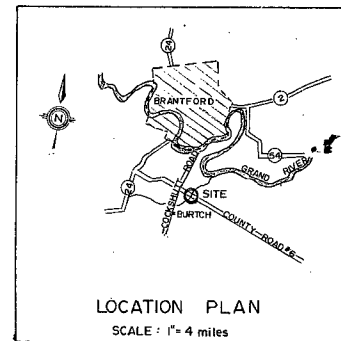
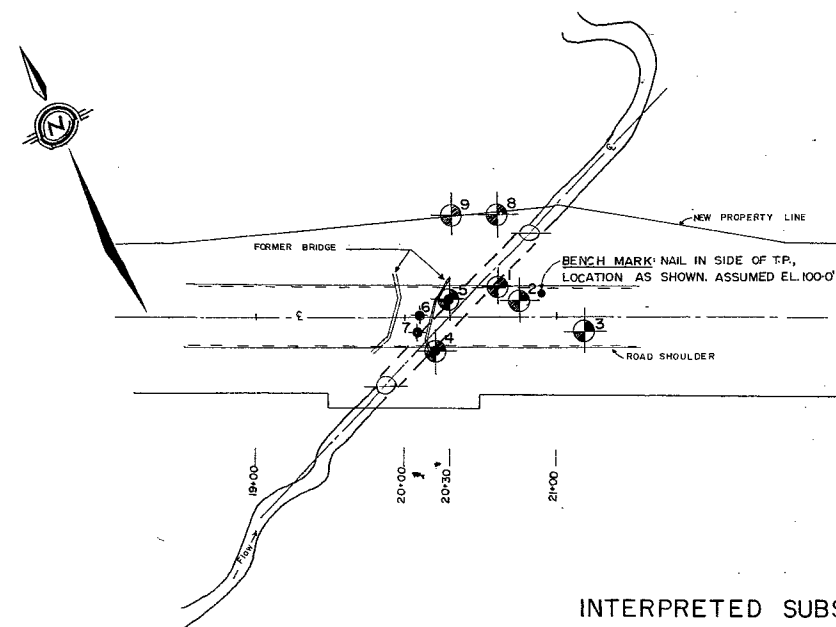
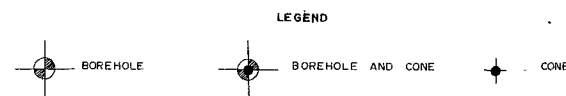


67-F-227M
BRANTFORD
SUBURBAN RD. #6
BELLHOUSE CULVERT

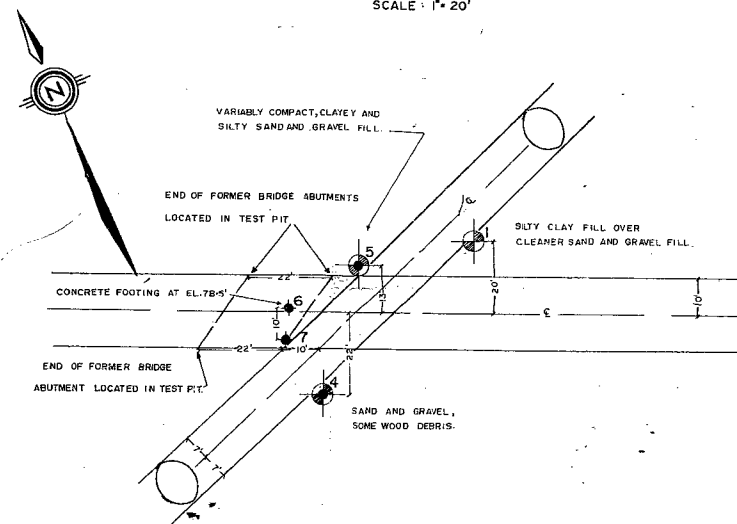
PLAN
SCALE: 1" = 50'



LOCATION PLAN
SCALE: 1" = 4 miles



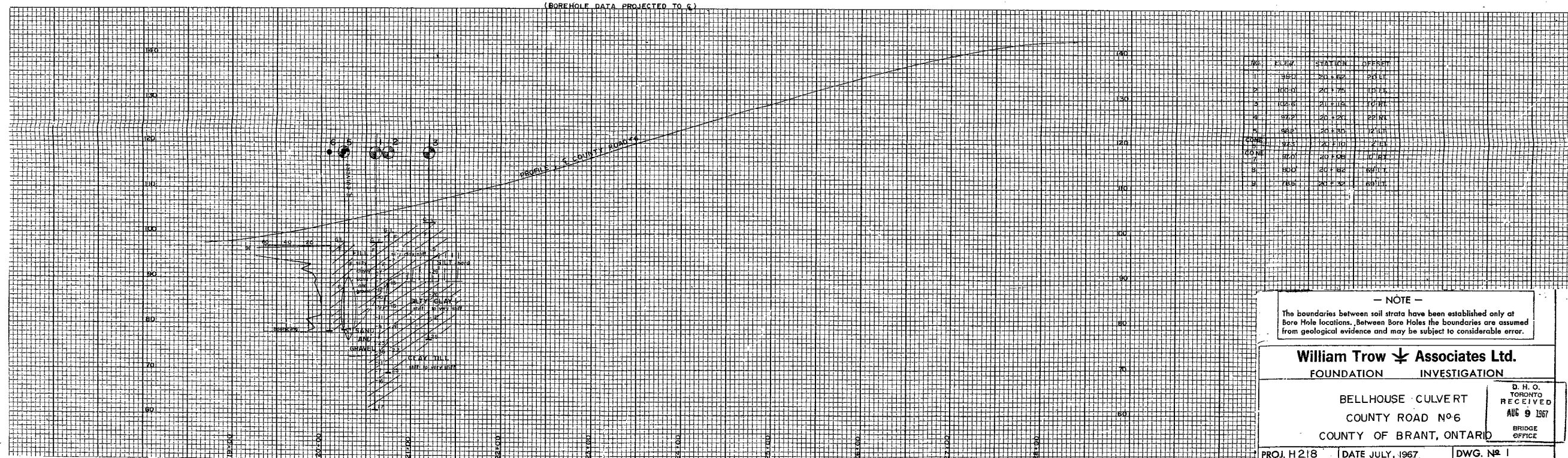
DETAIL
SCALE: 1" = 20'



