

Dist. 28-7
COPY

Ref. M.C. 10.

June 28, 1962.

Mr. G. T. Clarke,
Chief Engineer (Developments),
Department of Public Works,
Ottawa, Ontario.

Dear Mr. Clarke,

Herewith enclosed are two copies of the
report on the Stage II drilling for the foundation of the
bridge proper by H. L. Golder and Associates.

Copies have been distributed to the members
of the Liaison Board as indicated below:

Mr. Walker	Department of Highways of Ontario	- 6 copies
Mr. Martin	Public Works Department of Quebec	- 1 copy
Mr. Cornish	National Capital Commission	- 1 copy
Mr. Ayers	City of Ottawa	- 1 copy
Mr. Thauvette	City of Hull	- 1 copy

Yours very truly,

H.R.M. Murray, P. Eng.,
Project Manager.

HRM/vt
encl.

*Factual information reported and no specific
recommendations for the best suited type of
foundation are given. avg
July 12-1962.*

11th June 1962

meeting with Langham, Wyllie and Ufnal staff

Ted Hendon

- ① Proposed bored-in casing construction method feasible
- ② Drilling into rock preferred to blasting owing to layering of rock

Wyllie.

Department of Highways

COPY

For the information of

To file

Mr. ^{AC} P. Stermac,
Principal Foundation Engineer,
Department of Highways,
Room 107, Lab. Bldg.
Downsview, Ontario.

Mr. L. E. Walker

June 13, 1962.

District Engineer - Ottawa

Macdonald-Cartier Bridge

F. I. Hewson - Downsview

District #9

Our Consultants discussed their proposed pier foundations with us yesterday and we have no fault to find with it. The pre-pakt concrete carries no direct load but serves as lateral support for the 30" diameter caissons. We have "socketed" piles into rock on the Maitland River Bridge at Goderich and at Duffin's Creek at Pickering. Both jobs proved quite satisfactory.

The Benoto method is almost identical except it appears the piles are jacked down rather than driven by impact. The concreting of the socket requires great care and close supervision but all other operations are fairly simple.

We have always avoided the use of compressed air wherever possible although it is a time-tested method. Where the foundation conditions are uncertain it is invaluable. In this case, the rock has been explored quite thoroughly and we consider the drilled in piles a more satisfactory solution.

There might be some advantage to permitting alternate methods of founding these piers in the rock.

FIH:go
c.c. P. Stermac

F. I. Hewson,
Consultant Liaison Engineer.

June 15, 1962
agj

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS

H. Q. GOLDER
V. MILLIGAN

2444 BLOOR ST. W.
TORONTO 9
RO. 7-9201

REPORT
TO
CONSULTING ENGINEERS - MACDONALD-CARTIER BRIDGE
ON
SITE INVESTIGATION
STAGE II
PROPOSED MACDONALD-CARTIER BRIDGE
OTTAWA-HULL CANADA

Distribution:

20 copies - Consulting Engineers - Macdonald-Cartier Bridge
Ottawa, Ontario.

5 copies - H. Q. Golder & Associates Ltd.,
Toronto, Ontario.

June, 1962

6135-3

ABSTRACT

The factual results of the stage II site investigation carried out at the final pier and abutment locations for the Macdonald Cartier Bridge between Ottawa, Ontario and Hull, Quebec, are reported.

It was found that river bottom, except in the main channel near the Ottawa shore, is covered by up to about 15 feet of very loose sawdust and wood chips and very loose to loose organic silt and sand. The river bottom in the main channel is underlain directly by bedrock which also forms the Ottawa bank of the river below a shallow surface cover of cobbles and boulders.

The top of the west bank of the river at the Hull abutment is covered by about 5 feet of loose to compact silty sand fill underlain by about 30 feet of hard to stiff marine clay. The clay rests on a thin layer of compact silt. The silt at the Hull abutment and the recent alluvial deposit of organic silt in the river near the Hull shore are underlain by a stratum of generally compact silty sand till about 5 feet thick. A layer of cobbles and boulders up to 7 feet thick resting on the bedrock underlies the glacial till.

Bedrock across the site is a shaly limestone. The upper portion of the bedrock is slightly weathered and jointed. Below this upper weathered zone the bedrock is generally sound but contains both healed and open fractures together with solution channels some of which are filled with sand and clay.

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
PROCEDURE	1
SITE TOPOGRAPHY AND GEOLOGY	3
SUMMARIZED SOIL CONDITIONS	4
SUMMARIZED BEDROCK CONDITIONS	6
A Zone	6
B Zone	7
C Zone	8
WATER CONDITIONS	9
ABBREVIATIONS	11
Records of Boreholes	In Order
Figure 1 - Site and Boring Plan	Following
	Page 11
Figure 2 - Stratigraphy Along Centreline Bridge Crossing	
Figure 3 - Stratigraphy at Pier and Abutment Locations	
Figures 4 - Laboratory Test Results	
to 9	
Figure 10 - Site Photograph	

INTRODUCTION

H. Q. Golder & Associates Ltd. has been retained by the Consulting Engineers - Macdonald-Cartier Bridge to carry out the stage II site investigation for the proposed Macdonald-Cartier Bridge between Ottawa, Ontario and Hull, Quebec. The purpose of this work was to determine and interpret the soil and rock conditions at the final pier and abutment locations in relation to foundation design for the bridge structure.

The preliminary or stage I site investigation carried out at the site in 1961 to obtain the general soil and bedrock conditions covered the overall area of the bridge crossing. The detailed factual information obtained from this work is presented in our report, 6135, dated December 1961, which is included as Appendix B in "Report on Preliminary Engineering Studies, Macdonald-Cartier Bridge" prepared by the Consulting Engineers for the Macdonald-Cartier Bridge.

The results of the present investigation at the site confirm the soil and bedrock conditions encountered in the previous work. To eliminate repetition, this report presents the results of the stage II investigation in brief and should be read in conjunction with our report on the stage I work.

PROCEDURE

The field work for this investigation was carried out during the period February 6th to March 24th, 1962. A total of 24 boreholes, numbered 101 to 124 inclusive, were put down using 2

skid-mounted machine drillrigs. Thirteen of the borings were put down at the 4 pier locations in the river and 10 at the abutment locations on each bank of the river. The remaining borehole was located between the Ottawa abutment and pier of the bridge. The river borings for the piers were carried out first working from the ice.

Bedrock was core drilled in BXT size (approx. $1\frac{1}{2}$ inches diameter) in each borehole. After completion of the central borehole at each pier and abutment location, water pressure packer tests were carried out to access the permeability of the bedrock. Following the packer tests a porous pot piezometer was installed in the holes to establish the water conditions in the bedrock in relation to river level.

The locations of all the borings put down in this investigation are shown on Figure 1. Sections of the inferred soil and bedrock stratigraphy are given on Figures 2 and 3. A detailed log for each boring is given on the Records of Boreholes.

The soil samples obtained during the investigation were brought to our laboratory in Toronto for examination and testing. The rock core samples were examined at the site and handed over to the Consulting Engineers in Ottawa. The results of the laboratory testing on the soil samples are plotted on the Records of Boreholes and on the figures.

The elevations given in this report are referred to Geodetic datum. All the survey work connected with the investigation

was carried out by the Consulting Engineers.

SITE TOPOGRAPHY AND GEOLOGY

The site of the proposed crossing on the Ottawa River shown on Figure 1 is situated approximately 2,000 feet downstream or north of the existing Alexander or Interprovincial Bridge between Hull, Quebec and Ottawa, Ontario. The width of the river at the site is about 2,000 feet.

The ground surface on top of the east bank of the river around Sussex Street in Ottawa is relatively flat. To the west the ground surface drops about 45 feet over nearly vertical limestone bluffs to the narrow floodplain of the Ottawa River. From here the rock surface plunges steeply for about 60 feet to the deep channel which lies close to the Ottawa bank of the river. West of the main channel the river bed rises gently toward the Hull side and forms a swampy area near the west shore. The river bank on the Hull side is composed of overburden and rises about 30 feet in a relatively moderate slope above the narrow western floodplain.

The depth of water in the main channel near the Ottawa bank of the river reaches a maximum of about 60 feet. At the centre of the river the water depth is about 40 feet and gradually decreases towards the Hull side of the river.

A photograph of the site is shown on Figure 10.

The bridge site is underlain by limestone of Ordovician age. This bedrock is overlain, in most places, by a thin veneer of

Pleistocene till. However, in the river the till has been largely removed by stream erosion and bedrock forms the bed on the Ottawa side of the river. Elsewhere relatively thin deposits of marine clay, silt and sand overlies the till or rest directly on bedrock. Recent deposits of sawdust and fluvial sediments occur in the bed of the river in places.

A more detailed account of the physiography and geology of the site is given in our previous report.

SUMMARIZED SOIL CONDITIONS

The following sequence of main soil strata, which are detailed on the Records of Boreholes and on Figures 2 to 9 inclusive, was encountered by the borings put down in this investigation.

A layer of very loose brown coarse sawdust and wood-chips, ranging from about 2 to 15 feet in thickness, forms the bed of the river at the locations of piers 1, 2 and 3. The sawdust at piers 1 and 2 and on the north side of pier 3 is underlain by from 2 to 4 feet of very loose to loose dark grey organic silt and sand, which is a recent alluvial deposit.

The top of the west bank of the river at the location of the Hull abutment is covered, above approximately elevation 163, by about 5 feet of loose to compact silty sand fill. Underlying the fill and exposed on the bank of the river is a stratum of marine clay which extends down to an elevation between 129 and 133 across the abutment location. The silty clay is generally grey in colour,

except in about the upper 10 feet of the stratum where it has been desiccated and weathered to a mottled brown and grey. The clay stratum is relatively homogeneous in structure but occasionally is stratified with thin alternating layers of silty clay and clayey silt and contains thin random seams of silt and sand. Based on both in situ field vane and laboratory triaxial compression tests, the silty clay is hard becoming stiff with depth. The sensitivity of the marine clay, as inferred from the vane tests, varies between 2 and 15 with an average value of about 10.

The marine clay is underlain by from 2 to 4 feet of compact grey silt with a trace of clay and fine sand. The silt at the Hull abutment and the recent alluvial deposit of organic silt and sand at pier 1 and at the central portion of pier 2 are in turn underlain by a stratum of glacial till about 5 feet thick. The till which is generally compact is comprised of a well graded composite of particle sizes from the silt to cobble and boulder range.

A layer of cobbles and boulders resting on bedrock underlies the glacial till at the Hull abutment, at pier 1 and at the central portion of pier 2, underlies the organic silt on the north side of pier 3 and is present at ground surface at the Ottawa abutment. The layer varies from about 1 to 7 feet in thickness across the site and is comprised mainly of limestone cobbles and boulders from several inches to several feet in size. The cobbles and boulders were penetrated by core drilling and the core recovery obtained ranged from a value as low as 10 percent to 90 percent.

In general there was a complete water loss while drilling through this layer.

SUMMARIZED BEDROCK CONDITIONS

Bedrock was encountered at ground surface and river bottom at the Ottawa abutment and pier 4 locations, respectively, and beneath the overburden in the remaining pier and abutment locations. The local bedrock is composed of limestone, shaly limestone and shale of the Cobourg member, the uppermost part of the Ottawa formation of Ordovician age. The rock encountered by the borings may be conveniently divided into three zones which are briefly described separately below. Details of the bedrock cored in this investigation are given on the Records of Boreholes and on Figures 2 and 3. A detailed account of the bedrock conditions at the site together with photographs of typical core samples from each zone and the results of compression tests on selected cores are given in our previous report covering the stage I site investigation.

A Zone

This zone forms the upper portion of the bedrock at the pier and abutment locations. It is dominantly a dark grey brown fine to medium grained limestone with thin partings and minor laminae of black shale. This portion of the bedrock is also characterized by a breccia or intraformational conglomerate interspersed throughout. In places the limestone is

highly fossiliferous. The thickness of the A zone varies across the site from over 100 feet at the Ottawa abutment to about 5 feet at the Hull abutment. In general this zone occurs above about elevation 50 on the Ottawa side of the river and gradually rises to an elevation above 110 on the Hull side.

The upper several feet of the zone A bedrock across the site is slightly weathered and jointed resulting generally in poor core recovery during drilling. This weathering is less noticeable where the bedrock is protected from the elements by overburden and is more pronounced where it is exposed, as on the Ottawa bank. The bedrock, below the upper weathered and jointed portion, is generally sound as indicated by the good core recovery and the pressure packer tests which gave a coefficient of permeability below about 1×10^{-4} centimeters per second. Occasional vertical and inclined fractures, which in most cases are healed by calcite, and solution channels indicated by clay or sand seams occur at random throughout the sound portion of the zone A bedrock. This is particularly the case at the Ottawa abutment.

B Zone

This zone underlies the A zone and is marked by a well defined lower contact usually ascertained during drilling by loss of water in some of the boreholes. The upper contact is gradational and whereas in some drill cores the upper limit

can be fixed with certainty, in others it is arbitrary. The material is intermixed medium to fine grained dark grey brown limestone and black shale. The shale makes up approximately 50 percent of this zone and does not occur as discrete beds but as blobs or nodules in the limestone. The intermixing gives the rock a mottled appearance. This zone is about 10 feet thick and extends down to about elevation 40 at Ottawa abutment and to about elevation 100 at the Hull abutment.

