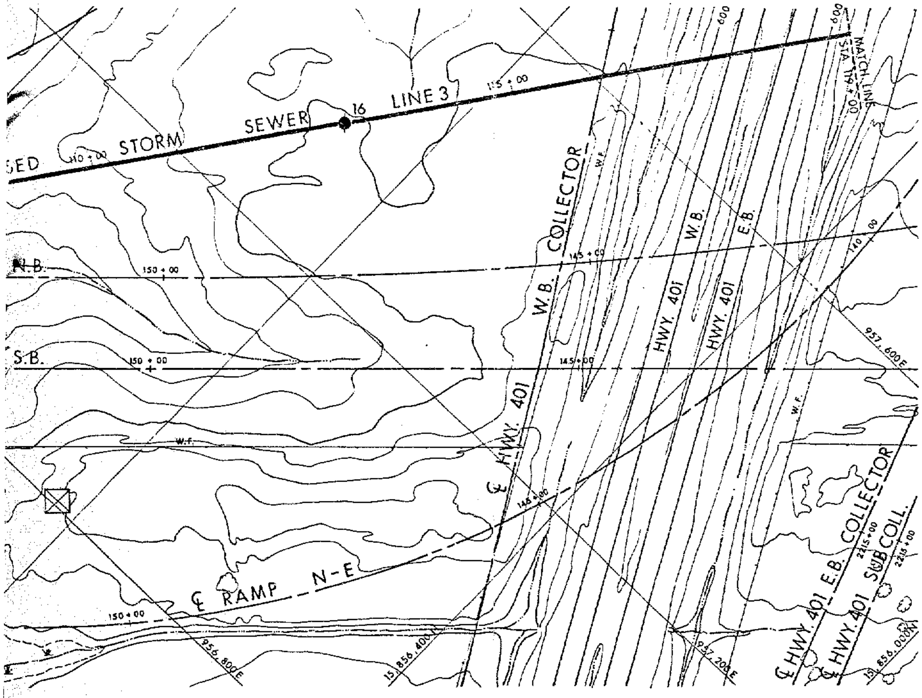


PROFILE

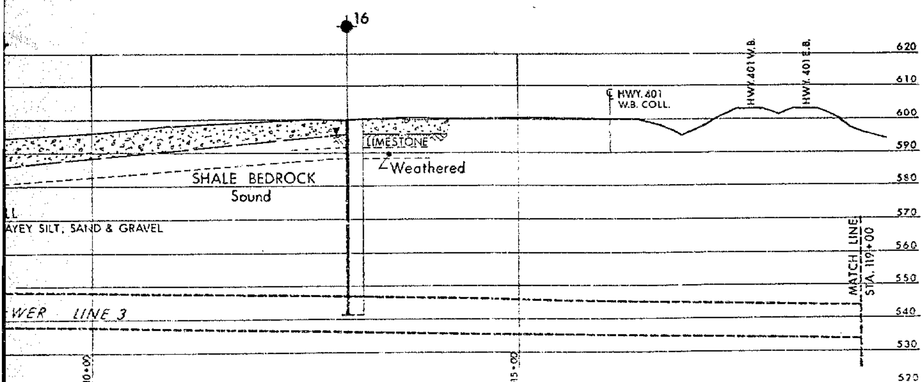
HORIZ. 80 40 0 SCALE 80 160 FT.

VERT 20 10 0 20 40 FT.





PLAN
SCALE 80 160 FT.



PROFILE
SCALE 80 160 FT.
20 40 FT.

LEGEND

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

NO.	ELEVATION	CO-ORDINATES NORTH	EAST
16	599·9	15,856,895	957,360
17	590·0	15,857,245	956,874
18	585·6	15,857,388	956,614

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

REVISIONS		
DATE	BY	DESCRIPTION

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

PROPOSED STORM SEWER

STA. 98 + 60 TO STA. 119 + 00

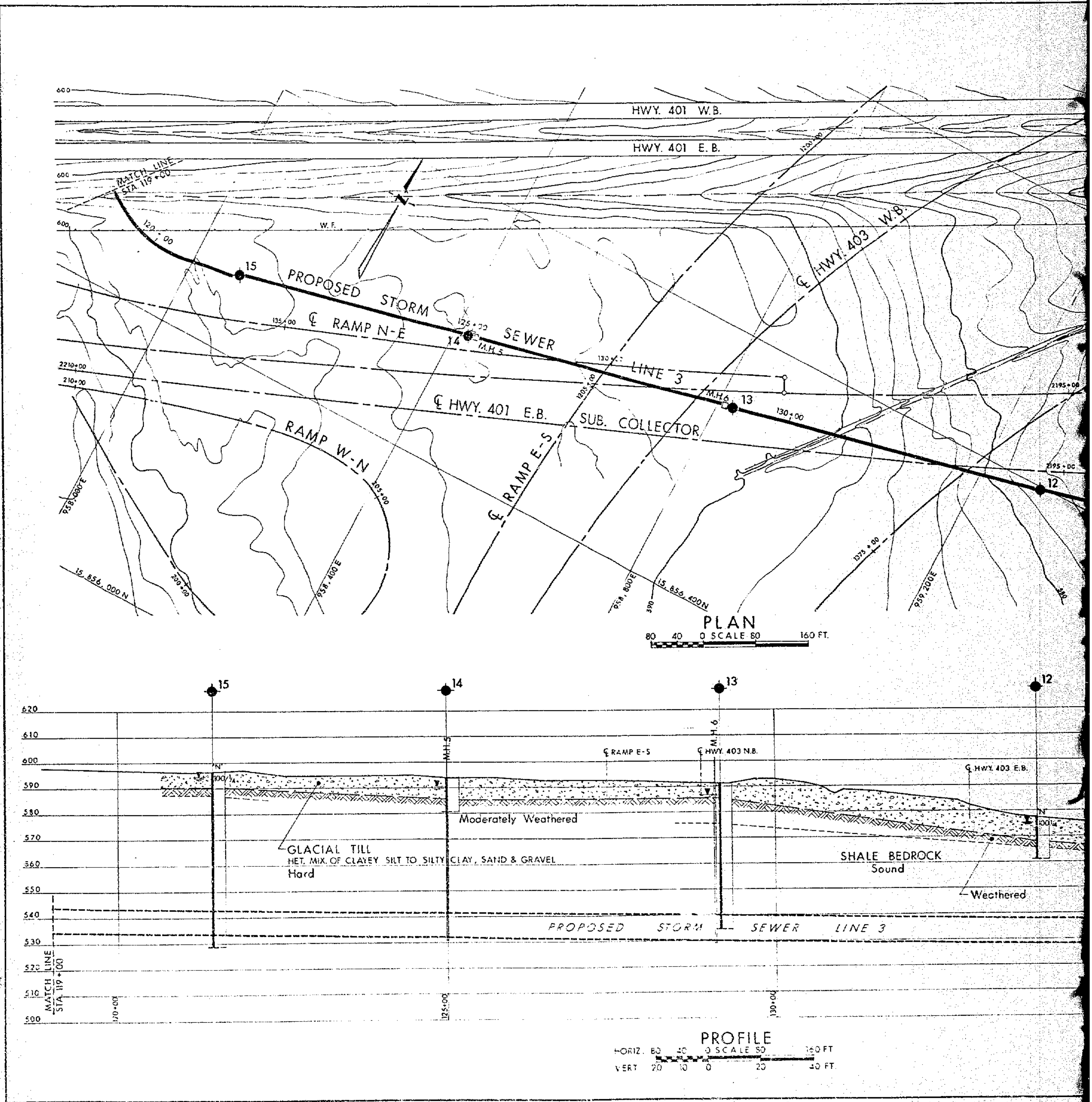
HIGHWAY NO. 401 & 410 DIST. NO. 6
CO. PEEL
TOWN OF MISSISSAUGA LOT CON

BORE HOLE LOCATIONS & SOIL STRATA

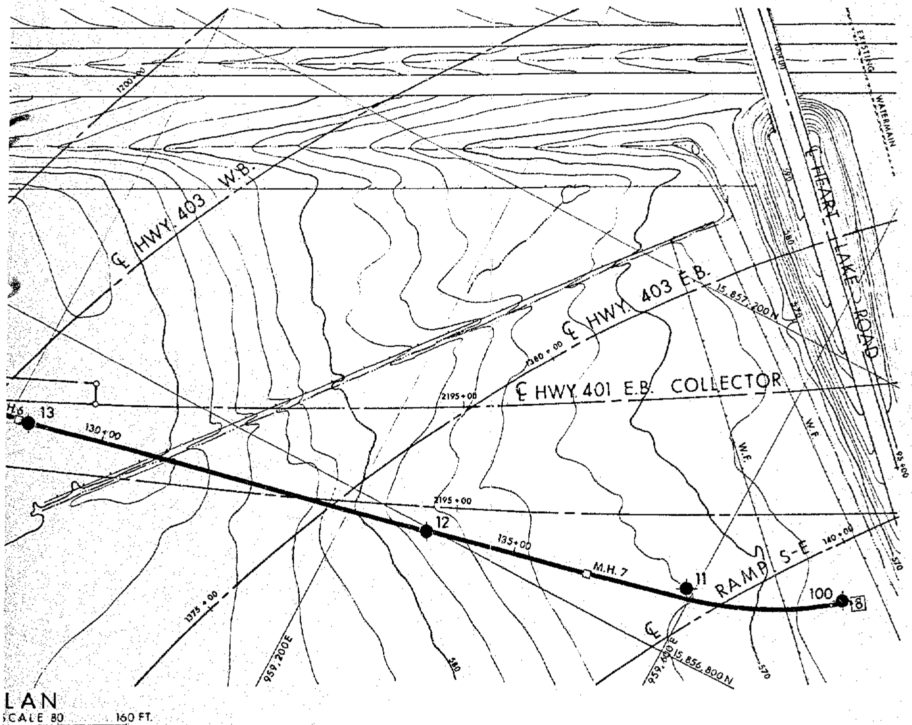
SUBM'D C.P.	CHECKED	W.P. NO. 127 - 66 - 34	DRAWING NO. 73 - 11014 A
DRAWN S.R.	CHECKED	W.O. NO. 73 - 11014	
DATE JUNE 27, 1973.		SITE NO.	BRIDGE DRAWING NO.
APPROVED	PRINCIPAL FOUNDATION ENGINEER	CONT. NO.	