INTERPRETED SUBSOIL PROFILE ALONG C₆ ROAD

SCALE VERTICAL: 1" = 10'
SCALE HORIZONTAL: 1" = 50'

(BOREHOLE DATA PROJECTED TO C₆)



NO.	ELEV.	STATION	DEPTH
1	98.0	20+1.82	20.11
2	100.0	20+1.75	10.11
3	102.5	21+1.05	10.21
4	97.2	20+2.21	20.21
5	98.2	20+3.35	12.11
6	97.3	20+1.10	2.11
7	97.0	20+1.05	10.11
8	100.0	20+1.82	60.11
9	98.5	20+1.32	60.11

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

William Trow & Associates Ltd.
FOUNDATION INVESTIGATION

BELLHOUSE CULVERT
COUNTY ROAD NO. 6
COUNTY OF BRANT, ONTARIO

D. H. O.
TORONTO
RECEIVED
AUG 9 1967
BRIDGE
OFFICE

PROJ. H 218 DATE JULY, 1967 DWG. NO. 1

BH 2631
Site - 1-C



COUNTY OF BRANT
ENGINEERING DEPARTMENT
COURT HOUSE,
BRANTFORD, ONTARIO

PLANS

67-F-227 M

FOUNDATION INVESTIGATION
BELLHOUSE CULVERT
BRANTFORD SUBURBAN ROAD NO.6,
TOWNSHIP OF BRANTFORD, CO. BRANT, ONT.

Project: H218

July 1967

William Trow Associates Limited

Project: H218

Soil Mechanics
Consultants
W. A. Trow
MSc. MEIC. P. Eng.
K. Peaker
PhD. MEIC. P. Eng.
D. H. Shields
PhD. MEIC. P. Eng.



Associates Ltd.

July 5, 1967

County of Brant,
Engineering Department,
Court House,
Brantford, Ontario.

Attention: Mr. G.G. Spencer, P.Eng.
County Engineer & Road Superintendent

Foundation Investigation
Bellhouse Culvert
Brantford Suburban Road No. 6,
Township of Brantford, Co. Brant, Ont.

Dear Sirs:

Further to your authorization of June 20th, 1967, we have carried out a subsoil investigation at the above site. The purpose of this investigation was to determine the cause of movement of the 14 foot diameter structural plate culvert, and to make recommendations as to possible remedial measures.

The field work was carried out during the period June 22nd to 24th, and comprised 7 boreholes and supplementary cone penetration tests. The boreholes and cone tests were located as shown on the enclosed plan, Dwg. 1, which also includes an interpreted stratigraphical profile derived from the borehole information. The detailed findings of the boreholes and the graphical results of the cone tests are included on the borehole logs, Dwgs. 2 to 9. The elevation of the top of each borehole is related to a bench mark described on Dwg. 1, and having an assumed elevation of 100.00 feet.



Our conclusions resulting from this investigation have been expressed verbally to a member of your staff, and consequently the following points will be related as briefly as possible.

1. CONDITION OF STRUCTURE

The existing skew culvert has deformed most evidently at two locations: a) at the northeast end, where general lateral movement towards the north has occurred, and - b) near the southern shoulder of the roadway, where the pipe has possibly been forced against the remains of the previous concrete bridge or culvert structure and has become buckled. The old abutments and footings of this structure were observed in test pits in several locations, and were encountered by a cone penetration test, (see detail of Dwg. 1). Distortion of the plates at shoulder level near the northeast end of the culvert has also occurred, possibly due to frost action.

2. SUBSOIL

The backfill material surrounding the steel plate culvert was found to be quite variable. To the southeast of the structure essentially granular material has been placed adjacent to the culvert (borings 1 and 4). Along the northeast side the backfill consists of moist to wet silty clay material, containing numerous gravel sizes (boring 5). The natural subsoil underlying the site consists generally of stiff to very stiff silty clay and clay till.

3. CAUSES OF DEFORMATION

(a) The major cause of deformation of the culvert section is the variable strength of the backfill material adjacent to the structure. In addition to being essentially granular along one side of the pipe and cohesive along the other side, the density of the backfill is also quite variable even within similar material. As an example, the cone penetration tests Nos. 5, 6 and 7, and penetration resistance of the sand and gravel backfill at boreholes 1 and 4, should be compared.

The variable backfill material placed on either side of the culvert results in an unbalanced earth pressure acting on the pipe, and a non-uniform strength developed by the composite soil-steel structure. A prominent additional imbalance of pressure is caused by the absence of backfill material along the northern side of the culvert at the easterly end.

(b) A further cause of deformation of the culvert section has probably resulted from the procedure followed during installation. The pipe section is presently resting against a portion of the concrete abutment walls or footings remaining from the previous structure. It is likely that during backfilling operations, the pipe was forced against these remains as backfill was added along the southern side, before being counterbalanced by fill along the northern side. The difference in the strength of the backfill on the two sides of the structure has magnified this condition of unbalanced loading.



(c) At the time of this investigation, groundwater was perched in the silty clay backfill adjacent to the eastern side of the culvert. Additional static pressure thus acts on the structure in this vicinity, as well as the possibility of pressure due to ice lensing and heaving during cold weather.

4. RECOMMENDATIONS

Although the subject structure does not appear to be in any imminent danger of failure, your personnel and other observers report a steadily worsening of the condition from year to year. Some repair is therefore essential before the pipe deteriorates to a dangerous condition. The following action is recommended:-

a) The remaining portions of the old concrete structure in the vicinity of the culvert should be removed, and the excavations made good with well compacted granular material.

b) The backfill surrounding the culvert should be removed and replaced with well compacted free-draining granular material. Some of the existing fill, particularly to the south of the structure is sufficiently free of cohesive and other deleterious material to be re-used, providing all fine grained silt and clay is removed. If necessary, the pipe should be re-bedded on a similarly free-draining granular mat at least 18 inches to 2 feet thick. All granular backfill should be placed in well compacted layers alongside the repaired culvert barrel, with each layer not exceeding about 9 to 10 inches loose thickness. The backfill must be built up to a similar height on either side of the structure, to avoid any eccentric loading.

c) The major portion of the steel plate pipe can be re-used. Badly deformed sections will probably have to be replaced, where the pipe has become structurally weakened (i.e., areas where buckling has occurred).

d) Provisions should be made to suitably drain the roadway embankment to the east of the culvert. Existing drainage ditches should be dug deep enough along the sides of the embankment to prevent water from the hillside and adjacent borrow pits entering the upper granular road base fill and seeping down against the top or sides of the steel pipe.

e) Alignment should be improved if possible.