The zone B bedrock based on the rock core recovery is generally sound across the site. This zone, particularly at the Hull abutment, contains solution channels either within it or at its base, which are void. The channels usually resulted in a complete loss of wash water during drilling. The presence of these channels is also shown by the pressure packer tests which gave a coefficient of permeability in the borehole for a 5 foot section of the bedrock of about 1×10^{-3} centimeters per second. Occasional fractures which are well healed with calcite are present in this zone.

C Zone

This zone is defined as that which underlies the B zone. The upper contact is well marked as noted above. The lower contact was not reached as no borehole was carried down deep enough to indicate any recognizable change in lithology. The rock is grey brown medium to coarse grained crystalline limestone with thin partings of black shale and beds of intraformational conglomerate. This zone of the bedrock is some-

what similar to the A zone except that the C zone contains less shale and conglomerate and thicker limestone beds.

Based on the rock core recovery and pressure packer tests, the zone C portion of the bedrock is generally sound. However, vertical and inclined fractures are common in this zone. These fractures have been healed by calcite but in some cases are open or filled with clay. Stylolites are also common in this zone. Neither the fractures or stylolites significantly affect the strength of the rock in its natural position. At pier 1 the zone C bedrock contains artesian water pressures with reference to river level indicating connecting solution channels with an aquifer at higher elevations to the west.

WATER CONDITIONS

A porous pot piezometer was installed in the bedrock at each of the central boreholes at the pier and abutment locations to determine the water level. These piezometers were read periodically until the river ice broke up several days after completion of the pier borings. The water level in each piezometer is given on the Records of Boreholes. The ice level during the period of the investigation varied between about elevations 133 and 135.

The readings showed that in general the water level in the bedrock was at about ice level and fluctuated with the ice level. This indicates that the water in the bedrock is apparently

in communication with the river water through cracks and fractures in the bedrock.

During drilling at pier 1 artesian water was encountered in the zone C portion of the bedrock. The water level in the casing rose 1.5 feet above ice level. After installation of the piezometer in the central borehole at this location, the water level stabilized at ice level. The drop from artesian to river level is attributed to dissipation of the excess head through fractures in the overlying A and B zones of the bedrock.

Samples of the groundwater at the Hull abutment and from the river near the Hull abutment location were obtained for chemical analyses. The analyses showed that the water is slightly alkaline to neutral. The soluble sulphate and chloride content is low and below 50 p.p.m. and based on this, the corrosion effects on concrete and steel from the chemical content in the groundwater should be negligible.

JLS/jb
6135-3



J. L. Seychuk, P. Eng.

June, 1962

V. Milligan
V. Milligan, P. Eng.

LIST OF STANDARD ABBREVIATIONS

The standard abbreviations commonly employed on each "Record of Borehole", on the figures, and in the text of the report are as follows:

SAMPLE TYPES

A.S. - Auger Sample	R.C. - Rock Core
C.S. - Chunk Sample	S.T. - Slotted Tube
D.O. - Drive Open	T.O. - Thin-walled, Open
D.S. - Denison Type Sample	T.P. - Thin-walled, Piston
F.S. - Foil Sample	W.S. - Wash Sample

PENETRATION RESISTANCES

Dynamic Penetration Resistance - The energy required to drive a 2 inch diameter, 60 degree cone attached to the end of the drilling rods into the ground: expressed in blows per foot, where each blow represents 4,200 inch-pounds of energy.

Standard Penetration Resistance, N - The number of blows by a 140 pound hammer dropped 30 inches required to drive a 2 inch drive open sampler one foot into the ground.

Sampler advanced by static weight	- weight, hammer	- Wh
Sampler advanced by pressure	- pressure, hydraulic	- Ph
Sampler advanced by pressure	- pressure, manual	- Pm

SOIL DESCRIPTION

The standard terminology for the descriptions of the relative density of cohesionless soils and the consistency of cohesive soils is as follows:

<u>Relative Density</u>	<u>N, Blows/ft.</u>	<u>Consistency</u>	<u>c, lb/sq. ft.</u>
Very Loose	0 to 4	Very Soft	Less than 250
Loose	4 to 10	Soft	250 to 500
Compact	10 to 30	Firm	500 to 1,000
Dense	30 to 50	Stiff	1,000 to 2,000
Very Dense	over 50	Very Stiff	2,000 to 4,000
		Hard	over 4,000

SOIL TESTS

C - Consolidation Test	Q - Undrained Triaxial
H - Hydrometer Analysis	Qc - Consolidated Undrained Triaxial
M - Sieve Analysis	S - Drained Triaxial
MH - Combined Analysis, Sieve and Hydrometer	U - Unconfined Compression
	V - Field Vane Test

Note: Undrained triaxial tests in which pore pressures are measured are shown as Q' or Q'c.

SOIL PROPERTIES

γ - Total Unit Weight	K - Coefficient of Permeability
γ_d - Dry Unit Weight	c - Undrained Shear Strength ($\frac{1}{2}$ Compressive Strength)
γ_b - Submerged Unit Weight	St - Sensitivity
L_L - Liquid Limit	ϕ' - Effective Angle of Shearing Resistance
P_L - Plastic Limit	c' - Effective Cohesion Intercept
W - Natural Water Content	Cc - Compression Index
G - Specific Gravity	Cv - Coefficient of Consolidation
e - Void Ratio	

RECORD OF BOREHOLE 101

PIER 4					
LOCATION	SEE FIGURE 1	BORING DATE	FEB. 6-8, 1962	DATUM	GEODETIC
BOREHOLE TYPE		WASH BORING	BOREHOLE DIAMETER		4" & 8" CASING
SAMPLER HAMMER WEIGHT 140 LB.		DROP 30 INCHES	PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES		

SOIL PROFILE			SAMPLES		ELEVATION SCALE ELEVATION / FT.	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT L _L	PLASTIC LIMIT P _L	WATER CONTENT W
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		20 40 60 80 100			
						SHEAR STRENGTH C, LB./SQ.FT.	WATER CONTENT, PER CENT		
134.0	ICE LEVEL								
0.0	ICE								
1.5									
	WATER								
81.1	RIVER BOTTOM								
52.9	LOOSE SAWDUST								
53.5									
	← Q' CLAY SEAM		1	BX RC					
	ZONE "A"		2	"					
	DARK GREY LIMESTONE BEDROCK SOUND BELOW ELEV. 78								
57.0	(PARTLY HEALED VERTICAL FRACTURE BETWEEN EL. 66 AND 64)		3	"					
77.0	ZONE "B"		4	"					
47.0									
87.0	END OF HOLE								

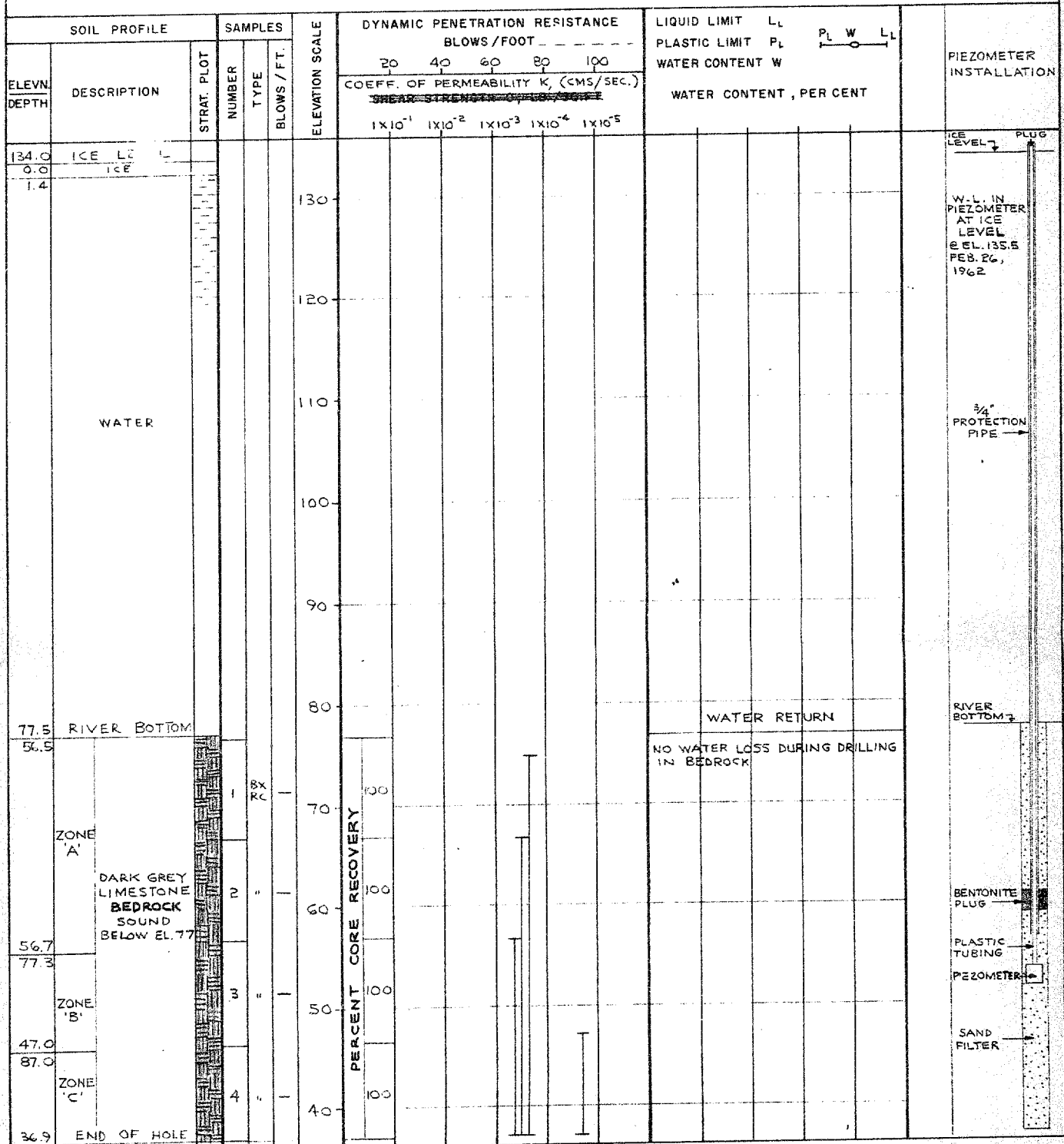
VERTICAL SCALE
1 INCH TO 10'-0"

DRAWN J.A.
CHECKED JAY

GOLDER & ASSOCIATES

RECORD OF BOREHOLE 102

LOCATION PIER 4 SEE FIGURE 1 BORING DATE FEB. 10-12, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" ϕ 8X CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *000*

RECORD OF BOREHOLE 103

LOCATION PIER 4 SEE FIGURE 1 BORING DATE FEB 8-9, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W			WATER CONTENT , PER CENT	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FT.						P _L W L _L			
							SHEAR STRENGTH C, LB /SQ.FT.								
134.4	ICE LEVEL					130									
0.0	ICE					120									
						110									
						100									
						90									
						80									
78.7	RIVER BOTTOM					70									
55.7						60									
						50									
						40									
						30									
						20									
						10									
						0									
									</						

VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED JBY

RECORD OF BOREHOLE 104

LOCATION PIER 3 SEE FIGURE 1 BORING DATE FEB. 8 & 9, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" \pm BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT -----					LIQUID LIMIT L_c PLASTIC LIMIT P_L P_L W L_L			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		20	40	60	80	100	WATER CONTENT W			
						SHEAR STRENGTH C , LB./SQ.FT.					WATER CONTENT, PER CENT			
134.4	ICE LEVEL				140									
6.0	ICE													
1.3					130									
					120									
					110									
					100									
93.4	RIVER BOTTOM				90									
41.0	VERY LOOSE DARK BROWN COARSE SAWDUST AND WOODCHIPS		1	2" D.O. WH										
81.2					80									
53.2														
	ZONE 'A'		2	BX RC										
70.4					70									
64.0	SOUND DARK GREY LIMESTONE BEDROCK		3	"										
61.9					60									
72.4	ZONE 'B'													
74.0	END OF HOLE				50									