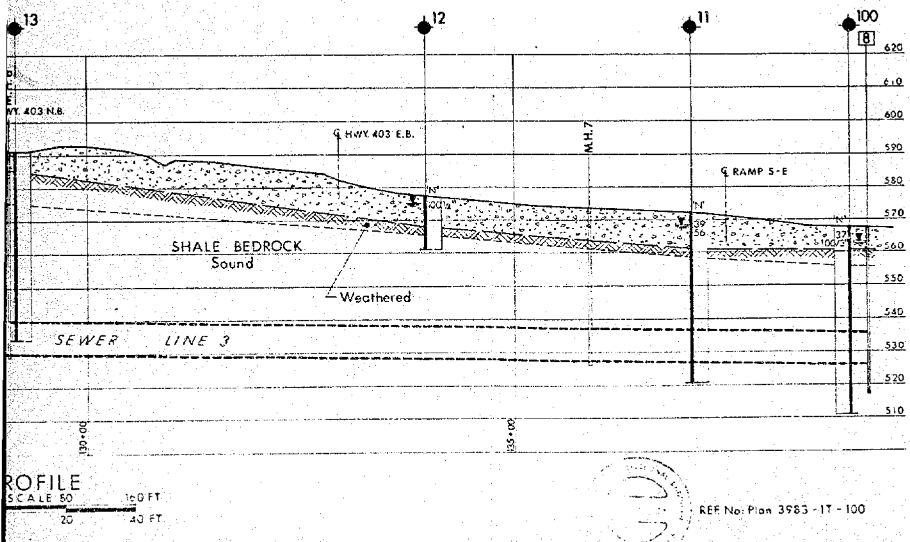
REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

REF No: Plan 3983 - IT - 100



HWY. 401 W.B.
HWY. 401 E.B.
MATCH LINE STA. 119+00
W.F.
PROPOSED STORM SEWER LINE 3
℄ RAMP N-E
℄ HWY. 401 E.B. SUB. COLLECTOR
RAMP W-N
℄ RAMP E-S
℄ HWY. 403 W.B.
M.H.5
M.H.6
15
14
13
12
15,856,000 N
15,856,400 N
958,000 E
958,400 E
958,800 E
959,200 E
PLAN
80 40 0 SCALE 80 160 FT.
℄ RAMP E-S
℄ HWY. 403 N.B.
℄ HWY. 403 E.B.
Moderately Weathered
GLACIAL TILL
HET. MIX. OF CLAYEY SILT TO SILTY CLAY, SAND & GRAVEL
Hard
SHALE BEDROCK
Sound
Weathered
PROPOSED STORM SEWER LINE 3
MATCH LINE STA. 119+00
120+00
125+00
130+00
PROFILE
HORIZ. 80 40 0 SCALE 80 160 FT
VERT. 20 10 0 20 40 FT.





REF No: Plan 3983 - IT - 100

SEE DWG. No. 73 - 11014 A

KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. May & June 73.
- [8] Access Shaft

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
11	572·2	15,856,878	959,592
12	577·5	15,856,794	959,293
13	590·8	15,856,690	958,823
14	593·8	15,856,597	958,420
15	596·4	15,856,515	958,074
100	567·6	15,856,946	959,758

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

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIO… – ONTARIO
DESIGN SERVICES BRANCH – FOUNDATIONS OF… E

PROPOSED STORM SEWER
STA. 119+00 TO HEART LAKE ROAD

HIGHWAY NO. 401 & 410 DIST. NO. 6
CO. PEEL
TOWN OF MISSISSAUGA LOT CON

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. C. P.	CHECKED	W.P. NO. 127-66-34	DRAWING NO. 73 - 11014 B
DRAWN S. R.	CHECKED	W.O. NO. 73 - 11014	BRIDGE DRAWING NO.
DATE JUNE 22, 1973.		SITE NO.	
APPROVED (signature) PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

Ministry of Transportation and Communications
Ontario

Memorandum

To: L. Cederberg
Director
Public and Safety Information Branch

From: Soil Mechanics Section
Engineering Materials Office
West Building, Downsview

Attention:

Date: 77 08 04

Our File Ref.

In Reply to

Subject:

Filming of
Storm Sewer Tunnel
Heart Lake Road to South of Britannia Road
Hwy. 410 - 401 Interchange
Contract 74-93, District #6

It was decided to produce a documentary movie for the Ministry outlining the various phases of design and construction of the above mentioned tunnel project using a Tunnel Boring Machine for tunneling operations. Such documentation will be of great benefit for the training of personnel for the future projects in the Ministry. This project was approved by the Director of Construction on January 10, 1975 and a committee was formed to co-ordinate the production of the documentary film with an approved budget of $8,000.

Filming of the major portion of the construction was carried out by the Audio Visual Section at the site. However, certain intricate operations of the Tunnel Bore Machine was not filmed during construction due to the physical constraints of the tunnel diameter. Various possibilities of obtaining this missing sequence was investigated by the committee. One method of achieving the desired sequence is by animation and the approximate estimated cost is $4,000. The second alternative is to request the project Contractor, S. McNally and Sons Ltd., to carry out a mock operation on their premises. It was ascertained by our District personnel that the Contractor could provide such a demonstration for filming purposes if a machine of similar type used in our construction is available in the Toronto area. Further, a minimum fee of $1,500 would be needed by the Contractor to set up such an operation for filming purposes. It is understood that all of their tunnel boring machines are currently engaged in various construction projects. In view of these delays and costs, the Soil Mechanics Section contacted the manufactures, The Robins Company in Seattle, Washington, U.S.A., for their assistance. The Tunnel Boring Machine manufacturer is willing to co-operate at no cost to the Ministry to demonstrate any sequence of operations of this machine in their plant in U.S.A. A similar machine used by the Contractor, S.A. McNally and Sons Ltd., on our project will be available for the required sequence of operations during the 2nd or 3rd week of August, 1977 in Seattle. In order to carry out the necessary filming to complete our documentary movie, it is essential that the Ministry personnel from the Audio Visual Section should be

... 2

permitted to travel to Seattle, Washington. In this respect may we request your approval. It is estimated that the ccsts for filming this sequence will be approximately $1,000, essentially for travelling expenses. We believe with your approval this documentary film can be successfully completed within the budget allocated.

M. Devata

M. Devata
Supervising Engineer

MD/kr

cc: B. Dunstall
J. Anderson
Files

Ministry of Transportation and Communications
Ontario

Memorandum

To: Mr. D. McDonald
Area Construction Engineer
Central Region

From: Soil Mechanics Section
Engineering Materials Office
West Bldg.

Attention:

Date: 77 05 13

Our File Ref.

In Reply to

Subject:

Sewer Tunnel at Heart Lake Rd.
Hwy. 401/403/410 Complex
Cont. #74-93 & 73-124
District 6, Toronto

This memorandum summarizes our discussions with you by telephone on April 22, 1977 pertaining to our site visit to the above mentioned tunnel and subsequent monitoring program initiated at this site.

A site visit was made by Dr. K.Y. Lo of the University of Western Ontario, Mr. J. Laviolette of your office, and the writer. The completed sewer tunnel inspection revealed the presence of some longitudinal cracking located three to eight feet above the invert elevation for a distance of 200 feet east of station 139+00. The longitudinal cracking is continuous on both sides with an opening ranging from 1/16 to 1/4 inch. The cracking was essentially within that portion of the tunnel constructed by drill and blast techniques under Contract 73-124. The pertinent details of the tunnel construction methods and related information are shown on the attached sketch.

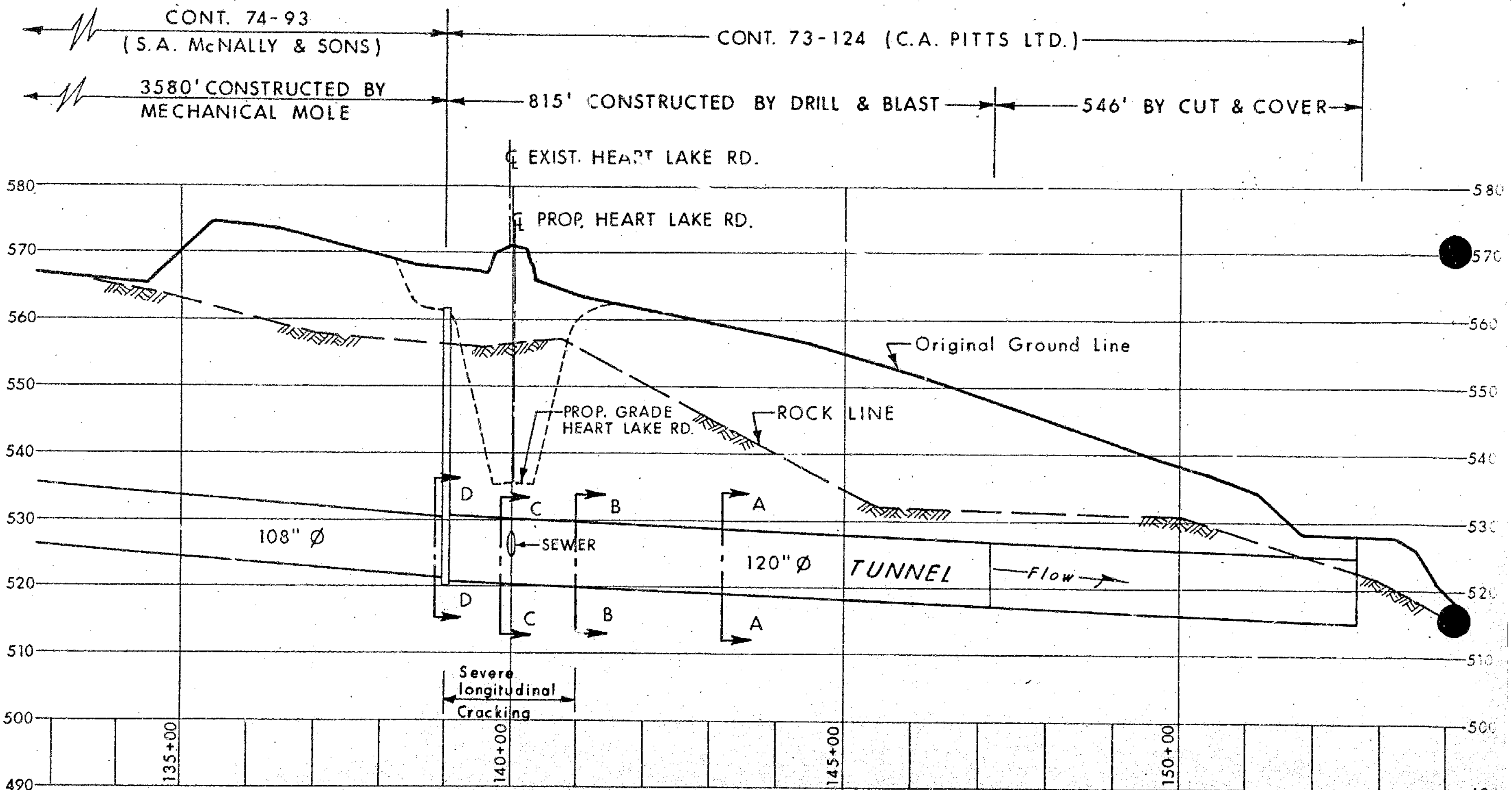
A preliminary monitoring of the cracks at four typical locations was initiated subsequently by Mr. M. MacLean of this Office. This simple monitoring system consists of filling the cracks at selected locations with Plaster of Paris. This will enable us to determine whether further longitudinal cracking is taking place. This section is also considering a more sophiscated monitoring system after reviewing the data of the preliminary monitoring program. For your information the initiated monitoring data is also enclosed with this memo.

We have also requested the Structural Office to assess the effects of longitudinal cracking on the structural integrity of the tunnel liner. We believe that the aforementioned information will provide you with the present performance of the tunnel and should you need any further clarification please contact our office.