We thank you for this opportunity to be of service, and trust you will find this report and our field test programme in order.

Yours very truly,
WILLIAM TROW ASSOCIATES LIMITED

Wm. L. White

W. White, P.Eng.

WN/yg








Encls.







Dist: County of Brant (6)

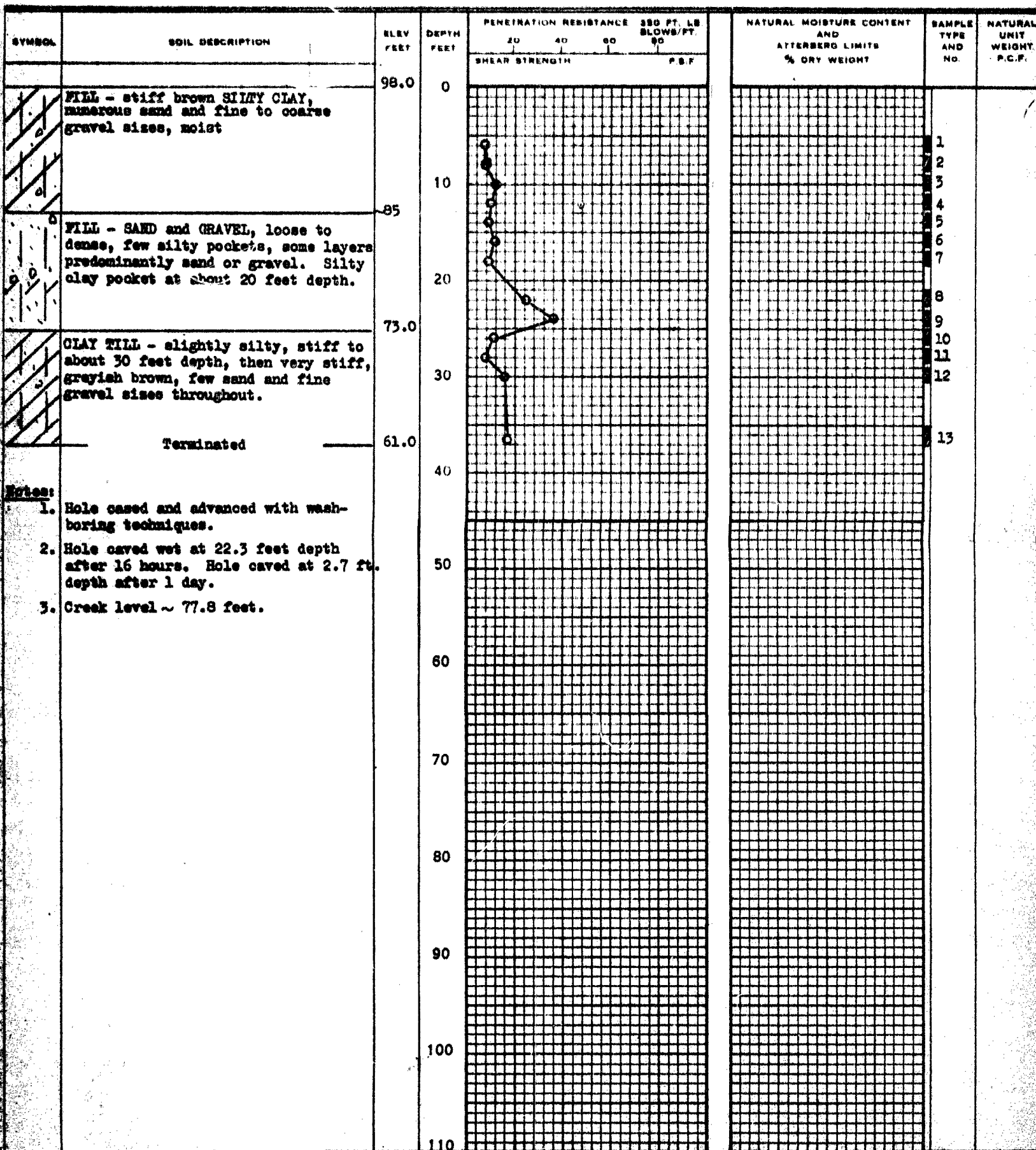
J. D. Morton

John D. Morton, P.Eng.

BOREHOLE NO. 1
 PROJECT Ballhouse Culvert
 LOCATION Brantford Suburban Rd. No. 6, Brant County
 HOLE LOCATION see Dwg. 1
 HOLE ELEVATION 98.0 feet
 DATUM see Dwg. 1




PENETRATION RESISTANCE
 2" O.D. SPLIT TUBE 
 2" I.D. SHELBY TUBE 
 2" DIA. CONE 
 SHEAR STRENGTH
 UNDRAINED TRIAXIAL AT OVERBURDEN PRESSURE 
 UNCONFINED COMPRESSION 
 VANE TEST AND SENSITIVITY  (B) 

NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX 
 ATTERBERG LIMITS
 LIQUID LIMIT 
 PLASTIC LIMIT 
 SAMPLE TYPE
 2" O.D. SPLIT TUBE 
 2" I.D. SHELBY TUBE 
 3" O.D. SHELBY TUBE 




BOREHOLE NO. 2
PROJECT Bellhouse Culvert
LOCATION Brantford Suburban Rd. No.6, Brant County
HOLE LOCATION see Dwg. 1
HOLE ELEVATION 100.0 ft.
DATUM see Dwg. 1

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE 
2" I.D. SHELBY TUBE 
2" DIA. CONE 

SHEAR STRENGTH

UNDRAINED TRIAXIAL AT OVERBURDEN PRESSURE 
UNCONFINED COMPRESSION 
VANE TEST AND SENSITIVITY (S) 




NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX

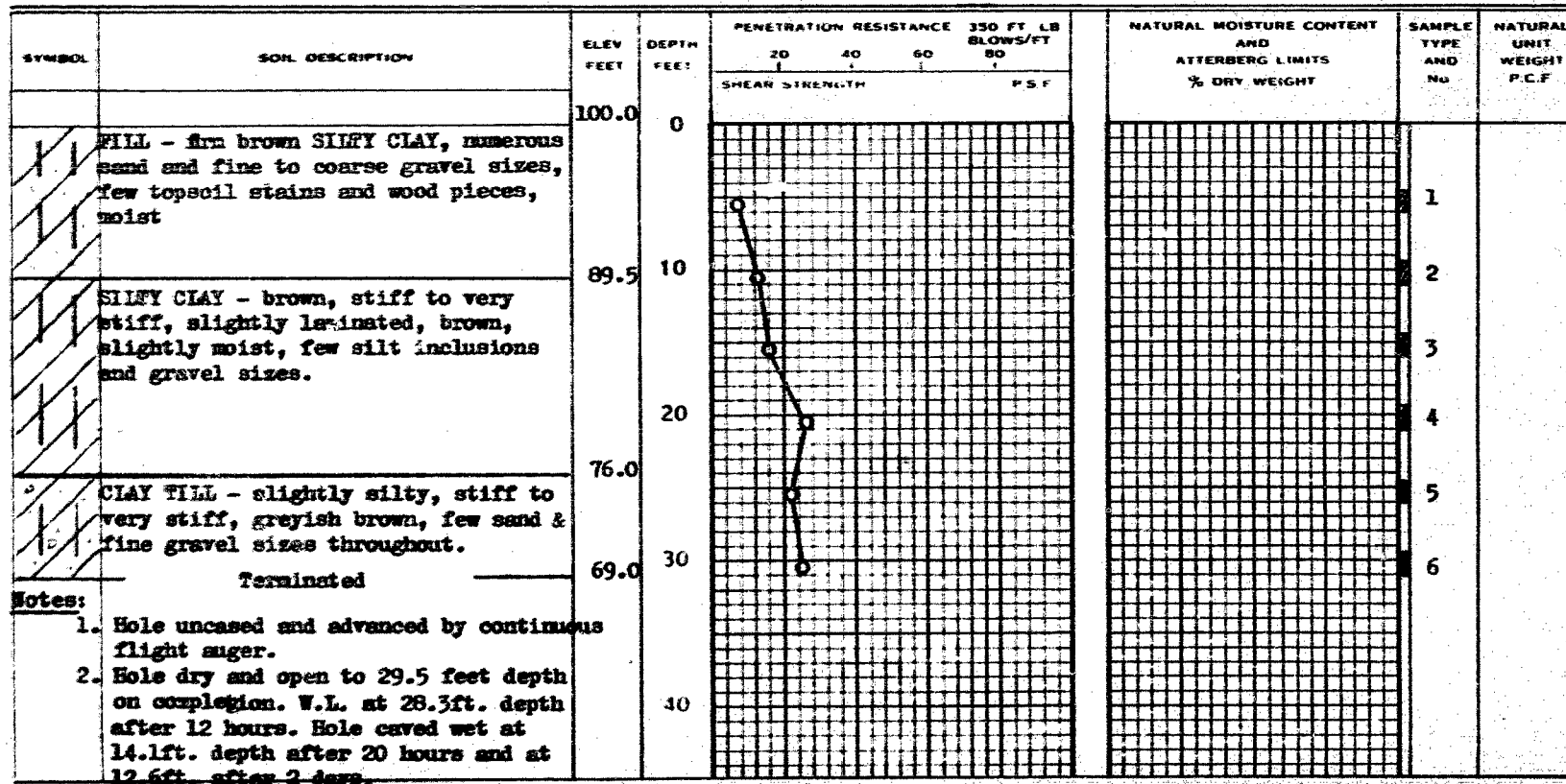
L_I
X

ATTERBERG LIMITS

LIQUID LIMIT 
PLASTIC LIMIT 

SAMPLE TYPE

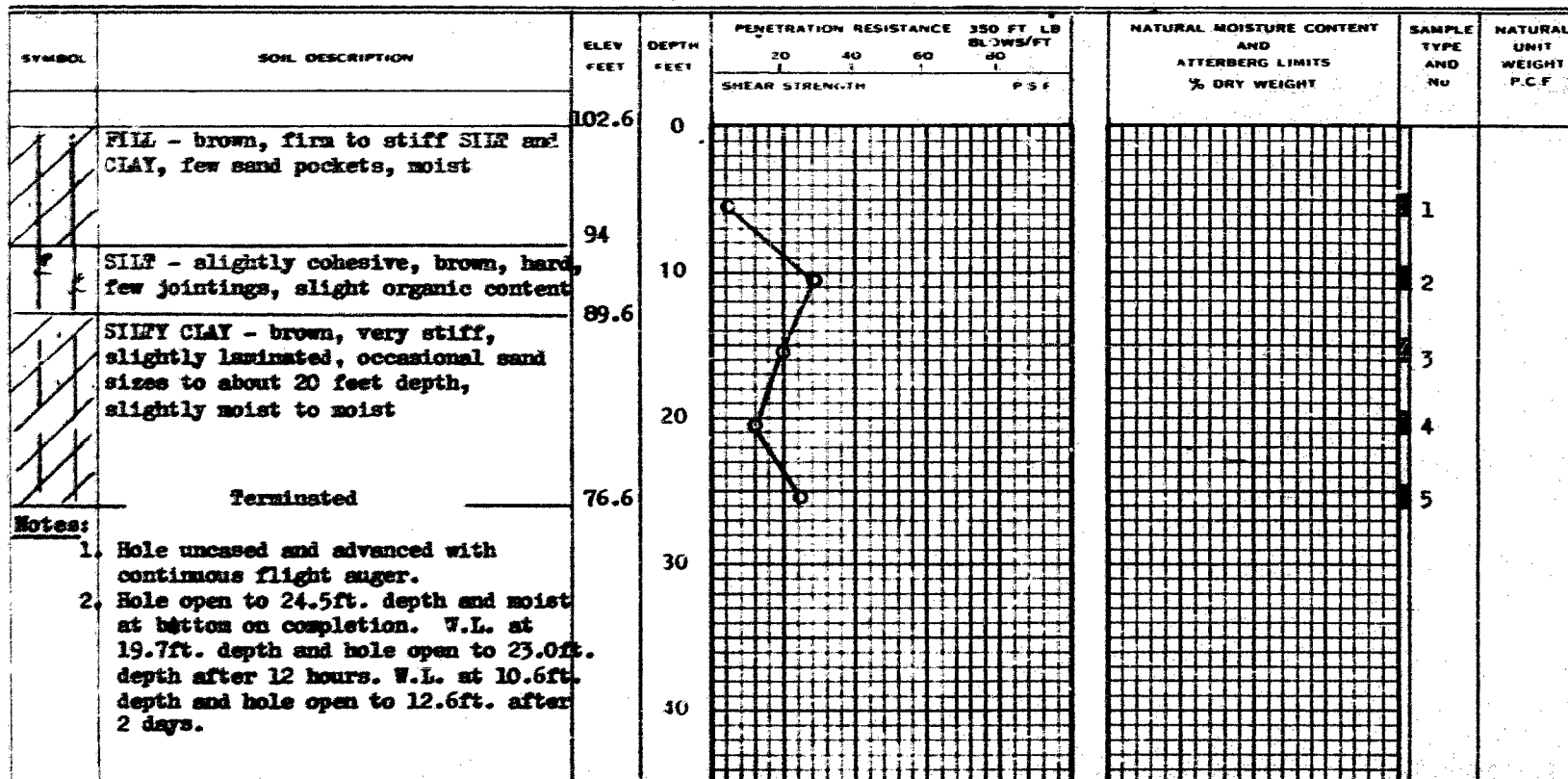
2" O.D. SPLIT TUBE 
2" I.D. SHELBY TUBE 
3" O.D. SHELBY TUBE 