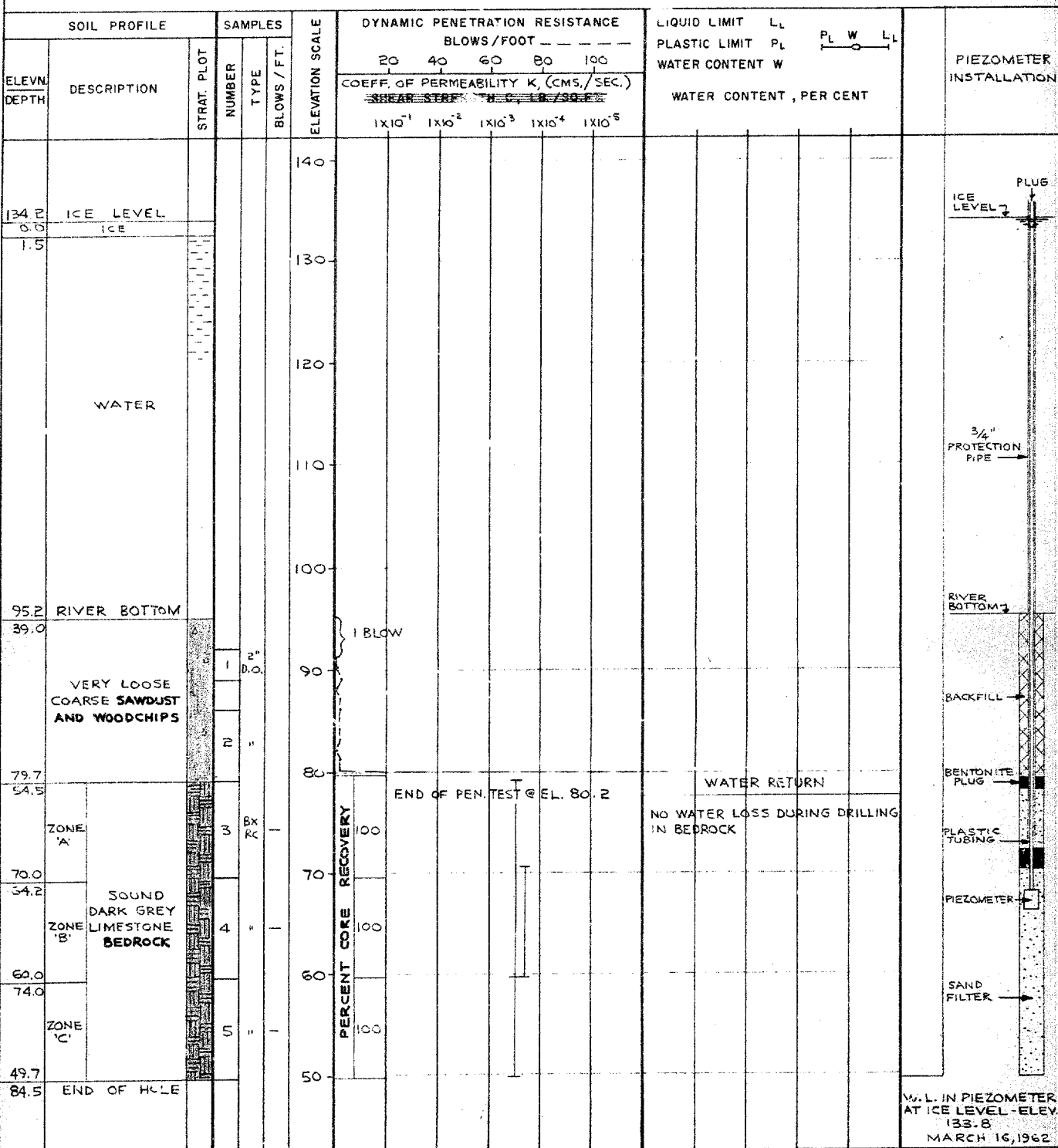
VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED JOR

RECORD OF BOREHOLE 105

LOCATION PIER 3 SEE FIGURE 1 BORING DATE FEB. 12-14, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{1}{8}$ " Bx CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE.
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.

CHECKED J.A.

RECORD OF BOREHOLE 106

LOCATION PIER 3 SEE FIGURE 1 BORING DATE FEB. 10-12, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W			
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		BLOWS / FT						P _L W L _L		
							SHEAR STRENGTH C, LB /SQ.FT					WATER CONTENT , PER CENT		
134.0	ICE LEVEL					140								
0.0	ICE					130								
1.2						120								
						110								
						100								
94.0	RIVE: BOTTOM					90								
40.0	VERY LOOSE COARSE SANDUST, WOODCHIPS, AND SMALL LOGS					80								
84.5						75								
49.5	LOOSE GREY SAND AND SILT WITH GRAVEL		1	P.O.	5									
51.4	LIMESTONE BOULDERS AND GRANITIC GRAVEL IN MATRIX OF SAND		2	BX RC										
78.0						100								
56.0						90								
	ZONE 'A'		3	"		80								
67.8						70								
66.2	SOUND DARK GREY LIMESTONE BEDROCK					60								
	ZONE 'B'		4	"		50								
59.2						40								
57.0	ZONE 'C'					30								
77.0	END OF HOLE					20								

PERCENT CORE RECOVERY

WEIGHT OF RODS
MANUAL PUSH

END OF PEN. TEST @ EL. 82.6
18 BLOWS FOR LAST 5 INCHES

WATER RETURN
NO WATER LOSS DURING DRILLING IN BEDROCK

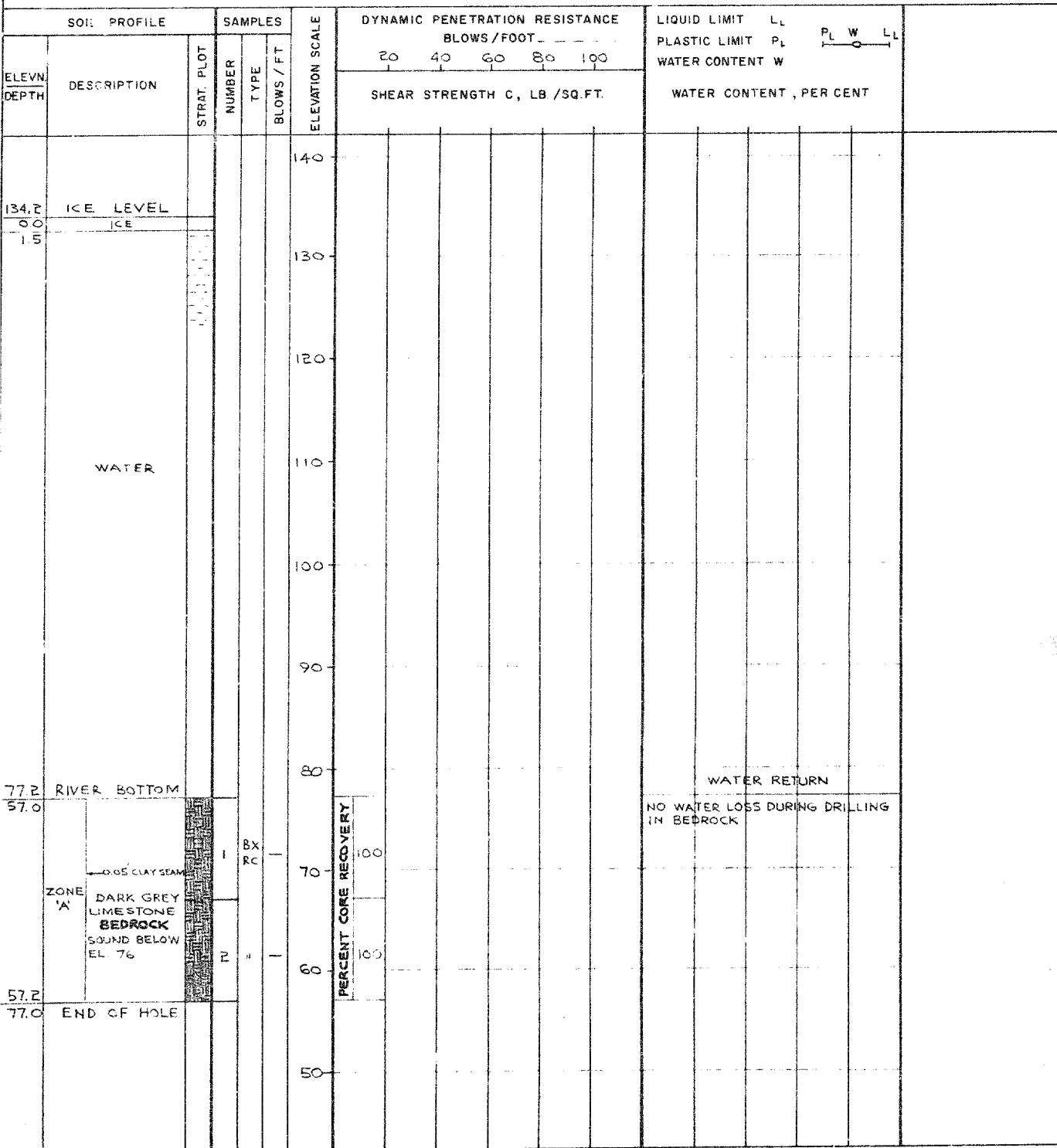
VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN JA
CHECKED JAY

RECORD OF BOREHOLE 107

LOCATION PIER 4 SEE FIGURE 1 BORING DATE FEB. 14, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{1}{2}$ BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED *[Signature]*

RECORD OF BOREHOLE 108

LOCATION PIER 2 SEE FIGURE 1 BORING DATE FEB. 15-16, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT L _L					LAB. TESTING		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.	BLOWS / FOOT					PLASTIC LIMIT P _L						
						SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT W						
						WATER CONTENT, PER CENT											
135.1	ICE LEVEL					20	40	60	80	100							
0.0	ICE																
1.7																	
	WATER																
113.1	RIVER BOTTOM																
22.0																	
	VERY LOOSE DARK BROWN COARSE SAWDUST AND WOODCHIPS		1	2' D.F. PM													
			2	2' D.O.													
100.6																	
34.5	VERY LOOSE DARK GREY SILTY SAND		3	"													
97.0	WITH ORGANIC MATTER																
38.1																	
	ZONE A		4	BX RC													
86.1																	
42.0	SOUND DARK GREY LIMESTONE BEDROCK		5	"													
	ZONE B		6	"													
77.2																	
57.9			7	"													
	ZONE C																
69.8																	
65.3	END OF HOLE																

VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED *[Signature]*

RECORD OF BOREHOLE 110

LOCATION PIER 2 TE FIGURE 1 BORING DATE FEB. 16-17, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		20	40	60	80	100	P _L W L _L		
						SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT, PER CENT		
135.1	ICE LEVEL				140								
0.0	ICE												
1.6													
					130								
					120								
					110								
103.1	RIVER BOTTOM												
30.0	VERY LOOSE COARSE SAWDUST AND WOODCHIPS												
101.1													
34.0	VERY LOOSE DARK GREY ORGANIC SILTY SAND WITH TRACE SAWDUST		1	2" P.O.	100								
97.6													
37.5			2	Bx RC									
	0.1' SAND SEAM		3	"									
	ZONE 'A'				90								
82.1	DARK GREY LIMESTONE BEDROCK		4	"	90								
53.0	SOUND BELOW EL. 91				80								
	ZONE 'B'												
73.2			5	"	100								
61.9	ZONE 'C'												
69.2					70								
65.9	END OF HOLE				60								

WEIGHT OF RODS

WATER RETURN

NO WATER LOSS DURING DRILLING
IN BEDROCK

PERCENT CORE RECOVERY

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *JSR*

RECORD OF BOREHOLE 111

LOCATION PIER 1 SEE FIGURE 1 BORING DATE FEB 23, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & 3X CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W					LAB TESTING
ELEV. DEPTH	DESCRIPTION	STRAT. PLAT	NUMBER	TYPE											
135.5	ICE LEVEL														
130.0	ICE														
128.5	WATER														
128.5	RIVER BOTTOM														
125.5	VERY LOOSE COARSE SAWDUST & WOODCHIPS		1	2" PM											
124.0	LOOSE BROWN SANDY SILT WITH SAWDUST		2	"											
119.0	LOOSE TO COMPACT GREY SILT, SAND, AND GRAVEL, TRACE OF CLAY (TILL)		3	"											
119.0	LIMESTONE COBBLES AND BOULDERS		4	"											
115.5			5	"											
115.5			6	"											
115.5			7	"											
110.0	ZONE 'A'		8	"											
103.0	DARK GREY LIMESTONE BEDROCK														
92.5	SOIL BELOW EL. 114.														
94.5	ZONE 'B'		9	"											
92.0	ZONE 'C'														
43.5	END OF HOLE														

PERCENT CORE RECOVERY

END OF PEN TEST AT EL. 119.4
50 BLOWS FOR LAST INCH

WATER RETURN

NO WATER LOSS DURING DRILLING IN BEDROCK. SLIGHT ARTESIAN PRESSURE FROM ZONE 'C' PORTION OF BEDROCK.