M. Devata
Supervising Engineer

MD/bp
Encl.

cc: C.S. Grebski
Files
Record Services



ROCK SQUEEZE MONITORING AT HEART LAKE RD. & HWY 401

CONT. 74-93
CONT. 73-124

PLASTER LOCATION POINT

Section AA Sta. 143 + 20

	Height Above Invert	Crack Width, April 28/77
A1	5'	1/16"
AA2	5'	1/16"

Section BB Sta. 141 + 00

	Height Above Invert	Crack Width, April 28/77
B2	7'	hair line
B1	3'	1/8"
BB4	3½'	1/32"
BB3	5½'	1/16"

Section CC Sta. 139 + 86

	Height Above Invert	Crack Width, April 28/77
C1	3'	not plastered hair line
C2	4½'	1/16"
C3	6'	1/16"
C4	7'	not plastered hair line
CC5	6'	¼" 1/8" 1/16"
CC6	3½'	1/16"

Section DD Sta. 138 + 83

	Height Above Invert	Crack Width, April 28/77
D1	2'	1/16"
DD2	3'	1/32"

GEOTECHNICAL OFFICE
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. J. E. Callaghan,
Director,
Construction Branch.

FROM: A. Rutka

ATTENTION:

DATE: January 8, 1975

OUR FILE REF.

IN REPLY TO

JAN 9 1975 CONSTRUCTION BRANCH

RECEIVED JAN 13 1975 MTC GEOTECHNICAL OFFICE

SUBJECT:

STORM SEWER TUNNEL
Heart Lake Road to South of Britannia Road
Highway 410 - 401 Interchange
Contract ~~73-93~~ 74-93 -- W.P. 127-66-53

The abovementioned project is under construction and the work is being carried out by the Contractor, S. McNally & Sons, Ltd. The technique for tunnelling is by means of T.B.M. (Tunnel Bore Machine) in shale bedrock, some 40 to 60 ft. below the existing ground surface. In the past, the Ministry's tunnelling work was carried out by open cut-and-cover construction, or by means of blasting techniques in bedrock. Tunnels constructed using blasting techniques tend to shatter the rock when horizontal laminations are present, especially in shale bedrock, which requires extensive roof support for the safety of tunnelling operations.

At the request of the District, our Soil Mechanics Section investigated various tunnel construction techniques and concluded that using a T.B.M. is the most efficient and satisfactory method of construction with nominal roof support by means of rock bolting with shotcreting to prevent the deterioration of the rock prior to placing concrete lining. In addition, the rate of progress would be extremely fast and, under favourable conditions, this could be as much as 10 feet per hour. According to District personnel, the progress by using T.B.M. at the abovementioned contract, was up to 100 feet per day. At this project railway cars on tracks are being used to remove mucking operations in spite of the diameter of the tunnel being only 11 ft. It is understood that the tunnel alignment requires a horizontal curve and the T.B.M. will be able to carry out such operations without the use of manual method of construction.

In the Ministry, the need to examine such application of advanced technique for underground construction demands a knowledge of new tunnelling methods, design and construction implications, as well as an appreciation of current technology for tunnels of small diameter (10 to 15 feet). Since this project provides such useful construction technology, the unique construction details using T.B.M. for tunnelling should be properly recorded and documented. This can only be achieved by filming the entire construction on a 16 mm sound movie film. This aspect has been discussed with our Audio-Visual Section and they are in a position to produce such documentary film outlining the various phases of design and construction. Such documentation will be of great benefit for the training of personnel for future projects in the Ministry.

..... 2.

Mr. J. E. Callaghan,
Director,
Construction Branch.

January 8, 1975

Storm Sewer Tunnel - Heart Lake Road to South of Britannia Road
Highway 410 - 401 Interchange - Cont. ~~73-93~~ 74-93 -- W.P. 127-65-53

The District has discussed the production of a documentary film with the Contractor and he expressed full co-operation in this respect. It is estimated that the production cost, including materials and salaries of the Audio-Visual Section, will be about $6000. - $8000. We are requesting your approval to pursue this project, by allocating necessary funds to the contract. * The production of the film has been discussed in detail with Mr. D. MacDonald, Construction Engineer, District 6.

A. Rutka

AR/MD/MdeF

A. Rutka
Manager, Geotechnical Office

cc: Messrs. D. F. MacDonald
W. G. Wigle
C. Mirza ✓
P. Smith

Charges :- initially salary charge & equip Audio-Visual Sect

* Approved
J. E. Callaghan
Director of Construction
Date Jan 10 1975

* Cont 74-93 will accept 50% of cost balance, 50%, to Geotech Office as per agreement with A. Rutka Jan 10/75

Mr. H. Greenland,
District Engineer,
District #6, Toronto.

Mr. D. McDonald.

Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

September 24th, 1974.

RE: Heart Lake Road
& Highway #401,
Contract 74-93.

Further to your verbal request, we have reviewed the proposed construction procedures for tunnel roof support by the Contractor, S. McNally & Sons, Limited, on the abovementioned project and submit the following comments: -

In our opinion, the proposed construction procedure submitted to your Office by the Contractor carrying out the tunnel excavation, using a T.B.M., appears to be a very satisfactory method compared to a blasted tunnel which tends to shatter the rock when horizontal seams are present. It should be noted that the shale bedrock at the Heart Lake Road and Hwy. 401 has a low percentage of limestone bands and in view of this, temporary roof support is essential for the safety and progress of tunnelling operations.

It appears that the suggested method of rock bolting with shotcreting is essential in this type of shale bedrock and due care must be exercised at all times by the Contractor to provide safe working conditions in the opened portion of the tunnel. For very bad rock conditions or fault zones, if required the Contractor should use WF ribs and the spacing should be determined as per the conditions of the exposed bedrock.

This Section discussed the proposed construction procedure with the owner's representatives who have been involved with it. These representatives are:

1) Mr. L.N. Hogarth - James F. MacLaren Association, Senior Project Engineer.

2) Mr. F. Horgan - Metro Toronto Works Department, Director of Engineering.

Mr. H. Greenland - RE: Contract 74-93.

3) Mr. R.E. Curtis - DeLeuw, Cather,
Chief Municipal Engineer(London)

All the abovementioned representatives have expressed great confidence as to the quality and ability to carry out tunnelling operations of the Contractor, S. McNally & Sons, Limited, using a full face rock boring machine both in Ottawa and Toronto. It is understood nearly 10 miles of tunnelling was successfully completed in Metro Toronto adopting the procedures outlined by the Contractor.

In view of the foregoing we feel that permission to bore the tunnel completely before placing any concrete lining can be granted, provided that the Contractor assures safety of personnel working in the tunnel at all times.

M. Devata,
Supervising Engineer.

MD/mj
c.c. Files
Documents

Toronto Office
1544 The Queensway
Toronto 540, Ontario
M8Z 1T5

M. Devato

Done

S. McNally & Sons, Limited
Engineers & Contractors

Head Office — 1855 Barton St. East
P.O. Box 3338, Station "C",
Hamilton, Ontario
L8H 7L8
Telex No. 021-8309

September 16, 1974

Mr. H. Greenland, P. Eng.,
District Engineer,
1201 Wilson Avenue,
Downsview, Ontario.
M3M 1J8

Attention: Mr. D. McDonald, P. Eng.

Re: Heart Lake Rd. & Highway #401
Contract 74-93

Dear Sir:

This letter is to clarify our proposed construction procedure for tunnel roof support on the above noted project.

We are proposing to bore the tunnel from Manhole X-1, using a full face rock boring machine, manufactured by the Robbins Company of Seattle, Washington. This machine, and another similiar machine, have just just completed approximately 10 miles of tunnel in Dundas Shale in downtown Toronto, for the Metro Toronto Works Department, and in Ottawa, for the Regional Municipality Ottawa - Carlton Works Department. The excavated tunnel, using a T.B.M., results in a perfectly round self supporting arch, as opposed to a blasted tunnel, which tends to come out square and shatters adjacent rock, especially when horizontal seams are present.

The T.B.M. at work in Ottawa, will finish boring September 17/74, and will be shipped down to this job, (Contract 74-93) and available for work in October 1974.

The rock in Ottawa has a considerably higher percentage of limestone than in Toronto, with the result that no temporary roof support was required for the full 8000 feet of bore. Concrete lining will commence one completion of the mining operation. The Toronto Shale requires temporary roof support, and we have developed a very safe procedure for support, which is done as the mining progresses.

....cont'd page (2)

We have mounted two stopers immediately behind the head of the boring machine. These are mounted on swivels, which are attached to the gripper assembly. As the machine moves forward, the gripper assembly remains stationary for the distance of one move, which is 42 inches. Four holes, 1½" diameter and 4 feet long, are drilled into the roof and four "selfix" high tensile rods are inserted with a "Celtite" sausage on the end of each rod. The rod is rotated, until the "catalyst" in the sausage mixes with the resin. This takes approximately 18 seconds. A metal roof pan is then bolted to the roof, using the 4 rods to anchor it. (See attached sketch - C-196-1). The machine then continues until the move is completed, the gripper assembly is then retracted and advanced another 42 inches, along the tunnel , regripped and the stoper men start drilling holes for the next roof pan.

For very bad rock conditions or fault zones, we have a hydraulically operated ~~operated~~ shield over the head of the machine with long, 4 inch wide slits in it. This can be used to hold up any "loose" until bolts can be installed through the slits in the shield. If required, we can further use 4" WF ribs, which are pinned to the shale at spring line. The spacing of these ribs would vary, but an average spacing would be 4'0". Lagging between ribs would be with 2" or 3" hardwood. Although it is unlikely that ribs will be required, we will have some on the job site for an emergency, if it should arise.

Every third shift, the tunnel roof will be shotcreted with approximately 1 inch of material, to eliminate air slakening. Please note that no mechanical rock anchors will be used as these have proved to be unsatisfactory in shale rock. The use of the "celtite" rock anchor, eliminates any transverse stresses in the rock which results from the use of mechanical anchors.

Muck will be hauled away from the boring machine, using two diesel operated trains. In order to have an efficient operation, we must have room in the tunnel for a "California" type switch, which will allow the trains to pass one another. If the tunnel has a concrete lining, we will not have room for this switch.

On completion of the bore, it will be necessary to remove our boring machine from the tunnel, either by excavating a shaft at the north end of the job or by backing the machine up the full length of the tunnel, back to Manhole X-1. It would be impossible to back up the machine if the concrete lining was in place.

To attempt a concrete operation at the same time as the machine was mining, would prove unsatisfactory. The machine mining entails a 3 shift/24 hour period with 2 shifts mining and one shift shotcreting. The concrete operation would be a two shift basis, with one shift setting forms and one shift placing concrete.

.....cont'd page (3)

We would therefore request a relaxation of Item #7, under Measurement and Basis of Payment, Page 16, of the Special Provisions. With our experience on approximately $30,000,000 worth of similiar work in shale tunnels over the past 4 years, and the method we have devised for temporary roof support, we would request permission to bore the tunnel completely before placing any concrete lining.