BOREHOLE NO. 3
PROJECT Bellhouse Culvert
LOCATION Brayford Suburban Rd. No.6, Brant County
HOLE LOCATION see Dwg. 1
HOLE ELEVATION 102.6 ft.
DATUM see Dwg. 1

PENETRATION RESISTANCE
2" O.D. SPLIT TUBE —○—○—○—
2" I.D. SHELBY TUBE —+—+—+—+—
2" DIA. CONE —————
SHEAR STRENGTH
UNDRAINED TRIAXIAL AT OVERBURDEN PRESSURE ⊗
UNCONFINED COMPRESSION ⊗
VANE TEST AND SENSITIVITY (S) ⊕

NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX L¹ X
ATTERBERG LIMITS
LIQUID LIMIT —○—
PLASTIC LIMIT ———
SAMPLE TYPE
2" O.D. SPLIT TUBE —■—
2" I.D. SHELBY TUBE —■—
3" O.D. SHELBY TUBE —■—



LEGEND

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE —○—○—○—
 2" I.D. SHELBY TUBE —x—x—x—x—
 2" DIA. CONE ————

SHEAR STRENGTH

UNDRAINED TRIAXIAL
 AT OVERBURDEN PRESSURE ⊗
 UNCONFINED COMPRESSION ⊙
 VANE TEST AND SENSITIVITY (S) +^S

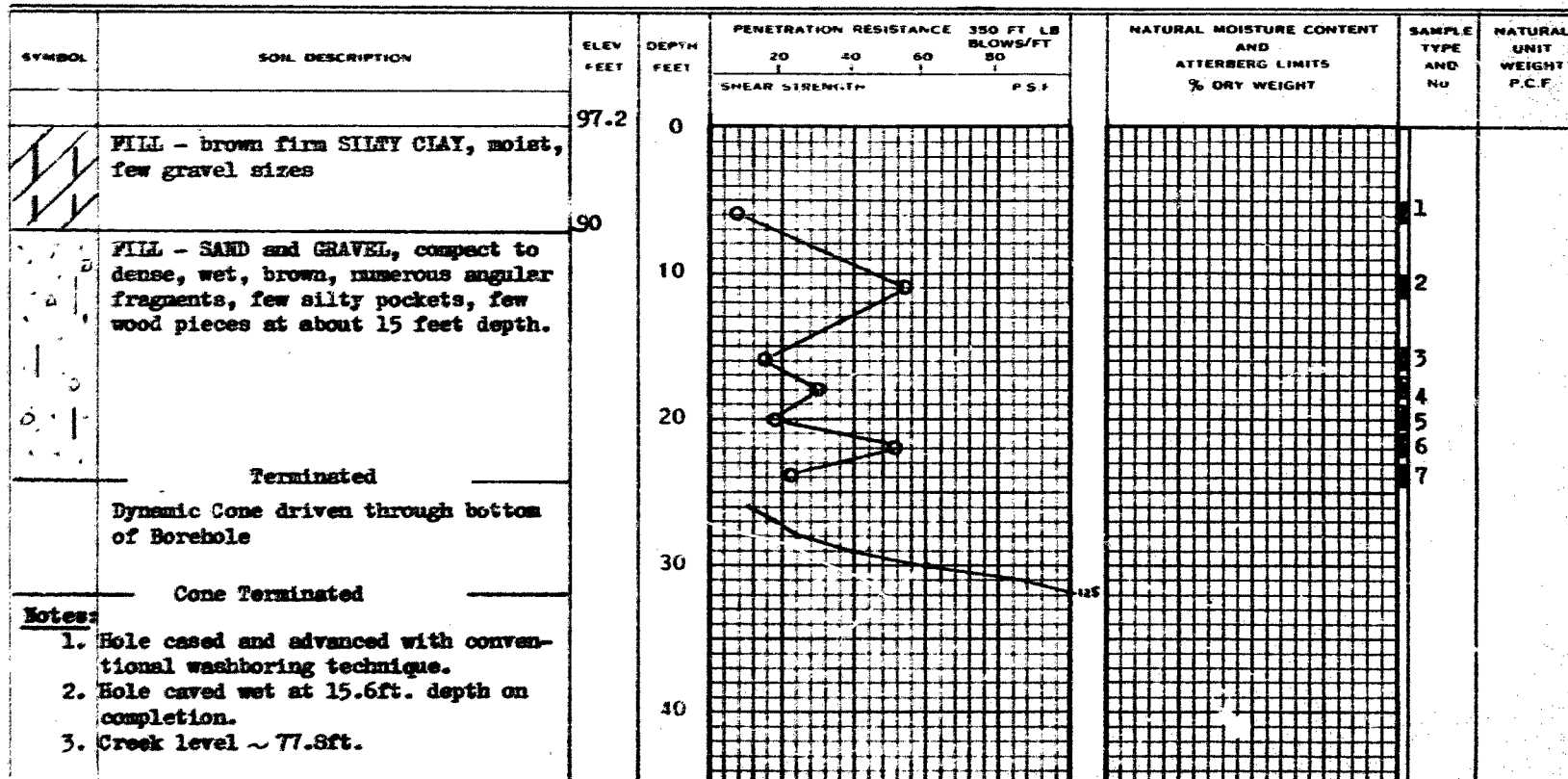
NATURAL MOISTURE CONTENT
AND LIQUIDITY INDEXLI
X