MH

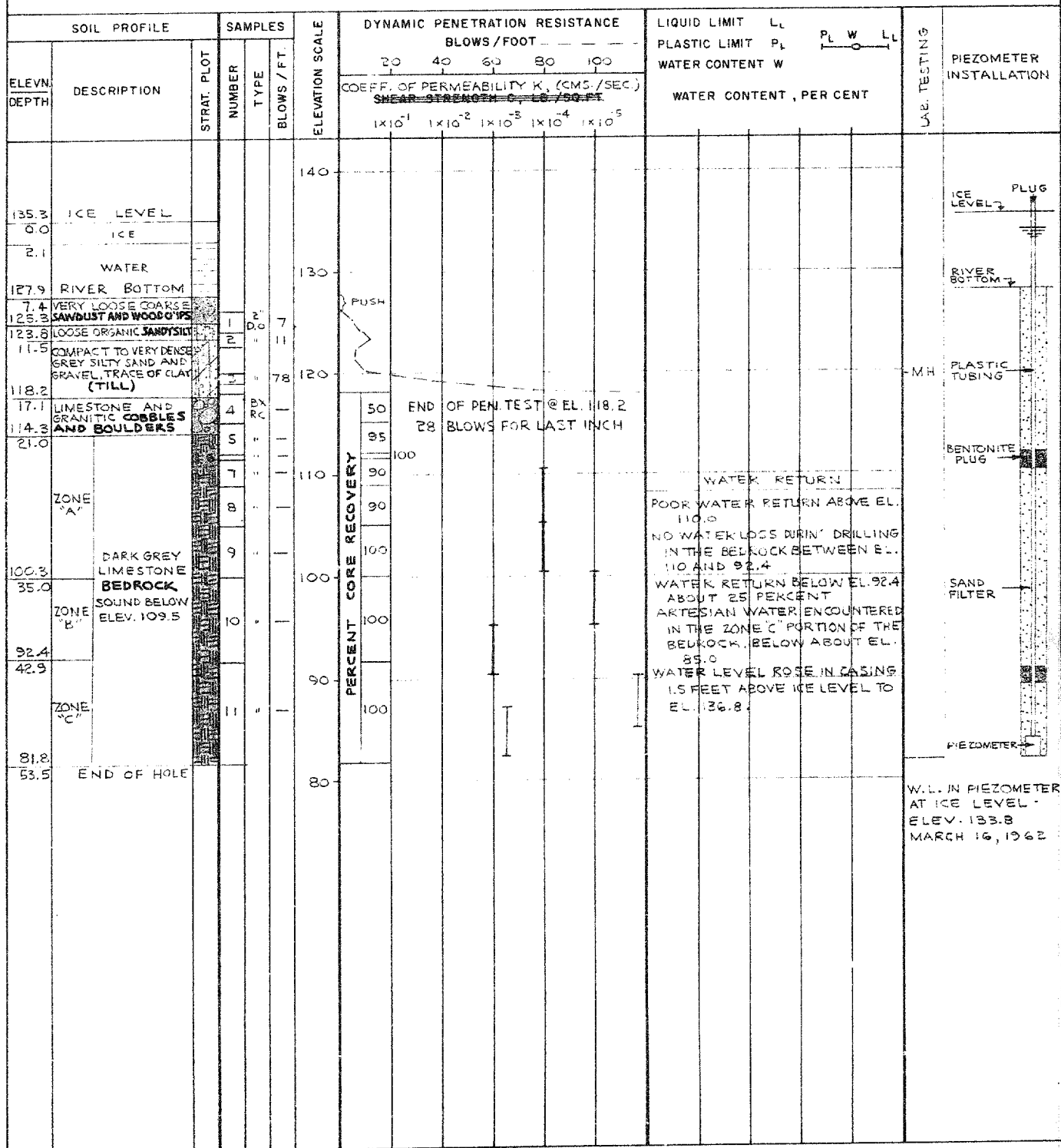
VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED J.A.

RECORD OF BOREHOLE 112

LOCATION PIER 1 SEE FIGURE 1 BORING DATE FEB. 15-19, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *dy*

RECORD OF BOREHOLE 113

LOCATION PIER 1 SEE FIGURE 1 BORING DATE FEB 21 & 22, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & 8X CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE						SHEAR STRENGTH C, LB./SQ. FT.				
135.5	ICE LEVEL													
130.0	ICE													
129.7	WATER													
127.4	RIVER BOTTOM													
126.6	VERY LOOSE COARSE SAND/ST & WOODCH 5		1	SC PM										
125.5	LOOSE ORGANIC SANDY SILT		2	PM										
120.2	COMPACT TO DENSE GREY SILTY SAND AND GRAVEL, TRACE OF CLAY COBBLES AND BOULDERS (TILL)		3	PM										
119.7			4											
115.8	GRANITIC GRAVEL AND LIMESTONE COBBLES AND BOULDER		5											
114.5			6											
21.0			7											
102.0	ZONE 'A' DARK GREY LIMESTONE BEDROCK SOUND BELOW EL. 111		8											
33.5	ZONE 'B' UNHEALED VERTICAL FRACTURE BETWEEN EL. 103 & EL. 102		9											
93.1			10											
42.4	ZONE 'C'		11											
86.5			12											
49.0	END OF HOLE													

WEIGHT OF RODS

END OF PEN. TEST @ EL. 119.4
 65 BLOWS FOR LAST 10 INCHES

WATER RETURN

POOR WATER RETURN DURING DRILLING TO EL. 114. FAIR WATER RETURN BETWEEN EL. 114 AND 111. FAIR WATER RETURN BELOW EL. 111

PERCENT CORE RECOVERY


VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED J.A.

RECORD OF BOREHOLE 114

LOCATION ONTARIO ABUTMENT SEE FIGURE 1 BORING DATE MARCH 13- 1962 DATUM GEODETIC
BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4 1/2 BX CASING
SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L  WATER CONTENT W		
ELEVATION DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT, PER CENT		
142.6	GROUND LEVEL				150								
0.0			1	BX RC	140	75					WATER RETURN		
			2	"		97					COMPLETE WATER LOSS DURING DRILLING IN BEDROCK TO EL. 140 NO WATER LOSS BELOW EL. 140		
			3	"	130	100							
			4	"		100							
			5	"	120	100							
			6	"		100							
			7	"	110	100							
			8	"	100	100							
					90								
38.8					80								
53.8	END OF HOLE												

142.6 GROUND LEVEL
0.0

ZONE "A"
DARK GREY LIMESTONE
BEDROCK
SOUND BELOW
ELEV. 137

PERCENT CORE RECOVERY

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J. A.
CHECKED *JOY*

Product of No.

$$\frac{1}{\Gamma(\alpha)} \int_0^t (t-\tau)^{\alpha-1} f(\tau) d\tau = \int_0^t \frac{(t-\tau)^{\alpha-1}}{\Gamma(\alpha)} f(\tau) d\tau$$

BOHRING DATE FEB 28 - MAR 14 1962 LATUM

GROUP 1

總行設於上海 分行設於

WASH. STATE UNIV.

BOREHOLE DIAMETER

A. J. R. GAINES

DANGER HAMMER WEIGHT 1 LB DROP 6 INCHES

PEN TEST HAMMER WEIGHT -- LB DROP -- INCHES

[illegible]

DRAWN J.A.
CHECKED BOY

RECORD OF BOREHOLE 116

LOCATION ONTARIO ABUTMENT SEE FIGURE 1 BORING DATE MARCH 8-9, 1962 DATUM GEODETIC
BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 8x CASING
SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB. / SQ. FT.				WATER CONTENT, PER CENT				
144.5	GROUND LEVEL				150									
0.0	LOOSE LIMESTONE SLABS			Bx CA	140									
2.0			1	Bx KC		100								
			2	"		100								
			3	"	130		96							
	ZONE 'A'		4	"	120		100							
	DARK GREY LIMESTONE BEDROCK SOUND BELOW EL. 138		5	"	110		100							
			6	"	100		100							
93.2					90									
51.3	END OF HOLE													

DARK GREY LIMESTONE BEDROCK
ZONE 'A' SOUND BELOW EL. 138

WATER RETURN
NO WATER LOSS DURING DRILLING IN BEDROCK

PERCENT CORE RECOVERY

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED [Signature]

RECORD OF BOREHOLE 117

LOCATION ONTARIO ABUTMENT SEE FIGURE 1 BORING DATE FEB 27-28, 1962 DATUM GEODETIC
BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 8X CASING
SAMPLER HAMMER WEIGHT --- LB. DROP --- INCHES PEN. TEST HAMMER WEIGHT --- LB. DROP --- INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB./SQ.FT.				WATER CONTENT, PER CENT			
185.4	DRILLING PLATFORM LEVEL				190								
182.0	GROUND LEVEL												
3.4			1	8X RL	180	95							
			2	"		100							
			3	"		100							
	0.02' CLAY SEAM		4	"	170	100							
			5	"		100							
	0.02' CLAY SEAM		6	"		100							
			7	"	160	100							
			8	"		95							
	DARK GREY LIME STONE BEDROCK		9	"		100							
	FAIRLY SOUND BELOW EL. 170		10	"	150	100							
	SOUND BELOW ABOUT EL. 149		11	"		100							
	WEATHERED AND FRACTURED WITH CASUAL THIN HORIZONTAL VOIDS ABOVE EL. 170.		12	"	140	95							
	PARTIALLY FRACTURED TO EL. 149.		13	"		100							
			14	"	120	100							
109.8					110								
75.6	END OF HOLE				100								

WATER RETURN
FAIR WATER RETURN DURING DRILLING IN BEDROCK EXCEPT AT EL. 163 WHERE THERE WAS TOTAL WATER LOSS.

RECORD OF BOREHOLE 118

LOCATION ONTARIO ABUTMENT
SEE FIGURE 1

BORING DATE MARCH 2-6, 1962

DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT				LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE					WATER CONTENT, PER CENT		
183.3 0.0	GROUND LEVEL										
	0.1' CLAY BEAM		1	BX RC		75			WATER RETURN		
			2	"		90			POOR WATER RETURN (25-50 PERCENT) DURING DRILLING IN BEDROCK.		
			3	"		98					
			4	"		100					
	DARK GREY LIMESTONE BEDROCK		5	"		100					
	FAIRLY SOUND BELOW EL. 166		6	"		100					
	SOUND BELOW EL. 143		7	"		100					
	WEATHERED AND FRACTURED ABOVE EL. 166		8	"		100					
	PARTIALLY FRACTURED TO EL. 143		9	"		100					
114.3 69.0	END OF HOLE		10	"		100					

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *gy*

RECORD OF BOREHOLE 119

BETWEEN PIER 4
LOCATION # ONTARIO ABUTMENT
SEE FIGURE 1

BORING DATE MARCH 10-12, 1962

DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

4" $\frac{1}{2}$ BX CASING

SAMPLER HAMMER WEIGHT — LB. DROP — INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W			ELEVATION SCALE	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB. / SQ.FT.				WATER CONTENT, PER CENT				
133.3	ICE LEVEL				140									
130.3	ICE				130									
124.6	WATER				120									
119.3	RIVER BOTTOM				110									
114.0	VERY LOOSE ORGANIC SILT WITH GARBAGE				100									
88.3	ZONE 'A' DARK GREY LIMESTONE BEDROCK SOUND BELOW EL. 118		1	BX RC	90									
85.0			2	"	100									
82.0			3	"	100									
79.0			4	"	100									
45.0	END OF HOLE				80									

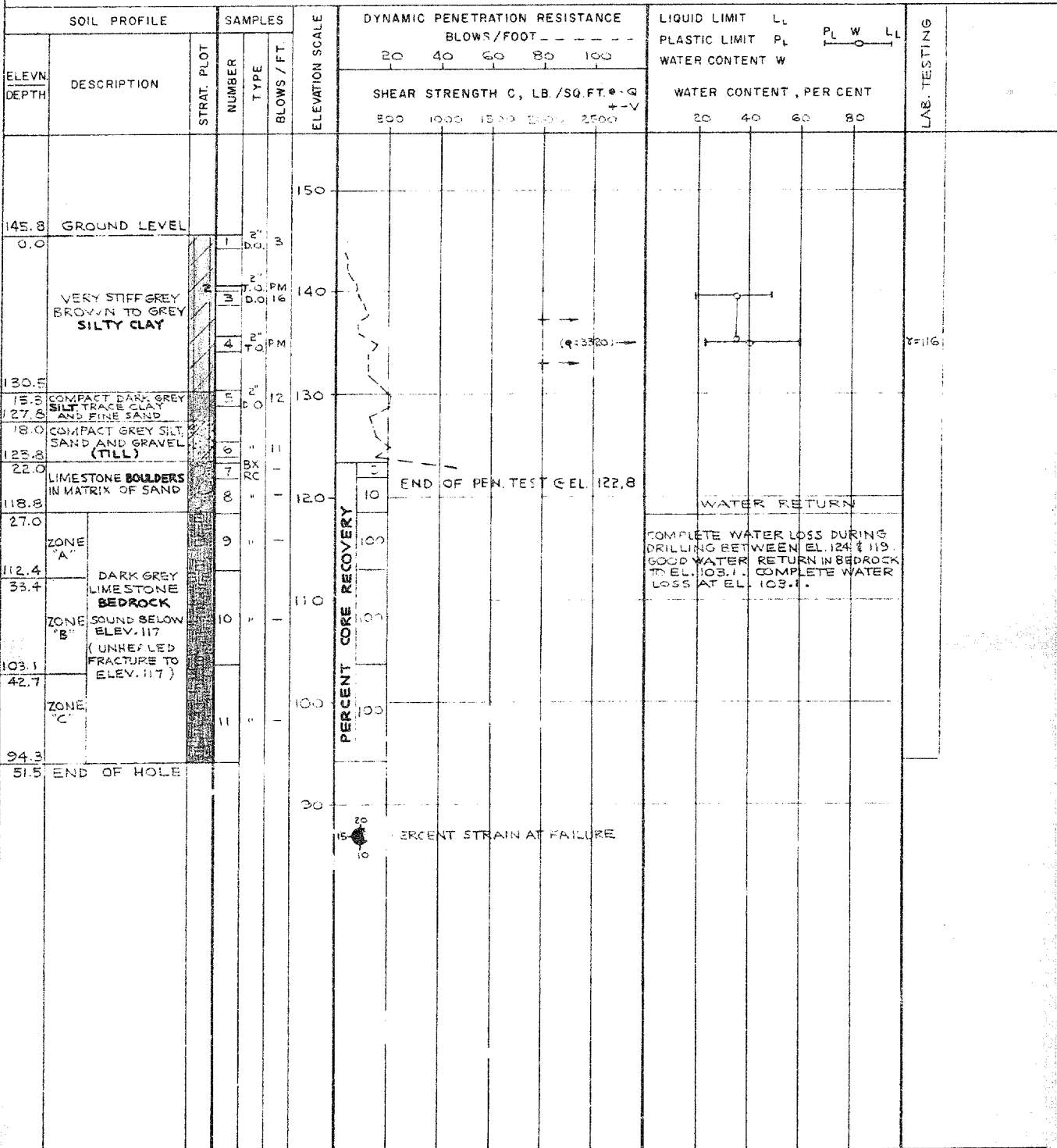
VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED 008