If you wish to consult any of the owner's representatives for their comments on our roof support operation, the following have been involved with it:

✓(1) L.N. Hogarth - James F. MacLaren Association, Senior Project Engineer - 499-088[illegible]

(2) F. Horgan - Metro Toronto Works Department - [illegible] Director of Engineering

(3) R.E. Curtis - Delew Cather Chief Municipal Engineer (Ottawa) (613) 733-92[illegible]

432-63[illegible] LONDO[illegible]

Yours truly,

S. McNALLY & SONS LIMITED

[signature]

P.S. Hobden, P. Eng.

PSH/jq
encl.

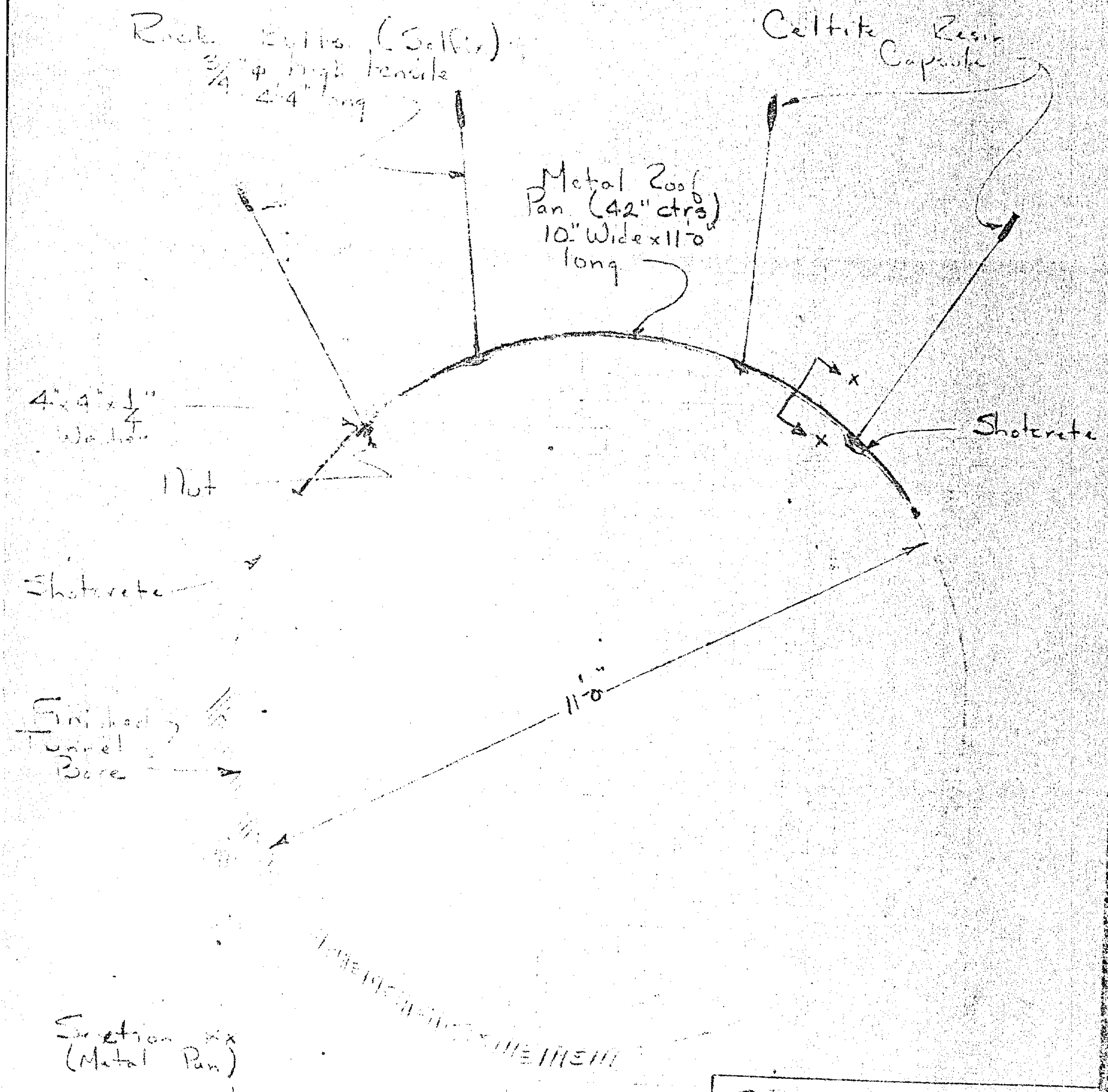
(1) Check with Foundations

(2) Check for construction of shaft at Britannia

→ Discussed with the above three mentioned persons and concluded that the proposed method by the Contractor is quite good and can be adopted. Informed Don MacDonald the results of my phone conversation.

M. Devata
23/Sept/74

Section Showing Roof Support
Shale Tunnel
(42 inch ctrs)



S. McNally & Sons Ltd.
Proj - M.O.T. 74-93
Dwg # C-196-1
Dr. PSL Date Sept 15/74

Mr. J. Foster,
Sr. Soils Engineer,
Materials & Testing Office,
Southwestern Region, London.

Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

July 12th, 1974.

RE: W.O. 73-33-014,
Highway #3,
Sewer Outlet.

We have reviewed the proposals for remedial measures to the drainage outlet over land owned by Mr. Peters. As we have no information on the subsoil in the area of the drain we can only base our suggestions on the existing topography.

As the existing slopes at the site are safely standing with very steep slopes (as much as 1:3.5) it should be safe for the dragline to approach the edge of the embankment at the back of the eroded area (i.e. where the erosion begins at the outlet).

With regards to the new outlet we believe the proposed system should be satisfactory provided the 15" diameter CSP is large enough to prevent blockage by freezing. Should the pipe become blocked, the weight of backed-up water could result in failure of the retaining system hence further eroding the slopes. In view of the magnitude of this operation we feel a pipe diameter of at least 24 inches would be preferable.

W.J. Alcock
Project Engineer
For:
K.G. Selby
Supervising Engineer

WJA/mj
c.c. J.L. Keen
Files
Documents

M. Devata

B.D.
File Please
73-11014

Distribution

Systems Design Branch
East Building

May 27, 1974

Contract 74-93, W.P. 127-66-53, Hwy 401, Storm Sewer System from Heart Lake Road to Britannia Road, Highway 401 & 410 Interchange, District 6

Following are the minutes of meeting held May 24, 1974.

Problem: Review of adequacy of contract requirements to diminish anticipated problems with tunnelling operations.

Basis: A recent and adjacent contract with similar work, exhibited cave-ins from shale rock having become unstable when exposed to air and water.

Attendance:

G. Martens	-	Chairman
D. McDonald	-	
B. Giroux		
M. Devata ✓		
C. Poon		
W. Roters		
N. Sen		
J. Wear	-	Secretary

A review of the contract special provisions satisfied those present that the Contractor would be constrained from performing all excavation before commencing concreting without dictating the manner of construction operations. The method of construction chosen by the Contractor is to be presented to and approved by the Engineer before work is commenced.

Following is an extract from the special provisions:

> "Because of the deterioration of rock when exposed to air and water, the tunnel roof shall be supported to the satisfaction of the Engineer until the permanent tunnel lining is placed. The lining shall be placed within 30 working days of the excavation, and no more than 165 L.F. of unlined tunnel will be permitted."

.... /2

The basis of selecting 165 feet is an anticipated tunnelling operation involving the laying of, or concreting 60 feet of pipe, while 60 feet is being formed and leaving a 45 foot clearance area adjacent for blasting and mucking.

It was agreed that no further detail be requested of the Contractor in the special provisions. Clarification of the Contractor's method of operation would be made at the time of his submission to the Engineer.

Compaction

D. McDonald identified that for contract 73-124 the specified compaction requirements were waived and the Contractor provided an alternative means acceptable to the Engineer.

Discussion on the requirement for compacting shale rock from tunnelling and other operations relating to contract 74-93 ensued.

It was resolved that a certain compactive effort be defined within a "general" special provision to be applied to shale rock in the same manner as contract 73-124, except that the provisal of "or an acceptable equivalent" be added.

Following the meeting, J. Wear obtained G. Wrong's concurrence for the following general special provision to be included in contract by the Project Review Section. The basis for the SP is SP7042.

"COMPACTION

This contract contains no separate tender item for compaction equipment as may be required to compact earth, shale rock or granular materials whether used for embankment construction base courses or backfill.

The contract prices for the materials to be placed or the work to be carried out shall include full compensation for supplying and operating such compaction equipment as the Contractor may require and for compacting the materials to the specified density, or in the case of shale rock to the compactive effort specified.

Shale Rock shall be placed in accordance with earth embankment construction requirements of MTC Form 200 and amendments thereto, except that compacted lifts shall not exceed 12 inches. Compaction for each lift shall consist of the combination of 2 passes with a 20 ton static roller and 2 passes with a 10 ton vibratory steel drum roller, or an equivalent compactive effort acceptable to the Engineer.

Sub-section 214-03 "Compacting Equipment" is not applicable to this contract.

The Provision of Sub-Section 214-04 that one compacting unit is to be provided for each 125 cubic yards of embankment material placed per hour is not applicable to this contract.

When it is impractical with the larger types of compaction equipment to obtain the required degree of compaction in areas where working space is limited, the Contractor shall provide and use mechanical hand compaction equipment in order to achieve the specified density.

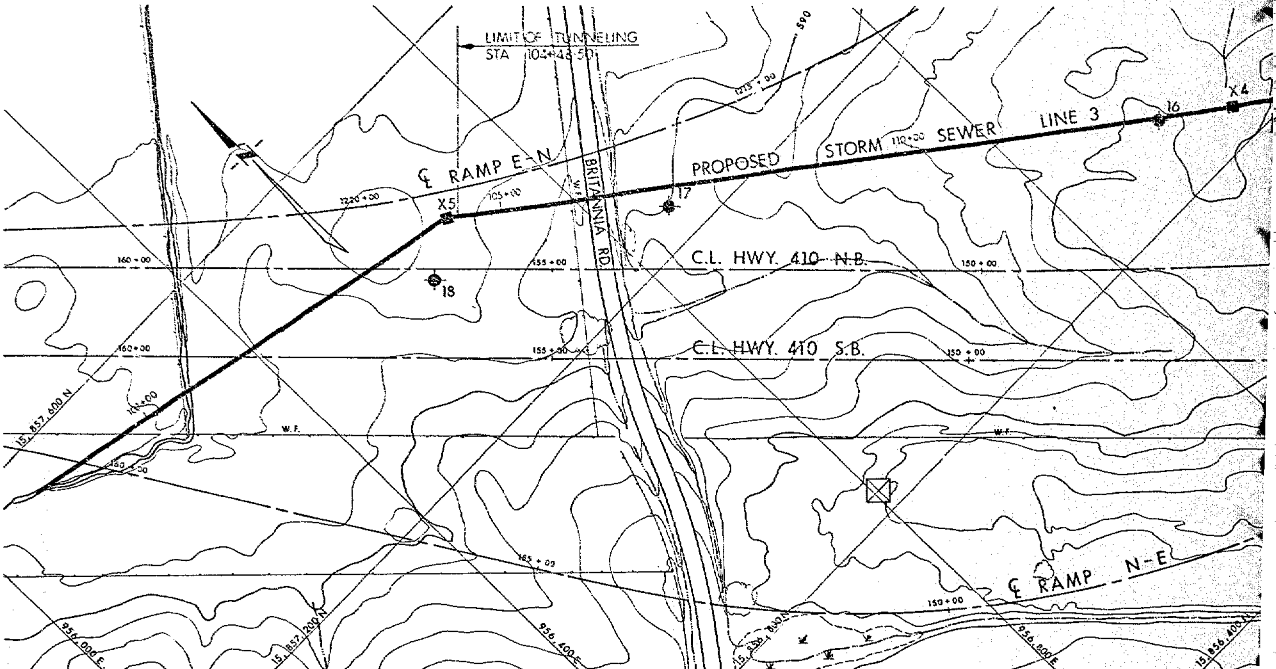
Granular materials used as base courses or as granular backfill shall be compacted to a density of 100% of the maximum dry density. All other earth materials shall be compacted to a density of 95% of the maximum dry density.