ATTERBERG LIMITS

LIQUID LIMIT —○—
 PLASTIC LIMIT ————

SAMPLE TYPE

2" O.D. SPLIT TUBE —■—
 2" I.D. SHELBY TUBE —■—
 3" O.D. SHELBY TUBE —■—

BOREHOLE 2 Cone 4PROJECT Bellhouse CulvertLOCATION Brantford Suburban Rd. No.6, Brant CountyHOLE LOCATION see Dwg. 1HOLE ELEVATION 97.2 feetDATUM see Dwg. 1

LEGEND

BOREHOLE & Cone 5

PROJECT Bellhouse CulvertLOCATION Brantford Suburban Rd. No.6, Brant CountyHOLE LOCATION see Dwg. 1HOLE ELEVATION 98.2 ft.DATUM see Dwg. 1

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE 2" I.D. SHELBY TUBE 2" DIA. CONE 

SHEAR STRENGTH

UNDRAINED TRIAXIAL
AT OVERBURDEN PRESSURE UNCONFINED COMPRESSION VANE TEST AND SENSITIVITY (S) NATURAL MOISTURE CONTENT
AND LIQUIDITY INDEXL_I
X

ATTERBERG LIMITS

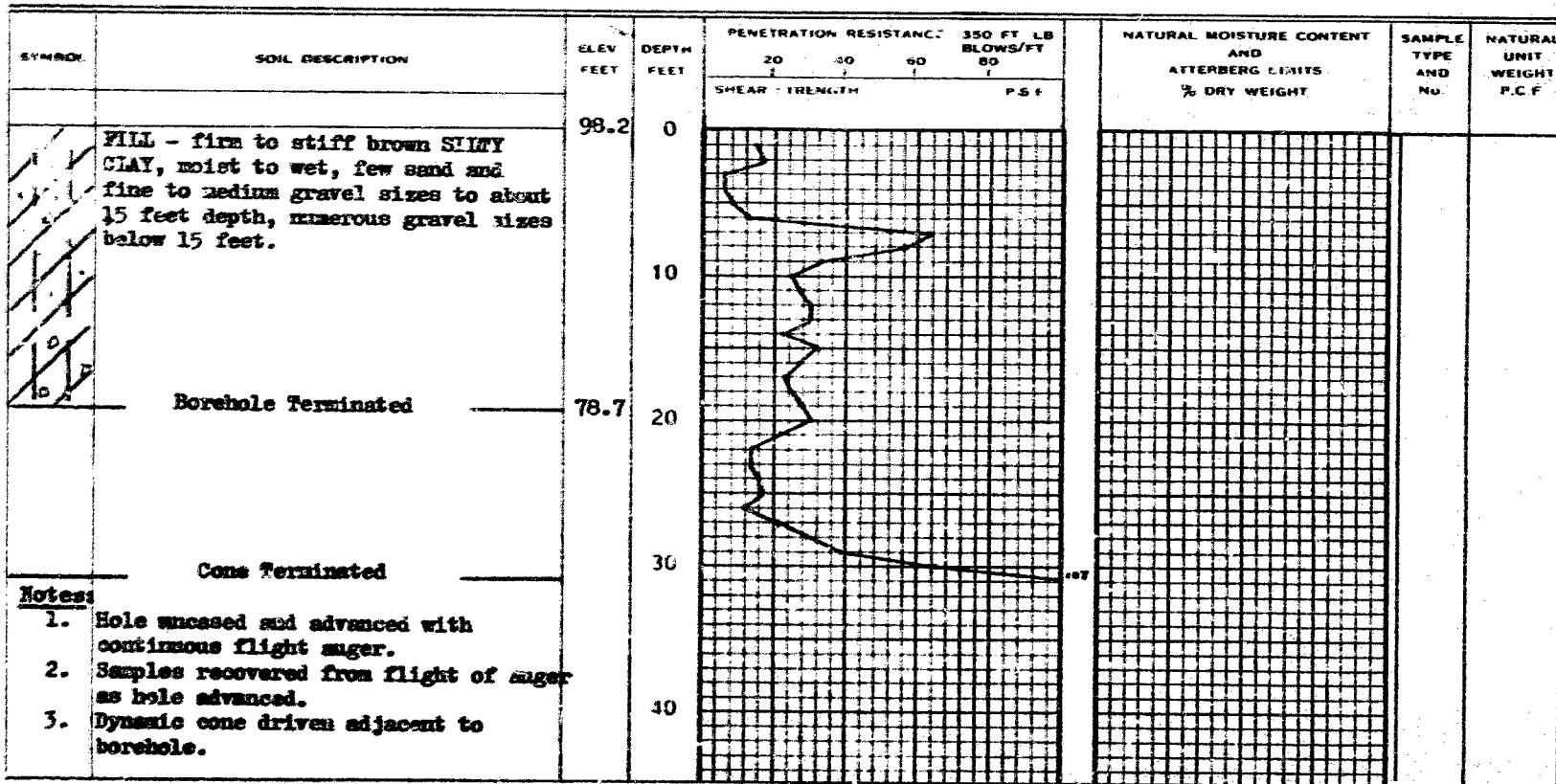
LIQUID LIMIT

—○

PLASTIC LIMIT

—|

SAMPLE TYPE

2" O.D. SPLIT TUBE 2" I.D. SHELBY TUBE 3" O.D. SHELBY TUBE 

Cone No. 6PROJECT Bellhouse CulvertLOCATION Brantford Suburban Rd. No.6, Brant CountyHOLE LOCATION see Dwg. 1HOLE ELEVATION 97.3 ft.DATUM see Dwg. 1