RECORD OF BOREHOLE 120

LOCATION QUEBEC ABUTMENT SEE FIGURE 1 BORING DATE MARCH 14-16, 1962 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{5}{8}$ BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED *007*

RECORD OF BOREHOLE 121

LOCATION QUEBEC ABUTMENT
CEL 113 (P. 1)

BORING DATE MARCH 17-20, 1962

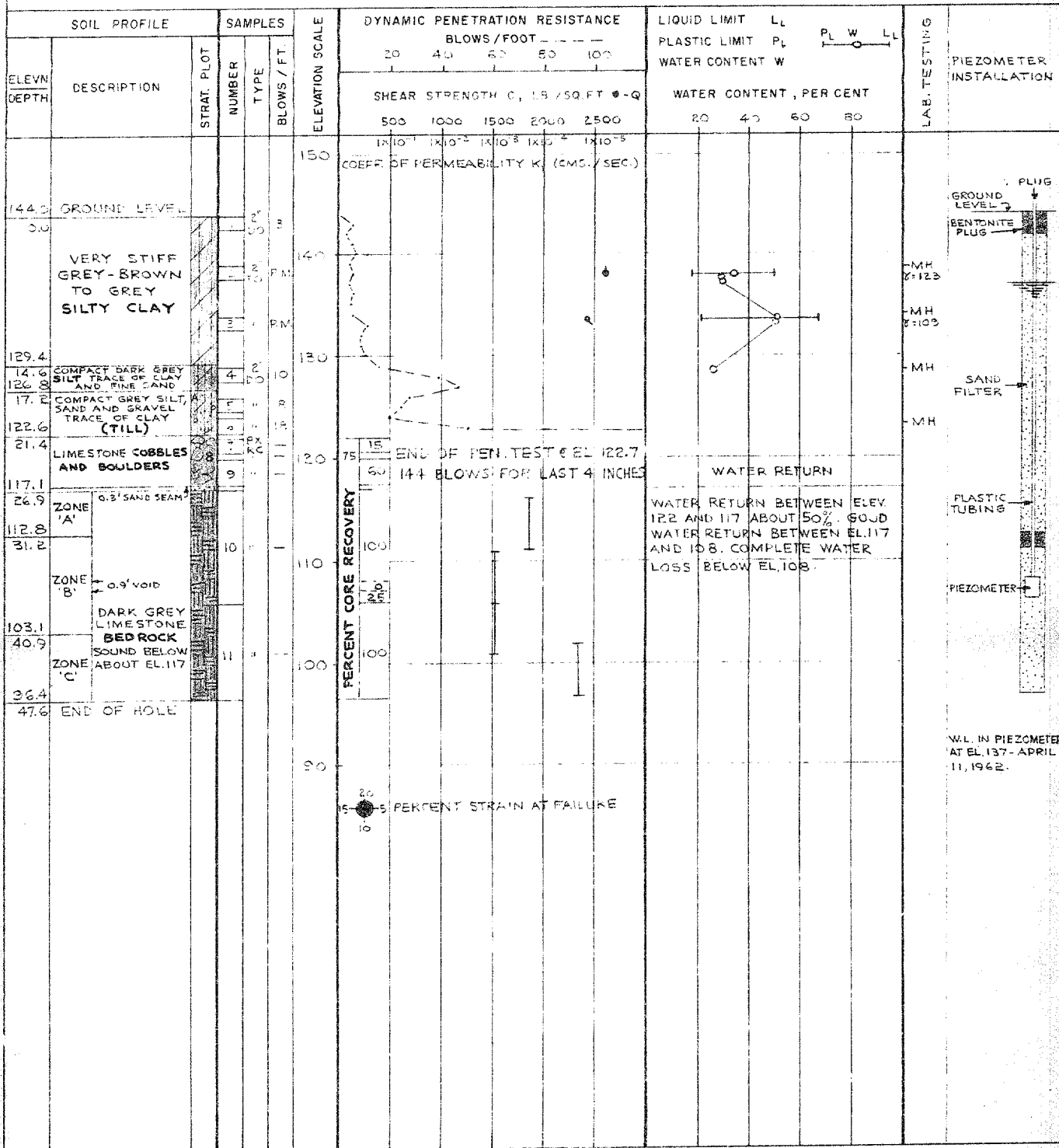
DATUM GEODETIC

BOREHOLE TYPE WASH BORING

BOREHOLE DIAMETER 4" ± BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN M.W.
CHECKED J.R.

RECORD OF BOREHOLE 122

LOCATION QUEBEC ABUTMENT
SEE FIGURE 1

BORING DATE MARCH 21-22, 1962 DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

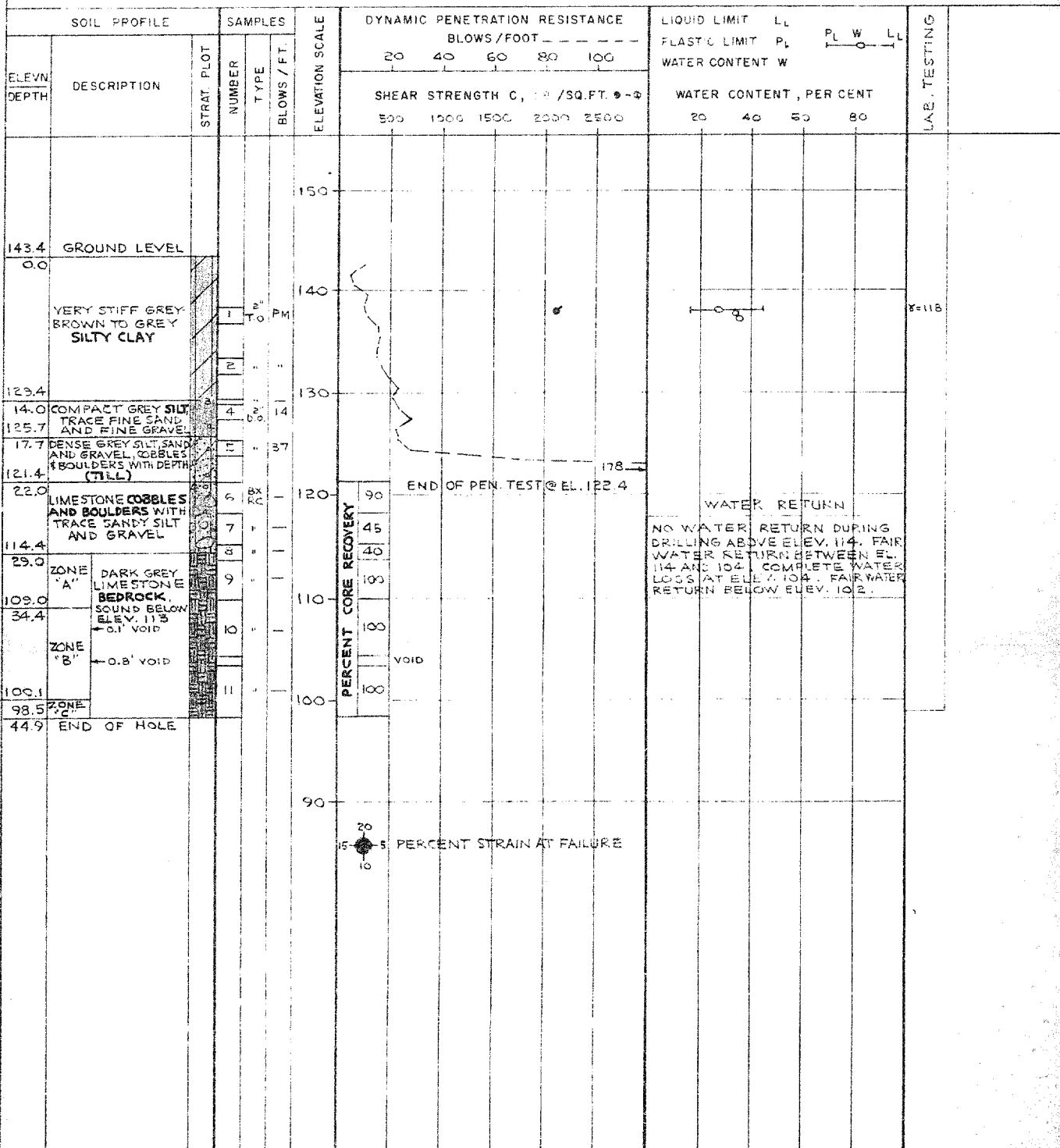
4" $\frac{1}{8}$ BX CASING

SAMPLER HAMMER WEIGHT 140 LB

DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB

DROP 30 INCHES

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *[Signature]*

RECORD OF BOREHOLE 123

LOCATION QUEBEC ABUTMENT
SEE FIGURE 1

BORING DATE MARCH 22-26, 1962

'DATUM'

GEODETIC

BOREHOLE TYPE

POWER AUGER & WASH BORING

BOREHOLE DIAMETER

4" BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

[illegible]