When field tests indicate that the required degree of compaction cannot be obtained with the equipment in use or the procedure being followed, the Contractor's operations shall be halted until the Engineer is satisfied that the Contractor has made such modifications, in his equipment and procedure, which will produce the required results."

JRW/jc

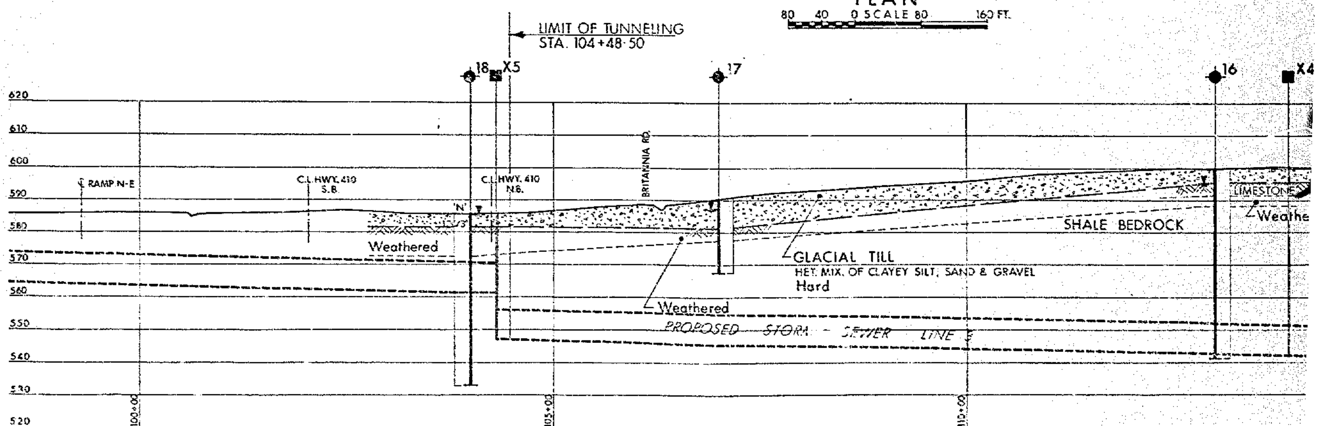
J. R. Wear
Project Review Engineer

c.c. Those attending
R. Verscheure
G. Wrong
E. J. Willis



PLAN

80 40 0 SCALE 80 160 FT.



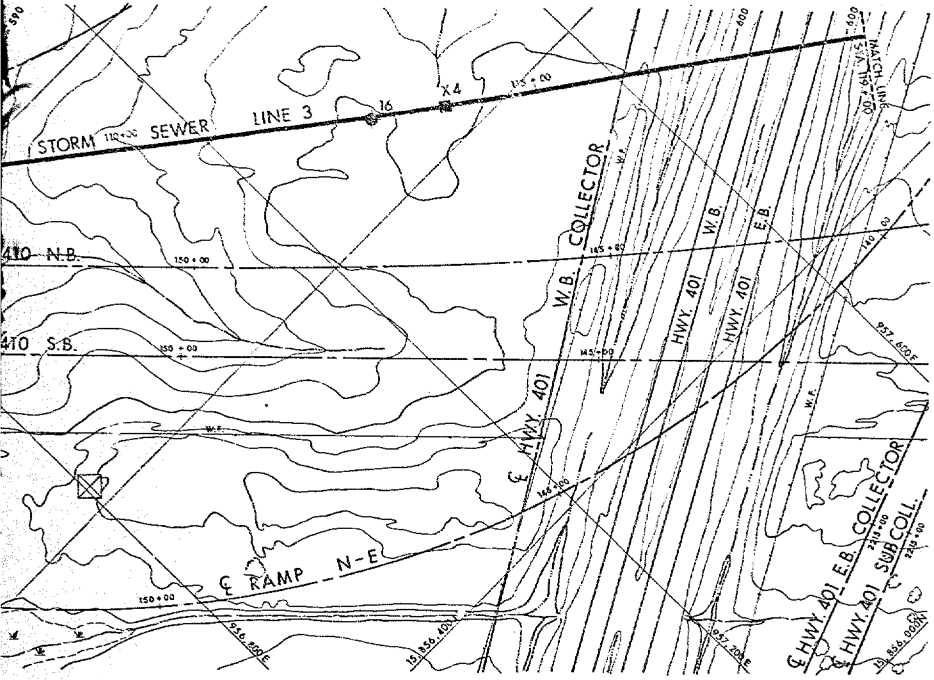
PROFILE

HORIZ. 80 40 0 SCALE 80 160 FT.

VERT. 20 10 0 20 40 FT.

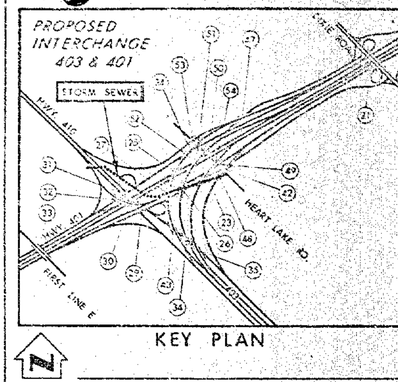
NOTE FOR CONTRACT DOC

The complete foundation inve this structure may be examin Office and Foundations Offic and at the TORONTO



PLAN

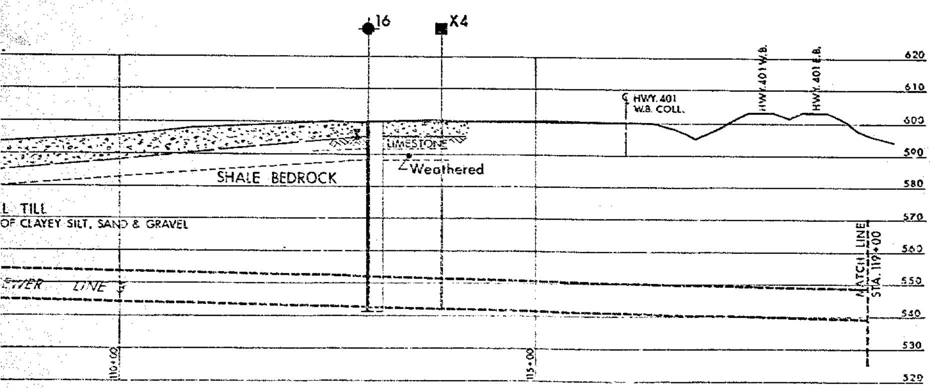
0 SCALE 80 160 FT.



LEGEND

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

NO.	ELEVATION	CO - ORDINATES	
		NORTH	EAST
16	599.9	15,856,895	957,360
17	590.0	15,857,245	956,874
18	585.6	15,857,388	956,614



PROFILE

0 SCALE 80 160 FT.

0 20 40 FT.

— NOTE —

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

NOTE FOR CONTRACT DOCUMENT:
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the TORONTO District Office.

REF. No. Plan 3983-IT-100

REVISIONS		
MAY 74	S.O	LIMIT OF TUNNELING REVISED
APR 74	S.R	SEWER REVISED IN PLAN & PROFILE
DATE	BY	DESCRIPTION

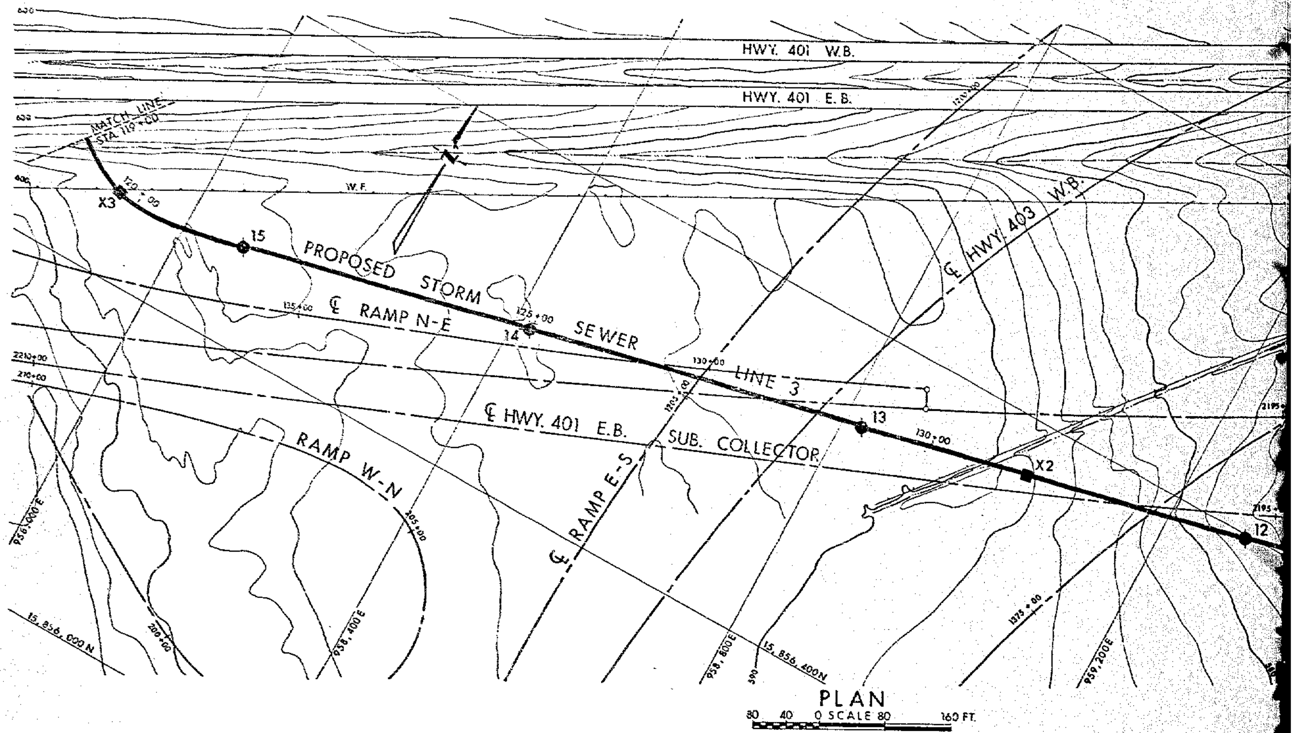
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH — GEOTECHNICAL OFFICE