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE —○—○—○—

2" I.D. SHELBY TUBE —+—+—+—+—

2" DIA. CONE —————

SHEAR STRENGTH

UNDRAINED TRIAXIAL
AT OVERBURDEN PRESSURE ⊗

UNCONFINED COMPRESSION ⊗

VANE TEST AND SENSITIVITY (S) †^SNATURAL MOISTURE CONTENT
AND LIQUIDITY INDEXLI
X

ATTERBERG LIMITS

LIQUID LIMIT —○—

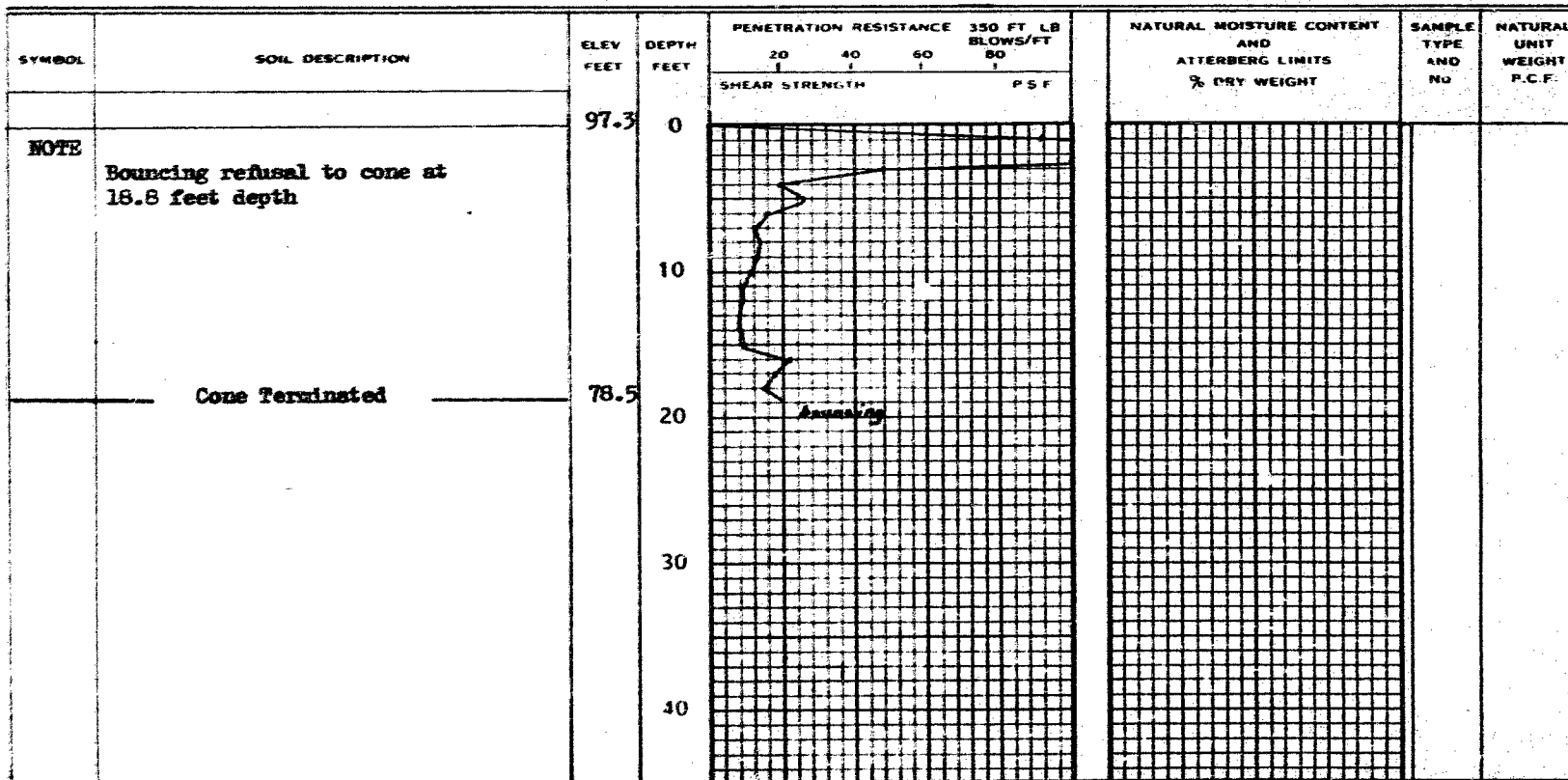
PLASTIC LIMIT —|—

SAMPLE TYPE

2" O.D. SPLIT TUBE —■—

2" I.D. SHELBY TUBE —■—

3" O.D. SHELBY TUBE —■—



LEGEND

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE —○—○—○—
2" I.D. SHELBY TUBE —x—x—x—x—
2" DIA. CONE —————