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED *[Signature]*

RECORD OF BOREHOLE 124

QUEBEC ABUTMENT

LOCATION SEE FIGURE 1

BORING DATE MARCH 21-24, 1962

DATUM

GEODETIC

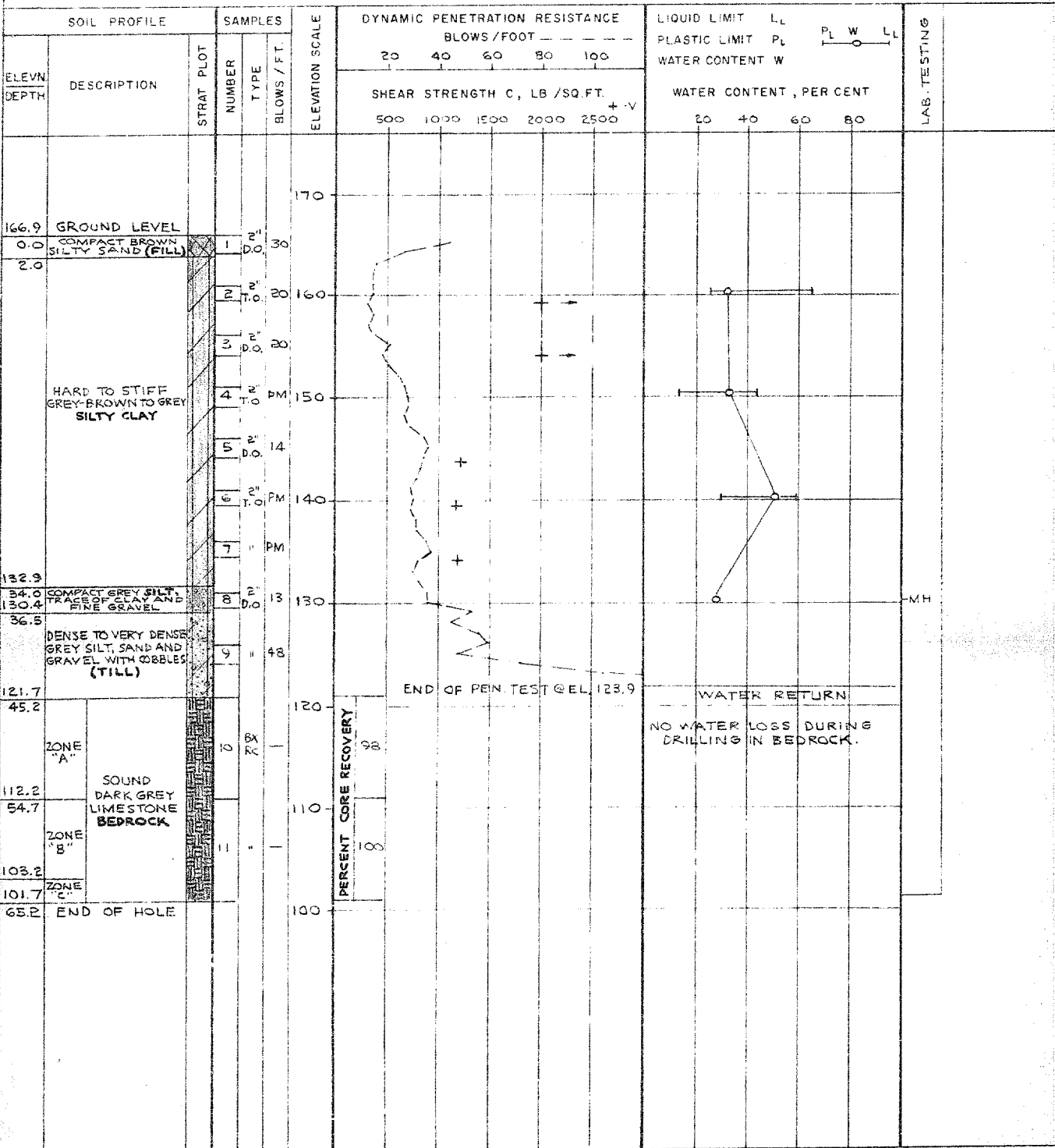
BOREHOLE TYPE POWER AUGER & WASH BORING

BOREHOLE DIAMETER

4" & BX CASING

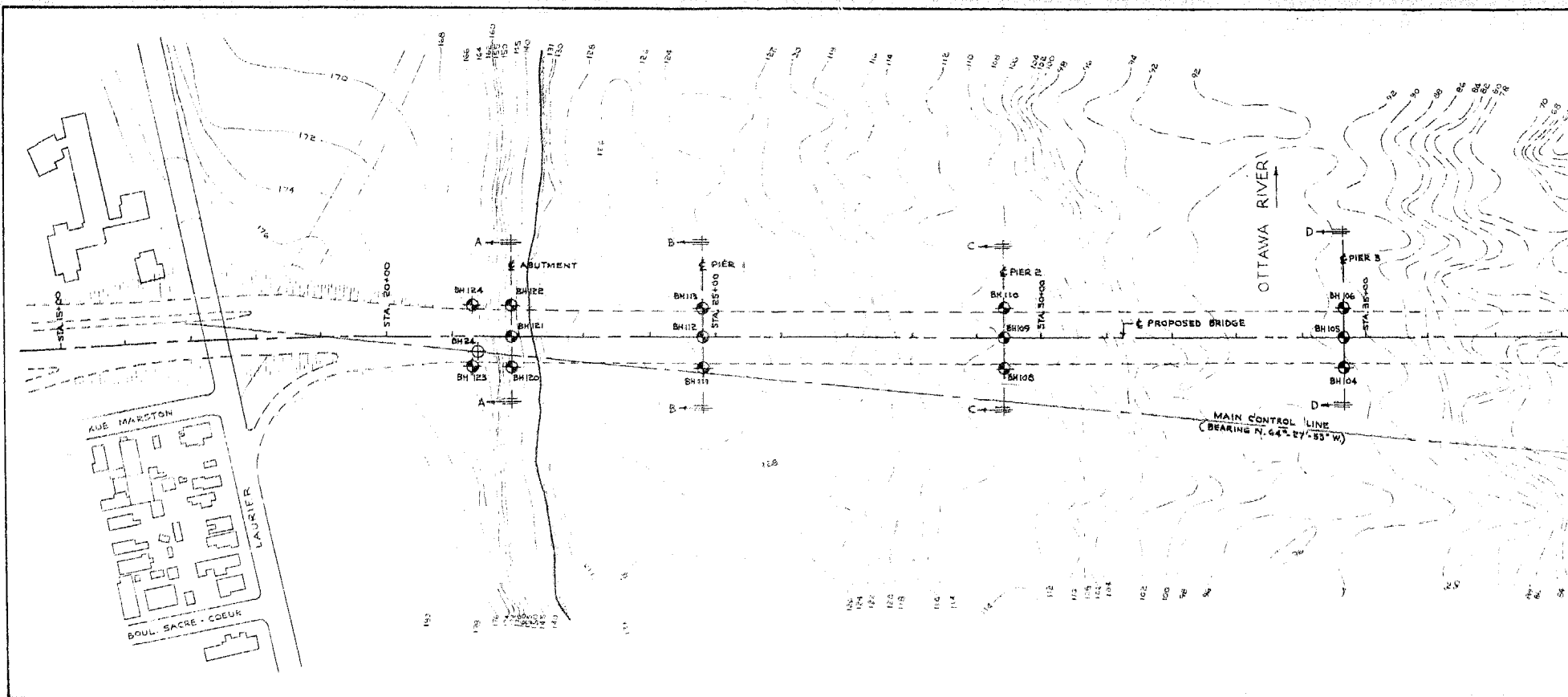
SAMPLER HAMMER WEIGHT 140 LB DROP 30 INCHES

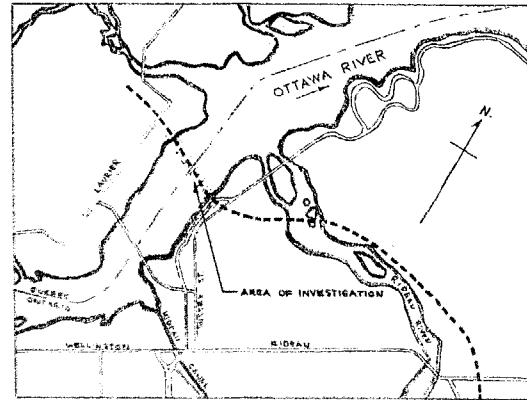
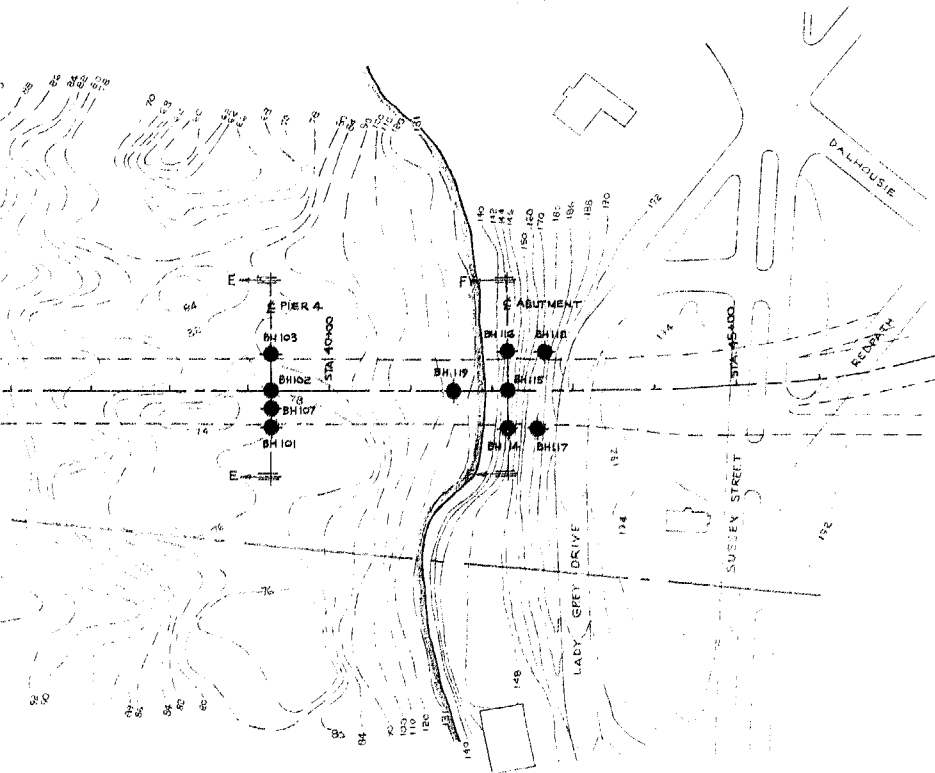
PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES




DRAWN J.A.
CHECKED *jm*



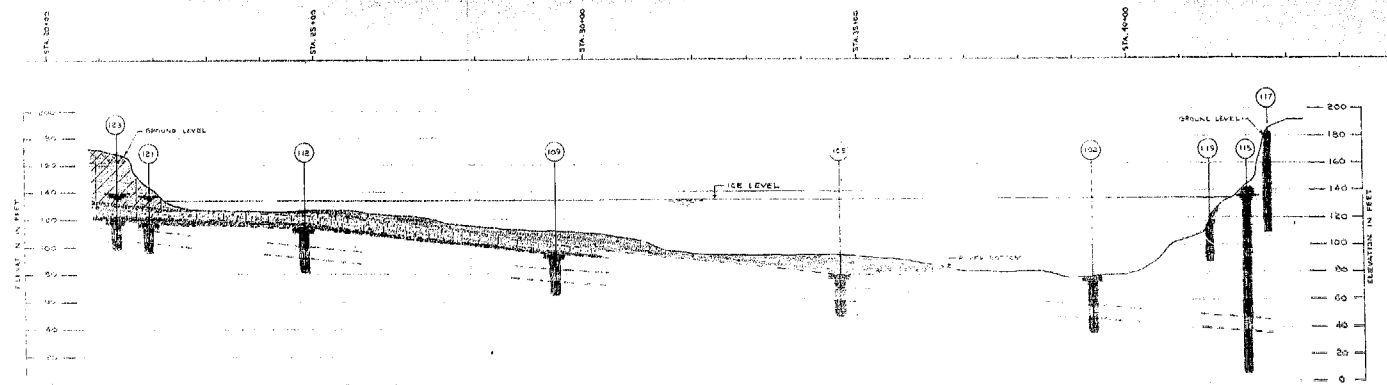


KEY PLAN
SCALE: 1" TO 2000' (APPROX.)

LEGEND

-  BOREHOLE WITH PENETRATION TEST IN PLAN
-  BOREHOLE ONLY IN PLAN
-  BOREHOLE FROM PREVIOUS INVESTIGATION IN PLAN (REPORT 9132)

REFERENCE		CONSULTING ENGINEERS MACDONALD - CARTIER BRIDGE OTTAWA - HULL ONTARIO CANADA		GOLDER & ASSOCIATES CONSULTING CIVIL ENGINEERS
DRWG. NO.	DESCRIPTION			
9	PLAN SHOWING HULL-OTTAWA INTERCHANGES, SCALE: 1" TO 100' CONTROLLED BY CONSULTING ENGINEERS, DATED JAN. 24, 1962	PROPOSED MACDONALD-CARTIER BRIDGE		DATE: APRIL 17, 1962 SCALE: 1" TO 100' 0"
BORING PLAN		MADE J.A.	CHKD. 870	APPRO. 114
		FIGURE 1		



SECTION ALONG CENTRE LINE OF PROPOSED BRIDGE

STRATIGRAPHY

- COMPACT TO DENSE BROWN SILTY SAND (FILL)
- VERY LOOSE BROWN COARSE SAWBUST AND WOODCHIPS
- VERY LOOSE TO LOOSE GREY ORGANIC SILT AND SAND
- STIFF TO HARD GREY-BROWN TO GREY SILTY CLAY
- COMPACT GREY SILT, TRACE OF CLAY AND FINE SAND
- LOOSE TO VERY DENSE GREY SILT, SAND AND GRAVEL, WITH COBBLES AND BOULDERS, TRACE OF CLAY (FILL)
- GRAVEL, COBBLES AND BOULDERS
- ZONE 'A' BEDROCK WEATHERED AND PARTLY FRACTURED, BECOMING SOUND INTERBEDDED DARK GREY LIMESTONE AND BLACK SHALE
- ZONE 'B' BEDROCK SOUND INTERBEDDED DARK GREY LIMESTONE AND BLACK SHALE
- ZONE 'C' BEDROCK SOUND DARK GREY LIMESTONE WITH SHALE PARTINGS

LEGEND

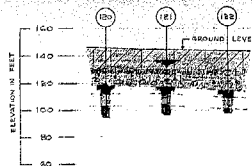
- BOREHOLE IN ELEVATION
- W.L. IN BOREHOLE, APRIL 11, 1962

SPECIAL NOTE:
STRAITS HAVE BEEN
SHOWN ONLY
BEHIND THE
ELEVATION

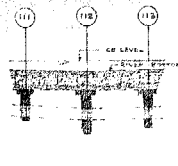
NOTE

AVERAGE ICE LEVEL DURING INVESTIGATION AT EL. 135

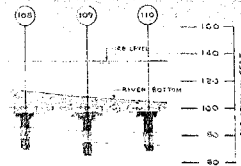
CONSULTING ENGINEERS MACDONALD - CARTIER BRIDGE OTTAWA, ONTARIO PROPOSED MACDONALD - CARTIER BRIDGE OTTAWA, HULL, CANADA		GOLDER & ASSOCIATES CONSULTING CIVIL ENGINEERS DATE: APRIL 17, 1962 SCALE: HORIZ. 1" = 100' VERT. 1" = 20' MADE BY: J.A. CHKD BY: [Signature] APPD BY: [Signature]	
SOIL STRATIGRAPHY		FIGURE 2	