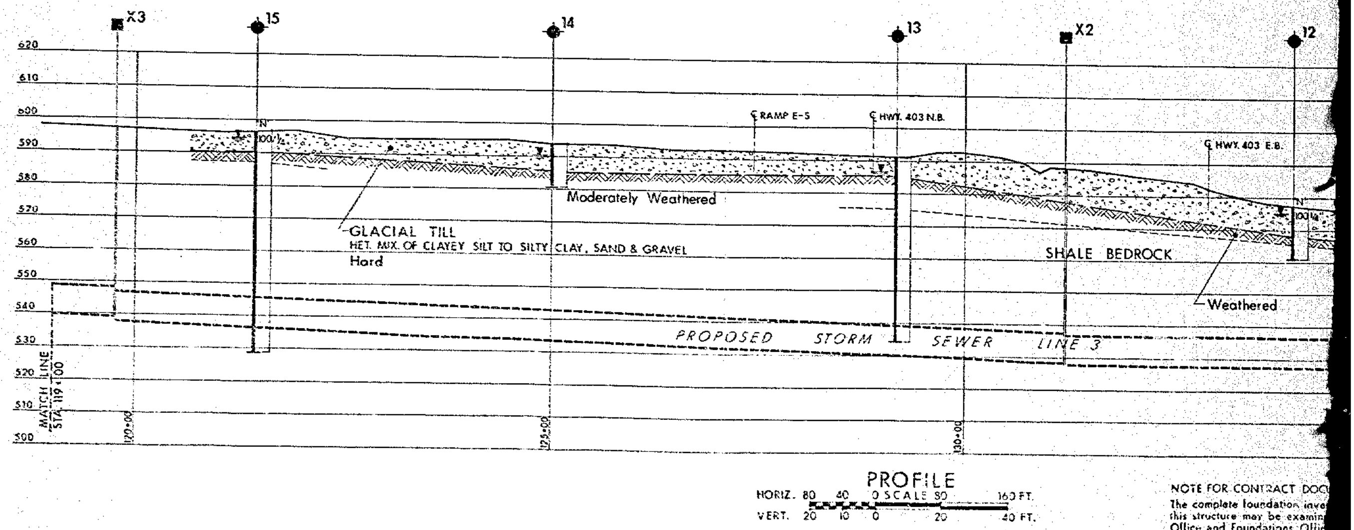
PROPOSED STORM SEWER
STA. 98 + 60 TO STA. 119 + 00

HIGHWAY NO. 401 & 410 DIST. NO. 6
~~CO~~ REG. MUN. OF PEEL
CITY OF MISSISSAUGA LOT ______ CON ______

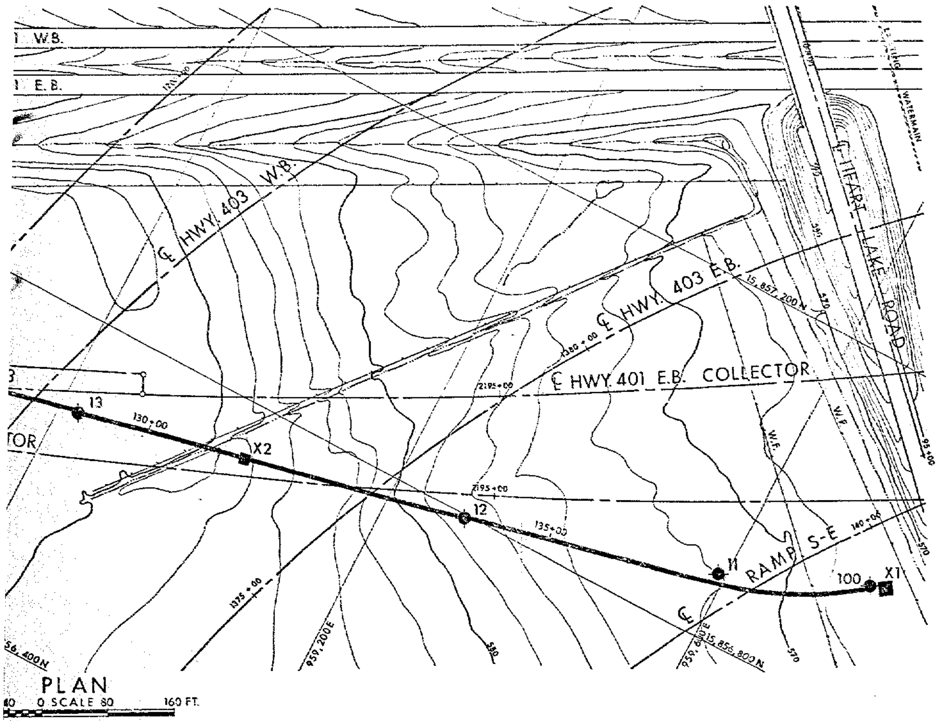
BORE HOLE LOCATIONS & SOIL STRATA

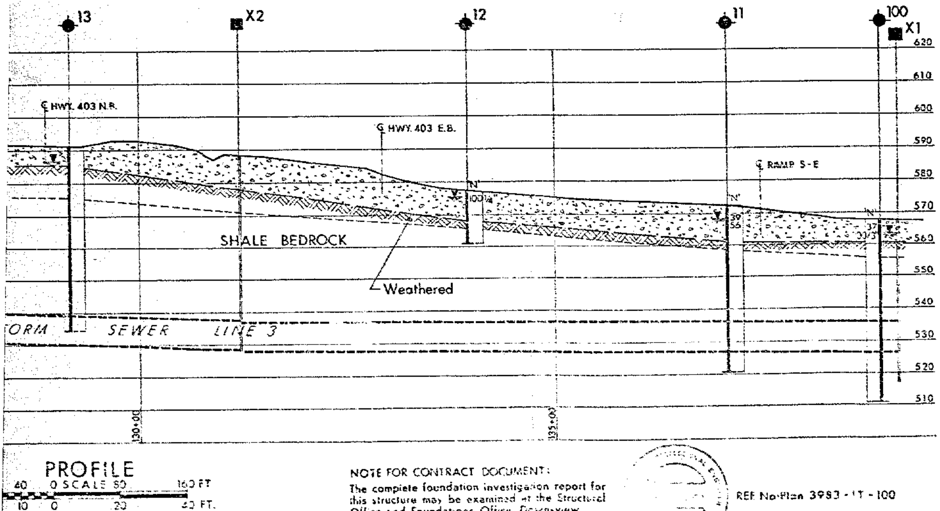
SUBMD. C.P.	CHECKED	W.P. NO. 127-66-53	DRAWING NO. 73 - 11014 A
DRAWN S.R.	CHECKED	W.O. NO. 73-11014	
DATE JUNE 27, 1973.		SITE NO.	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	





NOTE FOR CONTRACT DOC
The complete foundation inve
this structure may be examin
Office and Foundations Offi
and at the ______ TORONTO





SEE DWG. No. 73 - 11014 A

KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation: May & June 73.
- Man Hole

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
11	572·2	15,856,878	959,592
12	577·5	15,856,794	959,293
13	590·8	15,856,690	958,823
14	593·8	15,856,597	958,420
15	596·4	15,856,515	958,074
100	567·6	15,856,946	959,758

— NOTE —

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

DATE	BY	DESCRIPTION
APR. 74	S.R.	SEWER REVISED ON PROFILE

REVISIONS

NOTE FOR CONTRACT DOCUMENT:
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the TORONTO District Office.

REF No. Plan 3983 - IT - 100

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE

PROPOSED STORM SEWER
STA. 119+00 TO HEART LAKE ROAD

HIGHWAY NO. 401 & 410 DIST. NO. 6
REG. MUN. OF PEEL
CITY OF MISSISSAUGA LOT ____ CON. ____

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. C. P.	CHECKED	W.P. NO. 127 - 66 - 53	DRAWING NO. 73 - 11014 B
DRAWN S. R.	CHECKED	W.O. NO. 73 - 11014	BRIDGE DRAWING NO.
DATE JUNE 22, 1973.		SITE NO.	
APPROVED		CONT. NO.	

Planning
Engineering
Project Management

FENCO

1 Yonge Street
Toronto, Canada M5E 1E7
416-361-4722
Cable 'Foundaneng'
Telex 02 2814

April 4, 1974

Mr. M. S. Devata
Supervising Foundations Engineer
Design Services Branch
Ministry of Transportation
and Communications
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M IJ8

Dear Mr. Devata,

HIGHWAY 401 - HIGHWAY 410 INTERCHANGE
W.P. 127-66-53

We are returning your Borehole Locations and Soils Strata drawings 73-11014 A & B marked up with the revised sewer alignment and profile. Enclosed are FENCO drawings 3983-16H-3 giving alignment data, and drawings 3983-16H-8, -9 & -10 showing profile information.

Will you please have the drawings changed to show the revised sewer location.

Yours very truly,
FOUNDATION OF CANADA ENGINEERING
CORPORATION LIMITED

B T Stone

B. T. Stone
SECTION LEADER

BTS/me
3983-101-1
Encl.

cc: Mr. N. Sen
Ministry of Transportation
and Communications,

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: MEMO TO FILE

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

ATTENTION:

DATE: June 6, 1973.

OUR FILE REF.

IN REPLY TO

SUBJECT: Access Shaft (Station 139+00) - Trunk Sewer
Hwy. 401 & 403, Town of Mississauga, W.O. 73-11014

The following information was given to Mr. B. Phalp of FENCO by phone:

1. 3' diameter drilled caissons (approximately 35 ft. into shale bedrock) may be installed without any difficulties using churn drilling techniques, according to information provided by Mr. P. Kozzuki of Western Caisson.

2. Vertical cut in sound shale is stable provided:

   i) it is left unbraced for a period not more than 2 weeks, and

   ii) it is constructed in summer months

   (according to information provided by Mr. K. Ingham).

3. Dundas shale may be excavated by backhoe.

4. $K_o = 0.36$ & $K_a = 0.22$ may be used in computing earth pressure exerted by shale bedrock ($\phi' = 40°$).

C. S. Poon
Project Foundations Engineer.

CSP/ao

J. FULOP & ASSOCIATES
Geophysical Consultants
1727 Bayview Avenue,
Toronto, M4G3C1, ONTARIO
TEL: (416) 483-3616

Mr.Murty S.Devata,P.Eng.,
Supervisor Foundation Engineer,
Ministry of Transportation & Communication,
Downsview,Ontario.

May 15,1973.

Dear Mr.Devata;

Last week I talked to Mr.Paul Payer,foundation engineer of your department who agreed that I may run a little test free of charge,over part of the line of a project site,near the city in Mississauga Township at 2nd line East.
The test was carried out on May 9th over a 900 foot long section of the center line marked with pickets numbered from 10 to 4.
No borehole information or elevation values were available so the depth of calculated rock horizon and top of till layer is given with respect to arbitrary horizontal surface.
I am aware that the Ministry has its own geophysical staff and this is simply an expression of my continued interest in foundation engineering,suggesting that there are times when geophysics is a useful tool in pre engineering investigations of the subsurface.
Believing that you might be interested to read this short report on the survey I thank you for your attention and would be happy to discuss any point of interst.

Yours very truly;

J.Fulop,M.A.Sc.P.Eng.
Geophysical Consultant.

cc/P.Payer.