SHEAR STRENGTH

UNDRAINED TRIAXIAL AT OVERBURDEN PRESSURE ⊕
UNCONFINED COMPRESSION ⊙
VANE TEST AND SENSITIVITY (S. +) ^S

NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX

X^{LI}

ATTERBERG LIMITS

LIQUID LIMIT —○—
PLASTIC LIMIT —|—

SAMPLE TYPE

2" O.D. SPLIT TUBE —■—
2" I.D. SHELBY TUBE —■—
3" O.D. SHELBY TUBE —■—

Cone No. 7

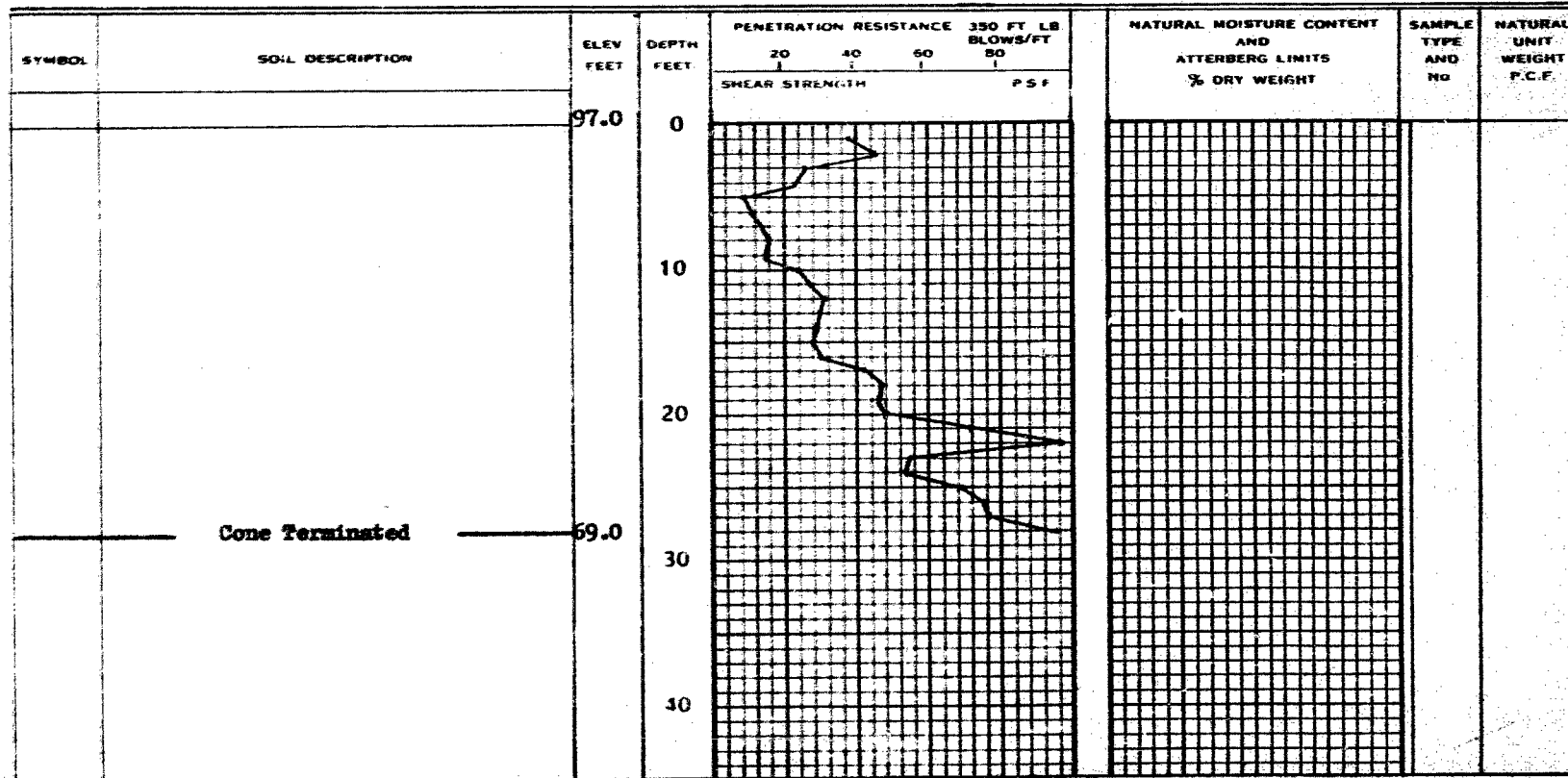
PROJECT Bellhouse Culvert

LOCATION Brantford Suburban Rd.No.6, County Brant

HOLE LOCATION see Dwg. 1

HOLE ELEVATION 97.0 ft.

DATUM see Dwg. 1



WILLIAM TROW ASSOCIATES LTD.



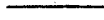
SITE INVESTIGATIONS SOIL MECHANICS CONSULTATION

LEGEND




DRAWING NO. 9
PROJECT NO. H218

BOREHOLE NO. B
PROJECT Ballhouse Culvert
LOCATION Brantford Suburban Rd. No.6, Brant County
HOLE LOCATION see Dwg. 1
HOLE ELEVATION 80.0 ft.
DATUM see Dwg. 1

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE 
2" I.D. SHELBY TUBE 
2" DIA. CONE 

SHEAR STRENGTH

UNDRAINED TRIAXIAL
AT OVERBURDEN PRESSURE 
UNCONFINED COMPRESSION 
VANE TEST AND SENSITIVITY (S) 




NATURAL MOISTURE CONTENT
AND LIQUIDITY INDEX


 LI

ATTERBERG LIMITS

LIQUID LIMIT 
PLASTIC LIMIT 

SAMPLE TYPE

2" O.D. SPLIT TUBE 
2" I.D. SHELBY TUBE 
3" O.D. SHELBY TUBE 

SYMBOL	SOIL DESCRIPTION	ELEV FEET	DEPTH FEET	PENETRATION RESISTANCE 350 FT. LB BLOWS/FT		NATURAL MOISTURE CONTENT AND ATTERBERG LIMITS % DRY WEIGHT	SAMPLE TYPE AND NO	NATURAL UNIT WEIGHT P.C.F.
				20	40			
				SHEAR STRENGTH				
		80.0	0					
	CLAY - silty, brown	78.4						
	Terminated							
<u>Note:</u>								
1.	Hole hand augered to check presence or absence of organic soil along former stream channel.		5					
			10					
			15					
			20					

LEGEND

BOREHOLE NO. 9
PROJECT Bellhouse Culvert
LOCATION Brantford Suburban Rd. No.6, Brant County
HOLE LOCATION see Dwg. 1
HOLE ELEVATION 78.6 ft.
DATE see Dwg. 1

PENETRATION RESISTANCE

2" O.D. SPLIT TUBE —○—○—○—

2" I.D. SHELBY TUBE

2" DIA. CONE

SHEAR STRENGTH

UNDRAINED TRIAXIAL
AT OVERBURDEN PRESSURE 

UNCONFINED COMPRESSION 6

VANE TEST AND SENSITIVITY (S) +

NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX

 x^L

ATTERBERG LIMITS

LIQUID LIMIT _____

PLASTIC LIMIT

SAMPLE TYPE

2" O.D. SPLIT TUBE

2" I.D. SHELBY TUBE _____

3- O.D. SHELBY TUBE _____

SYMBOL	SOIL DESCRIPTION	ELEV FEET	DEPTH FEET	PENETRATION RESISTANCE		350 FT. LB BLOWS/FT 80	NATURAL MOISTURE CONTENT AND ATTERBERG LIMITS % DRY WEIGHT	SAMPLE TYPE AND NO	NATURAL UNIT WEIGHT P.C.F
				70	40				
		78.6	0						
///	CLAY & SILT (ALLUVIUM)	77.1							
	Silt - grey	76.8							
	Terminated								
<u>Note</u>									
1. Hole hand augered to check for possible organic layer along former stream channel.				5					
			10						
			15						
			20						