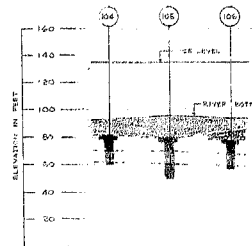
SECTION A-A
QUEBEC ABUTMENT



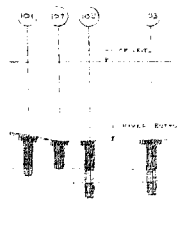
SECTION B-B
PIER 1



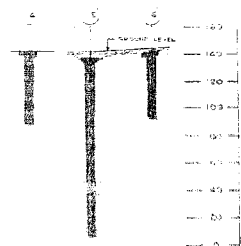
SECTION C-C
PIER 2



SECTION D-D
PIER 3



SECTION E-E
PIER 4



SECTION F-F
ONTARIO ABUTMENT

STRATIGRAPHY

- VERY LOOSE BROWN COARSE SAND AND WOODCHIPS
- VERY LOOSE TO LOOSE GREY ORGANIC SILT AND SAND
- STIFF TO HARD GREY-BROWN TO GREY SILTY CLAY
- COMPACT GREY SILT, TRACE OF CLAY AND FINE SAND
- LOOSE TO VERY DENSE GREY SILT, SAND AND GRAVEL, WITH COBBLES AND BOULDERS, TRACE OF CLAY (TILL)
- GRAVEL, COBBLES AND BOULDERS
- ZONE 'A' BEDROCK WEATHERED AND PARTLY FRACTURED, BECOMING SOUND INTERBEDDED DARK GREY LIMESTONE AND BLACK SHALE
- ZONE 'B' BEDROCK SOUND INTERMIXED DARK GREY LIMESTONE AND BLACK SHALE
- ZONE 'C' BEDROCK SOUND DARK GREY LIMESTONE WITH SHALE PARTINGS

LEGEND

- BOREHOLE IN ELEVATION
- W.L. IN BOREHOLE, APRIL, 1912

REMARK: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE STRATIGRAPHY HEREIN IS BASED ON THE DATA OBTAINED FROM BOREHOLE DATA AND NOT FROM THAT WHICH

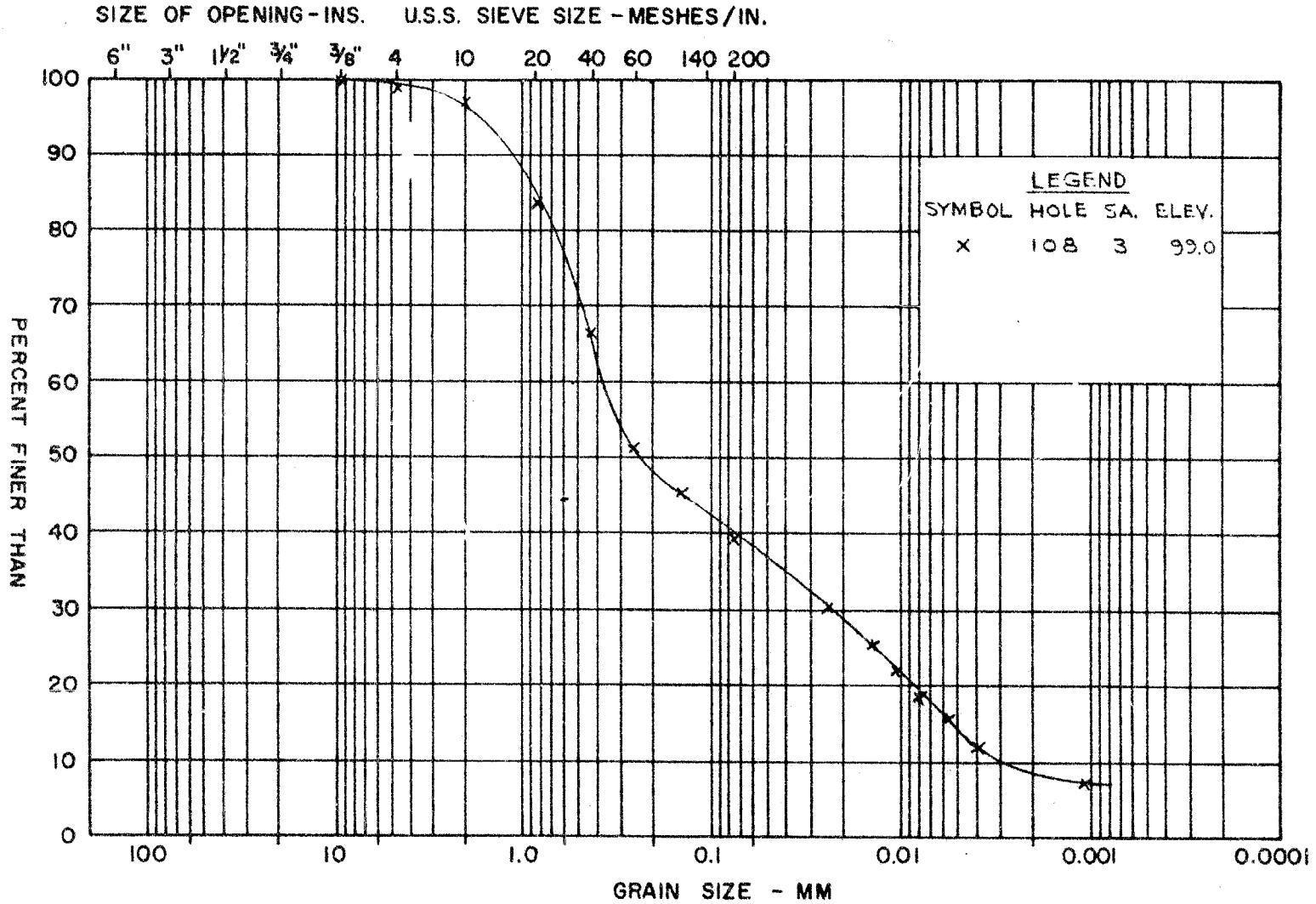
NOTES

1. FOR LOCATION OF SECTIONS SEE FIG. 1
2. AVERAGE ICE LEVEL DURING INVESTIGATION AT EL. 135

CONSULTING ENGINEERS
MACDONALD-CARTIER BRIDGE
OTTAWA, ONTARIO
PROPOSED MACDONALD-CARTIER BRIDGE
OTTAWA - HULL
SOIL STRATIGRAPHY

GOLDER & ASSOCIATES
CONSULTING CIVIL ENGINEERS
DATE: APRIL 17, 1968 SCALE: 1" TO 40'-0"
MADE: J.A. CHKD: J.A. APPD: J.A.
FIGURE 3

M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
ORGANIC SILTY SAND

FIGURE 4

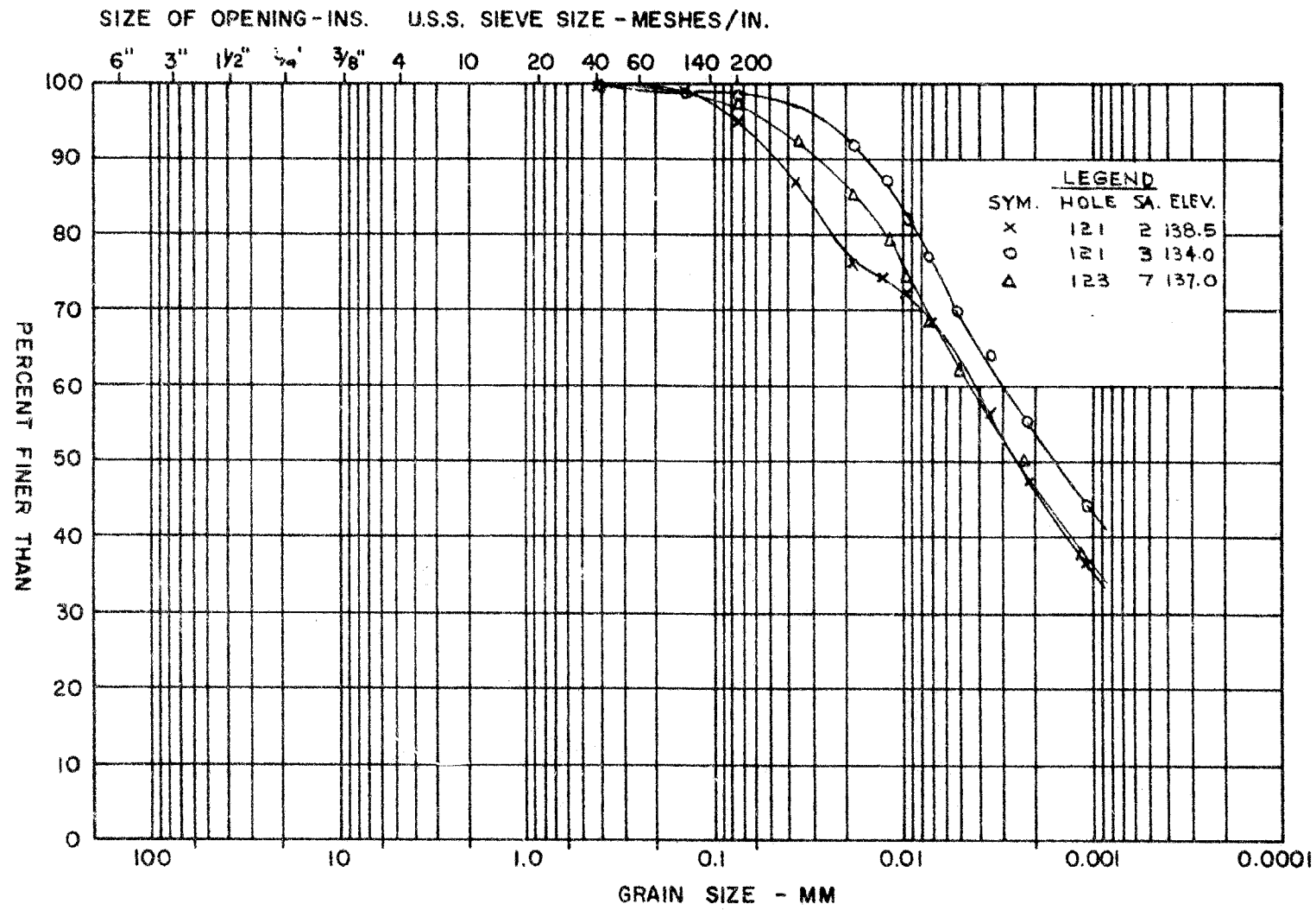
COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE	
	GRAVEL SIZE			SAND SIZE			FINE GRAINED			

M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION
SILTY CLAY

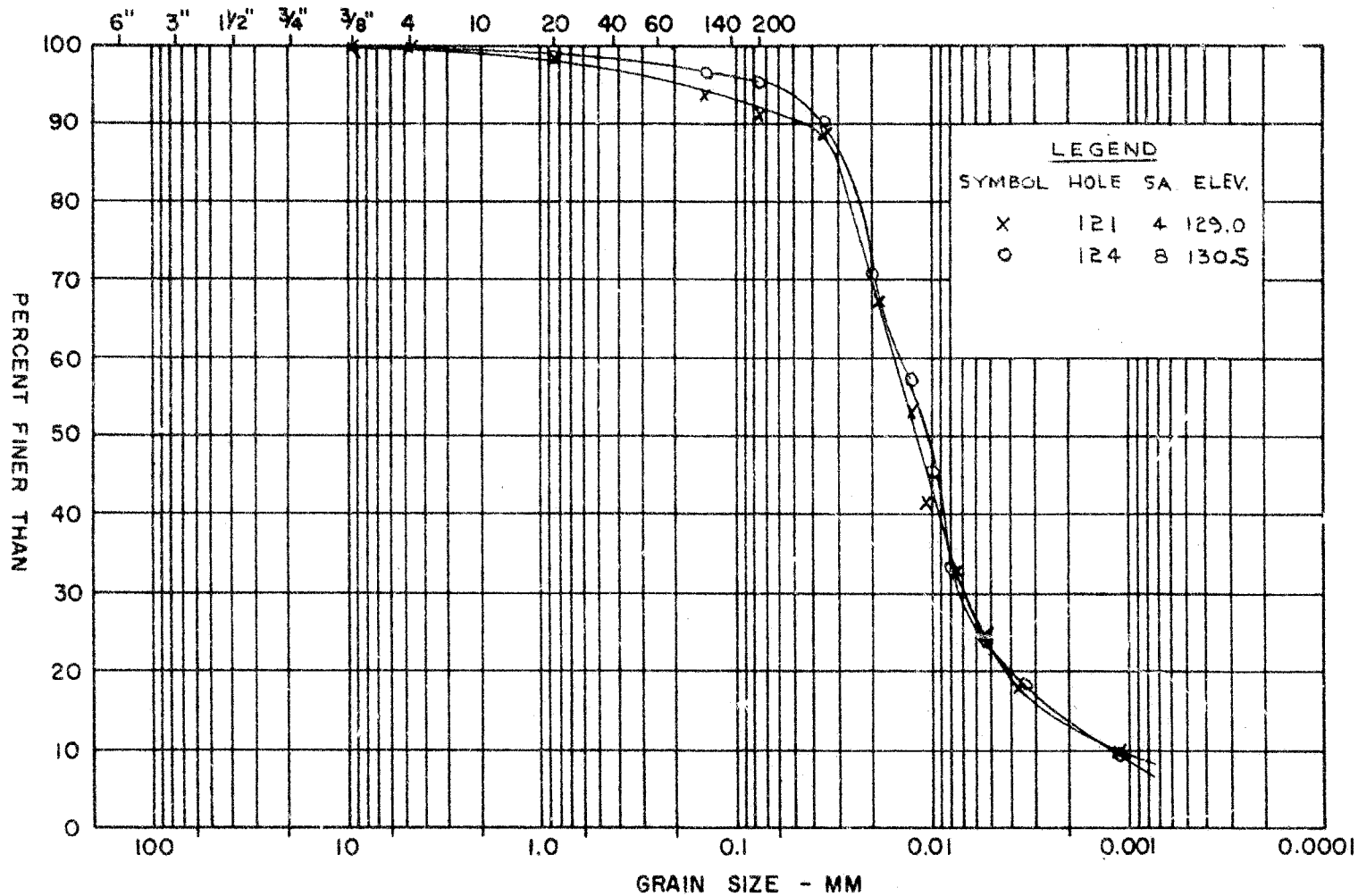
FIGURE 5

GOLDER & ASSOCIATES



M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.