REPORT ON SEISMIC TEST.

OBJECTIVE: to show that the seismic refraction method provides useful information in special cases.

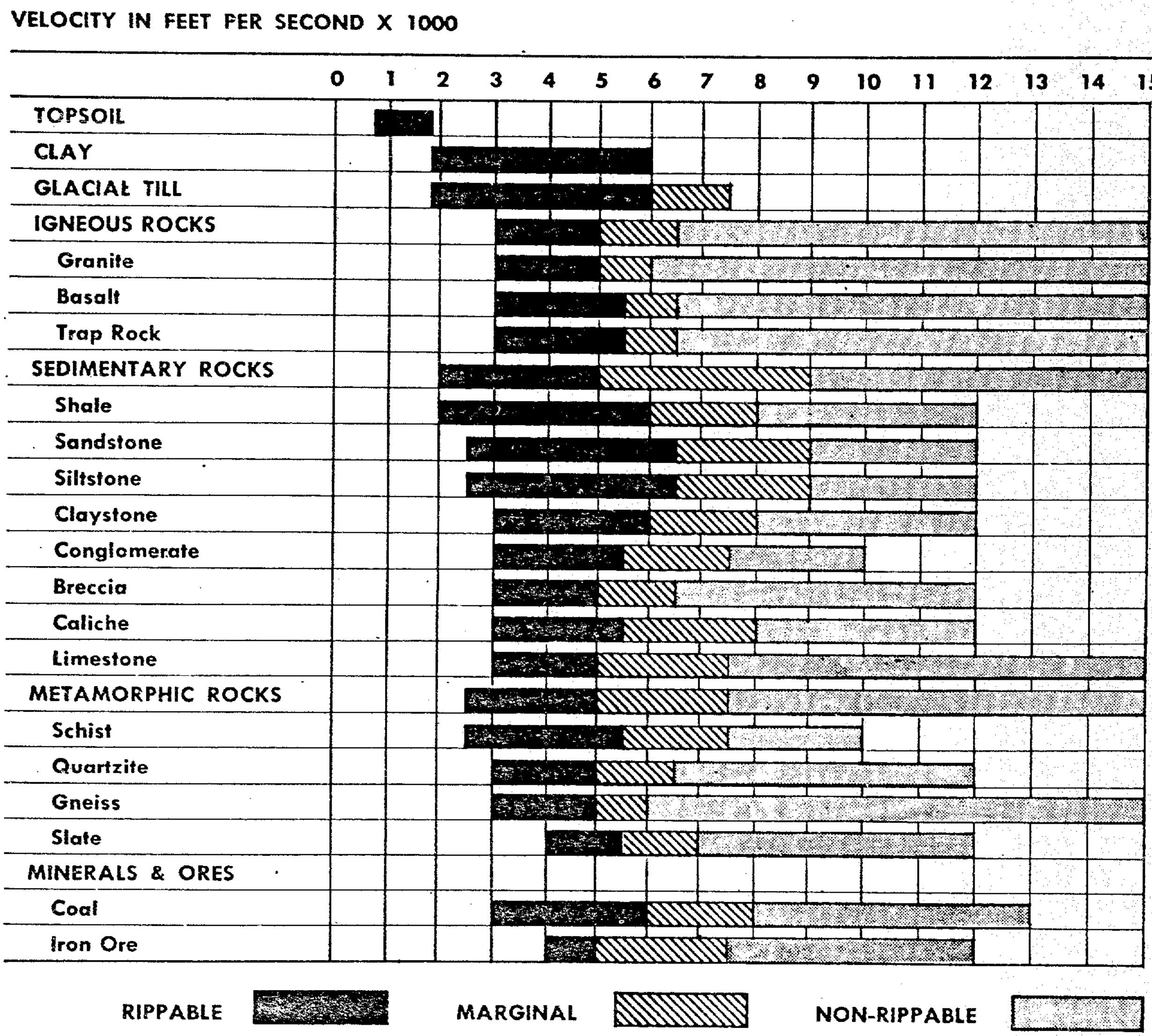
GENERAL: it is understood that excavation or/and tunneling are considered to complete the project.
The boreholes would provide sufficient data for that but the seismic survey gives a continuous although a less accurate profile.
Enclosed with the sample records are the calculated section, some literature and a brief explanation on the technique which is not a study of the vertically reflected waves but the measurement of their travel-time in the horizontal direction, the origin being at the impact point.

APPLICATION OF SEISMIC SURVEY:

A/ By measuring the surface distance to each detector, (geophone) and the travel-time of shock waves, a characteristic seismic velocity is calculated which is used for calculating the depth of refractor. Thus if the interval of geophones is large e.g. 50 ft. the measurement of differential wave arrivals may not allow depths calculated at more than ±10%. But at the same time this calculated profile is continuous in comparison to borehole values which are really point values considering the dimension of a line.
The first requirement is the existence of a measurable elastic (seismic) contrast between layers of different geology. Another condition is that the thickness of these layers must increase downwards (in a multylayer case), in order to propagate another set of waves traveling at a different velocity.
The top of shale is the 2nd and 3rd layer in our case. It shows a slight dip to the East but may be considered reasonably flat. At the sections marked with X a delay of seismic waves was recorded interpreted as dip in the shale (refractor) surface. Larger delays in some cases may be caused by a less competent, fractured rock zone. The uniform velocity associated with the shale in this case indicates a lithologically homogeneous shale.
The East end of the profile might be part of a pre-glacial, glacial eroded then buried riverbed.

B/ The speed of shock waves (seismic velocities) through the bulk of sub-surface material is characteristic for the physical properties of the rock or other material. They show whether or not the material is rippable.

SEISMIC RIPPABILITY CHART*



*Developed by Caterpillar Tractor Co., using the MD-1, for the Caterpillar D9 with mounted hydraulic No. 9 ripper.

The enclosed chart developed by the Caterpillar Tractor Company for a hydraulic 9 ripper may be useful in estimating contract work for excavation.

CONCLUSION: ALL unconsolidated material including the till with 7500ft./sec.velocity are rippable.
ALL shale material falls into the category of "nonrippable".

C/ Seismic refraction can beneficially be used to determine at least the RELATIVE elastic moduli of the subsurface materials and in case of hard rocks their approximate ABSOLUTE compressive strenghts.
Considering the STATIC and DYNAMIC loading of a volume of material when impacting the ground one measures the compressional and shear waves travel-time in comparison to a stress-strain analysis of the static loading.
From the two waves the Poisson's Ratio is calculated and knowing the density, the Elastic Moduli (E,G,L) may be calculated.
Using the compressional velocity obtained within this test and from other sources (Toronto Gore Twp) accepting the the shear wave velocity and the density of Dundas shale the elastic modulus E is calculated from;

$$E = V_c^2 \cdot \rho \times 0.0134 \frac{(1+\mu)(1-2\mu)}{(1-\mu)} \text{ [psi]}$$

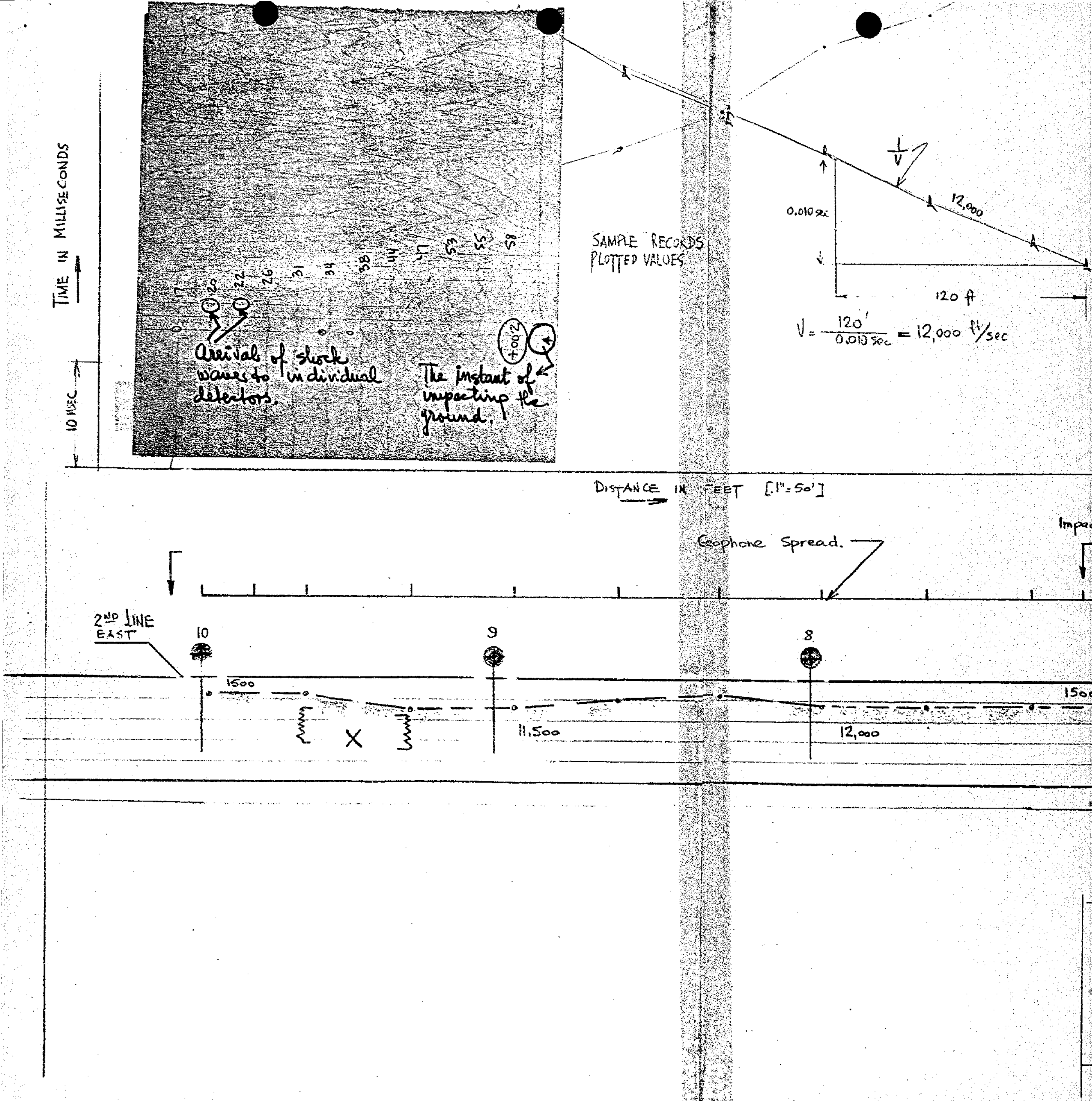
V_p COMPRESSIONAL SEIS. VELOCITY 12000 ft/sec.
V_s SHEAR WAVE SEIS VELOCITY 5,500 ft/sec.
δ DENSITY 2.47 gr/cc = (154 lbs/ft³)
μ - POISSON'S RATIO $= \frac{0.5R^2-1}{R^2-1}$ WHERE $R = \frac{V_p}{V_s} = \frac{12{,}000 \text{ ft/sec}}{5{,}500 \text{ ft/sec}} = 2.18$ $\mu = 0.37$

$$E = 144 \times 10^6 \times 2.47 \times 0.0134 \left(\frac{\overbrace{1.37 \times 0.26}^{0.57}}{0.63} \right) \qquad E = 2.7 \times 10^6 \text{ p.s.i.}$$

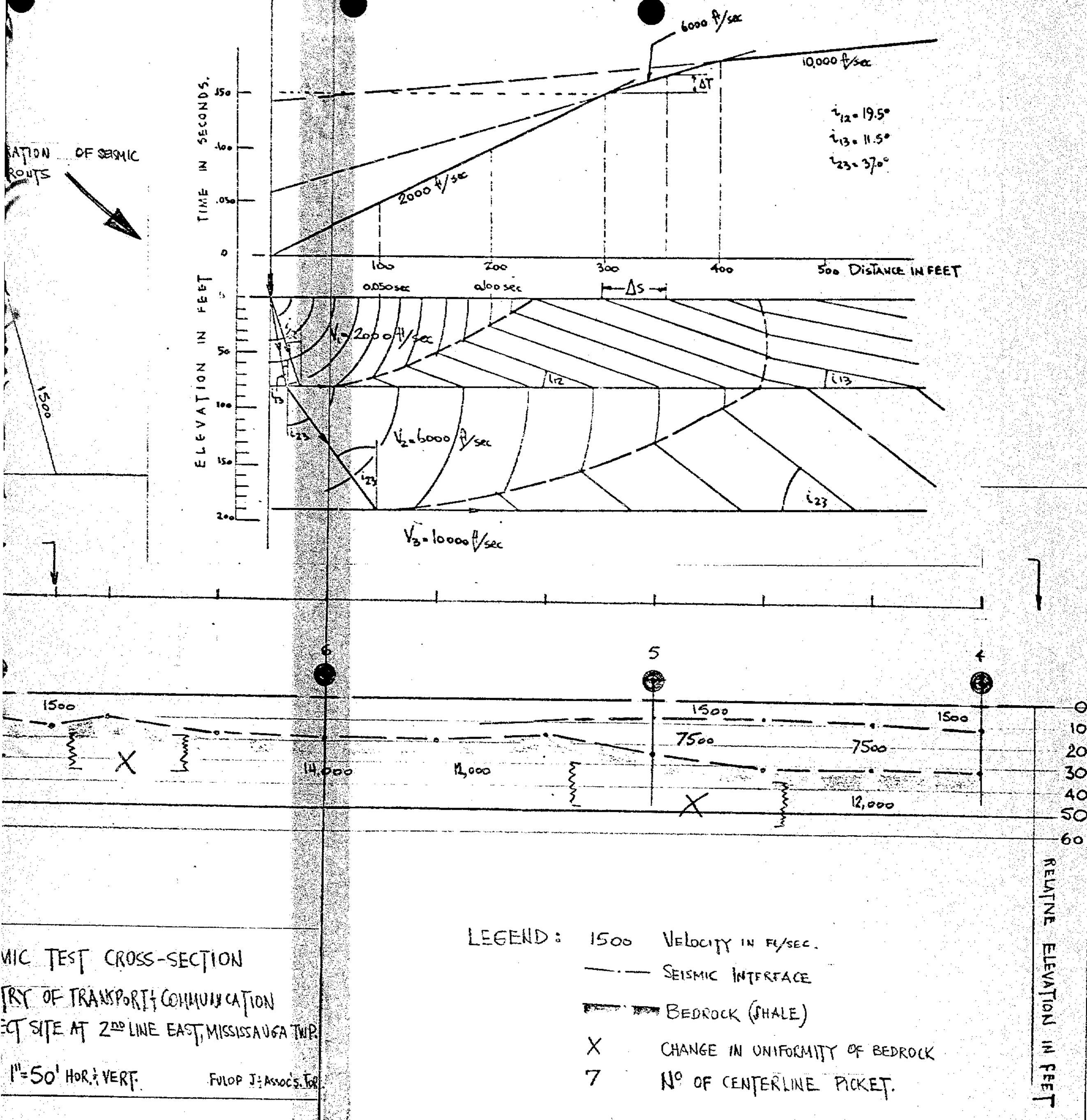
CONCLUSIONS: there is a sufficient elastic contrast between the Dundas shale and the overlying unconsolidated material (even dense till).
: the shale is reasonably uniform in its physical properties and shows some dip to the East.
: on the East end overlying bedrock an intermediate (perhaps dense till) layer is shown which may be the West side of an ancient erosional feature, a glacial buried channel.

Respectfully submitted;

J. Fulop, M.A.SC.P.Eng.,
Geophysical consultant.



TIME IN MILLISECONDS
10 MSEC
0
17
20
22
26
31
34
38
44
47
53
55
58
Arrivals of shock waves to individual detectors.
+.002
The instant of impacting the ground.
SAMPLE RECORDS
PLOTTED VALUES
1/V
12,000
0.010 sec
120 ft
V = 120' / 0.010 sec = 12,000 ft/sec
DISTANCE IN FEET [1" = 50']
Geophone Spread.
2ND LINE EAST
10
9
8
1500
X
11,500
12,000



MIC TEST CROSS-SECTION

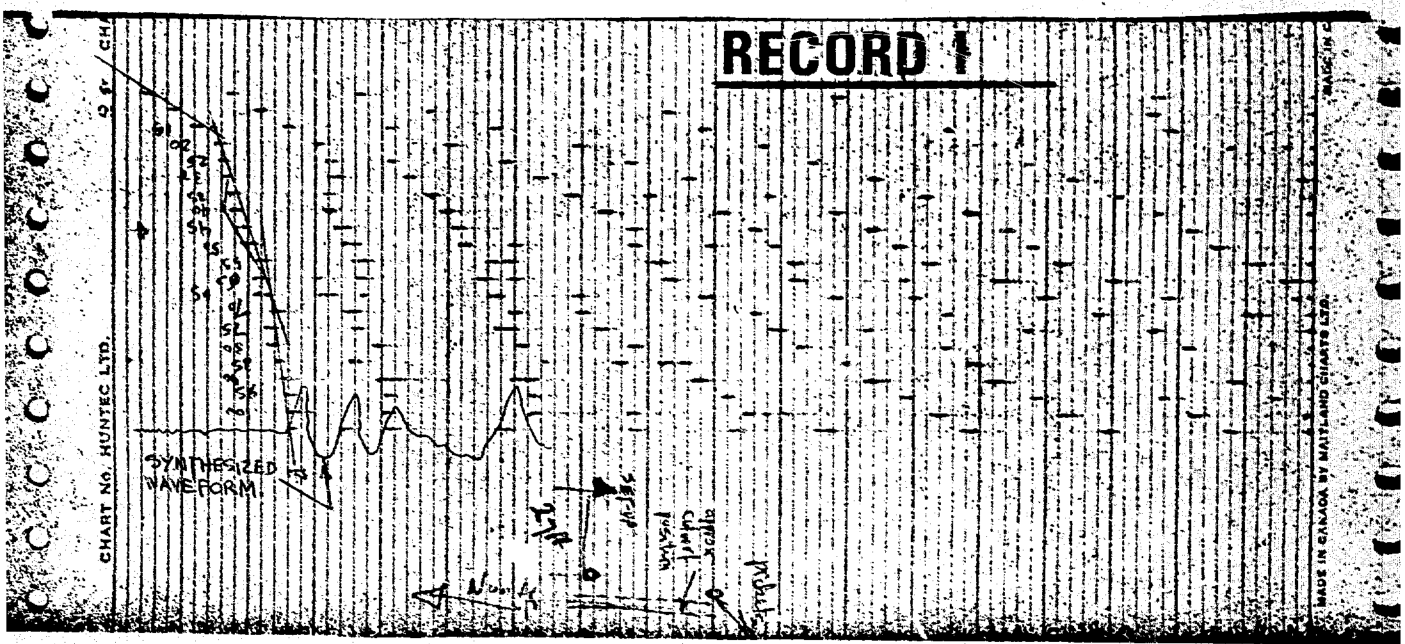
TRY OF TRANSPORT & COMMUNICATION

ECT SITE AT 2ND LINE EAST, MISSISSAUGA TWP.

1" = 50' HOR. & VERT. FULOP J. & ASSOC'S. TOR.

LEGEND:

1500	VELOCITY IN FT/SEC.
—·—	SEISMIC INTERFACE
▬ ▬	BEDROCK (SHALE)
X	CHANGE IN UNIFORMITY OF BEDROCK
7	Nº OF CENTERLINE PICKET.



THIS IS A SAMPLE RECORD PRODUCED BY THE SAME EQUIPMENT WHAT THE SOILS OFFICE OF YOUR DEPARTMENT HAS.

ONTARIO

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

MINISTER: HONOURABLE GORDON CARTON, Q.C.
PARLIAMENTARY ASSISTANT: WILLIAM NEWMAN, M.P.P.

DEPUTY MINISTER: A. T. C. McNAB

Design Services Branch
Downsview, Ontario

Telephone 248-3282

Dominion Soil Investigation Ltd.
104 Crockford Blvd.
Scarborough, Ontario

Dear Sirs:

This letter confirms our request of April 27th, 1973 for the supply of a Drill Rig together with all necessary equipment, as specified under the terms of our Special Agreement with Dominion Soil Investigation Ltd. dated April 24, 1973.

Mobilization will be from Toronto.

Our Project Number is W.O. 73-11014.

Yours truly,

M. Devata
Supervising Foundations Engineer
For: A. G. Stermac
PRINCIPAL FOUNDATIONS ENGINEER

MD:mt

cc: W. W. Fry
(Attn: Mrs. M. Andrews)

Foundation Files
Documents

Con. Y. 74-93 73-11008

Planning
Engineering
Project Management

FENCO

1 Yonge Street
Toronto Canada
416-361-4722
Cable 'Foundaneng'
Telex 02 2814

REQUESTED BY: REG. SYSTEM DESIGN

March 27, 1973 (CENTRAL)

April 25

Mr. M. Devata
Supervising Foundations Engineer
Design Services Branch
Ministry of Transportation and Communications
1201 Wilson Avenue
West Building
Downsview, Ontario
M3M 1J8

Dear Sir,

HIGHWAY 401 - HIGHWAY 410 INTERCHANGE
ADVANCE GRADING AND STORM SEWER CONTRACT
W.P. 127-66-34

We enclose for your information a preliminary print of our drawing 3983-1T-100 showing plan and profile of the proposed storm sewer. At present neither the alignment nor profile have been finalized. The location shown as "Line 2" is preferred for alignment, and is presently under review by Structural Planning Office. Invert elevation for the sewer is not yet settled because of Brittania Road, but if the sewer is in rock then its depth may not be critical.

We understand that MTC is to lay out the sewer, and we hope this information will enable you to initiate your investigation.

Yours very truly,
FOUNDATION OF CANADA ENGINEERING CORPORATION LIMITED

REG. SYSTEM DESIGN

B.T. Stone

B.T. Stone
SECTION LEADER

BTS/bhw
3983-101-1
Enc.

cc: Mr. W.C. Friedmann
MTC Downsview

M.D.D. APR. 25/73