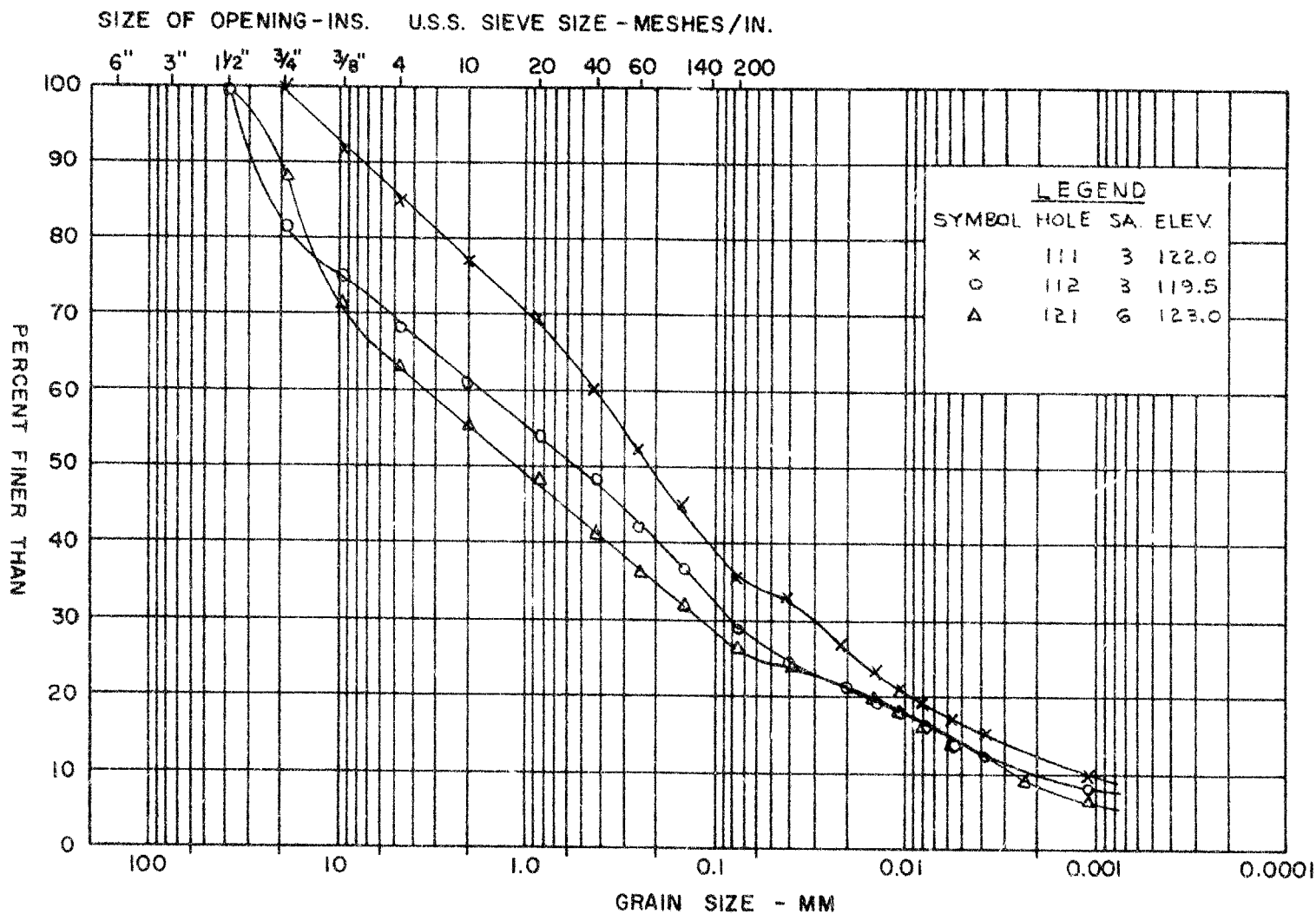
GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
SILT

FIGURE 6

COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED		

M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

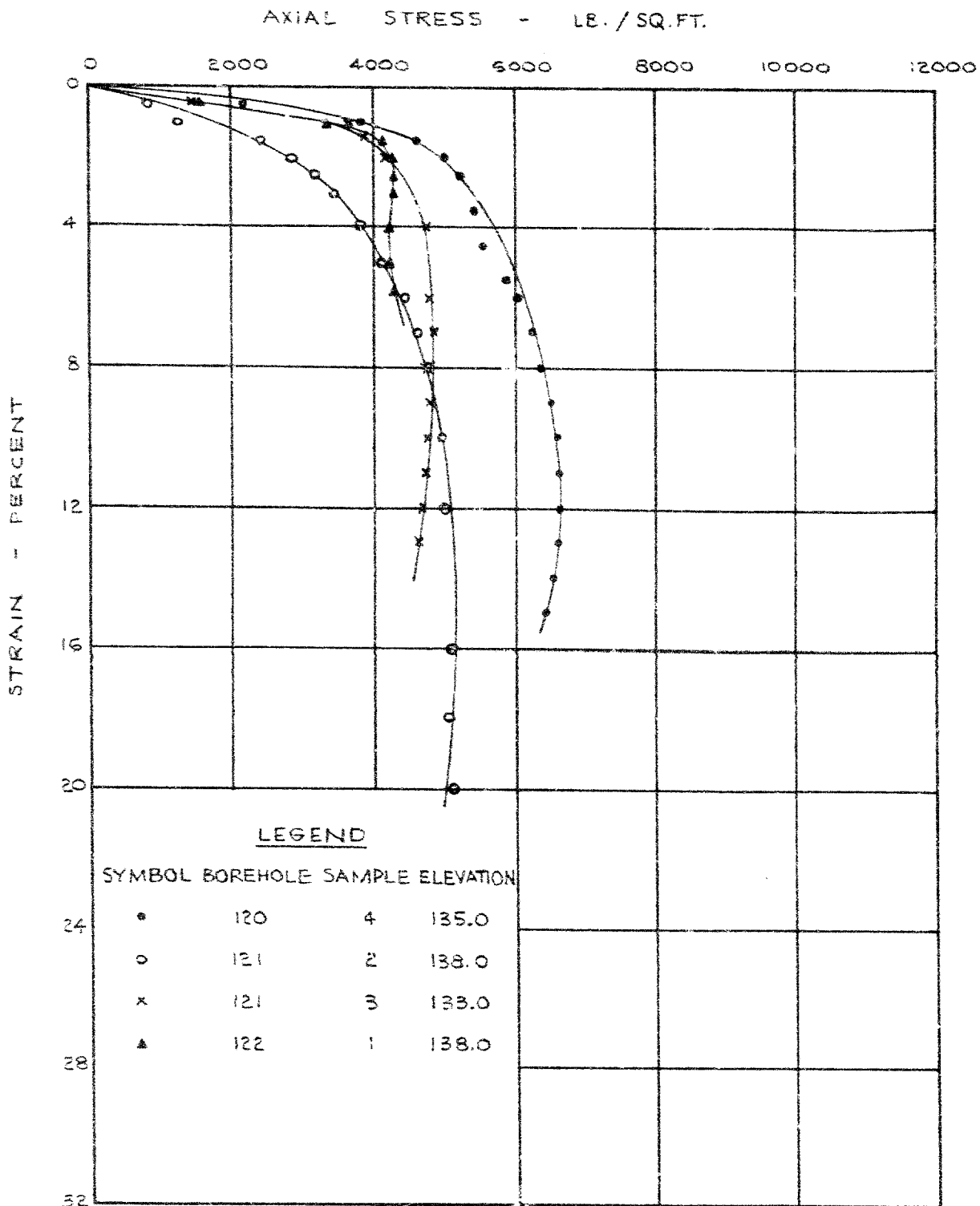
GRAIN SIZE DISTRIBUTION
TILL

FIGURE 7

COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED		

UNDRAINED TRIAXIAL COMPRESSION TESTS STRESS - STRAIN CURVES SILTY CLAY

FIGURE 8

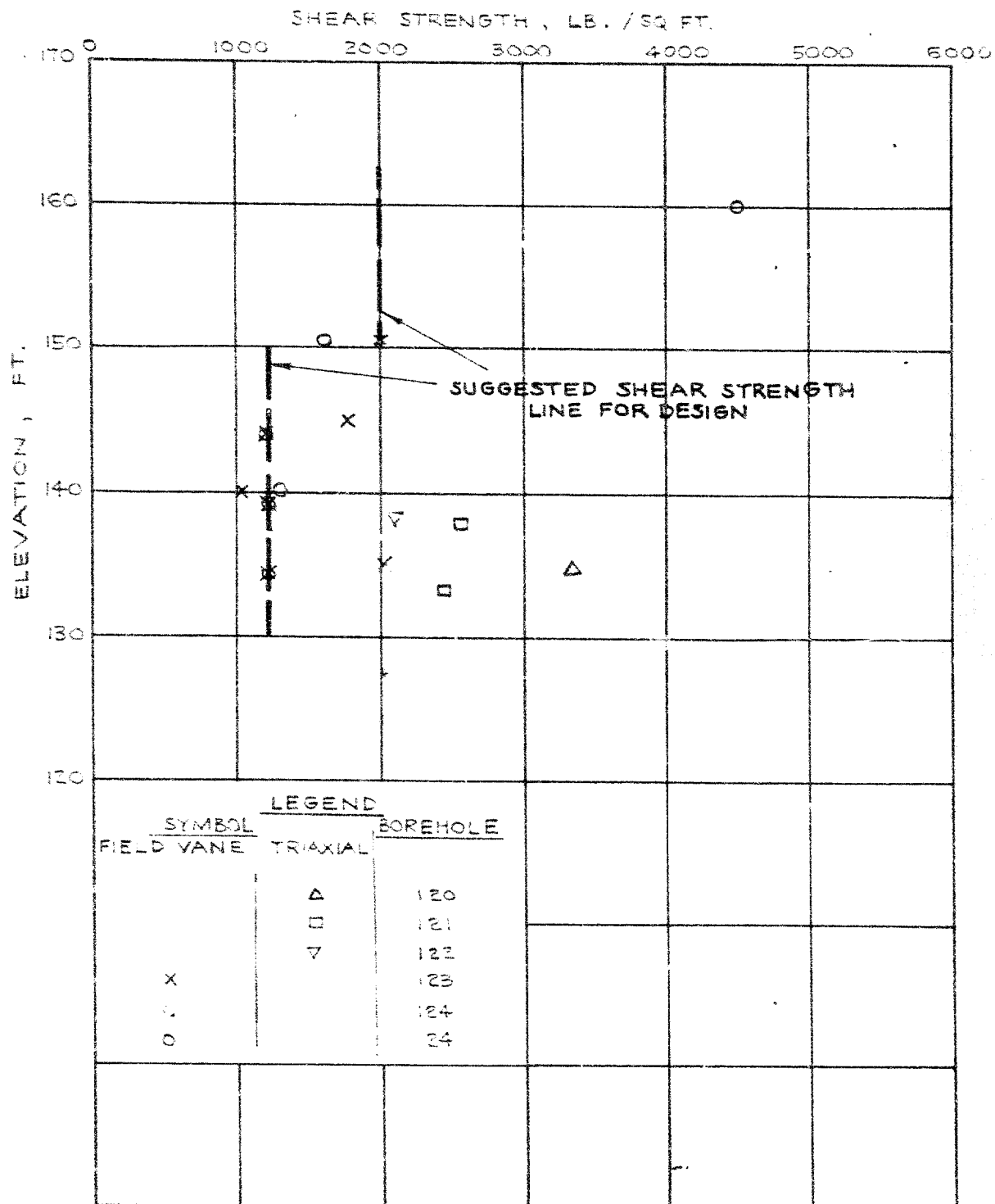


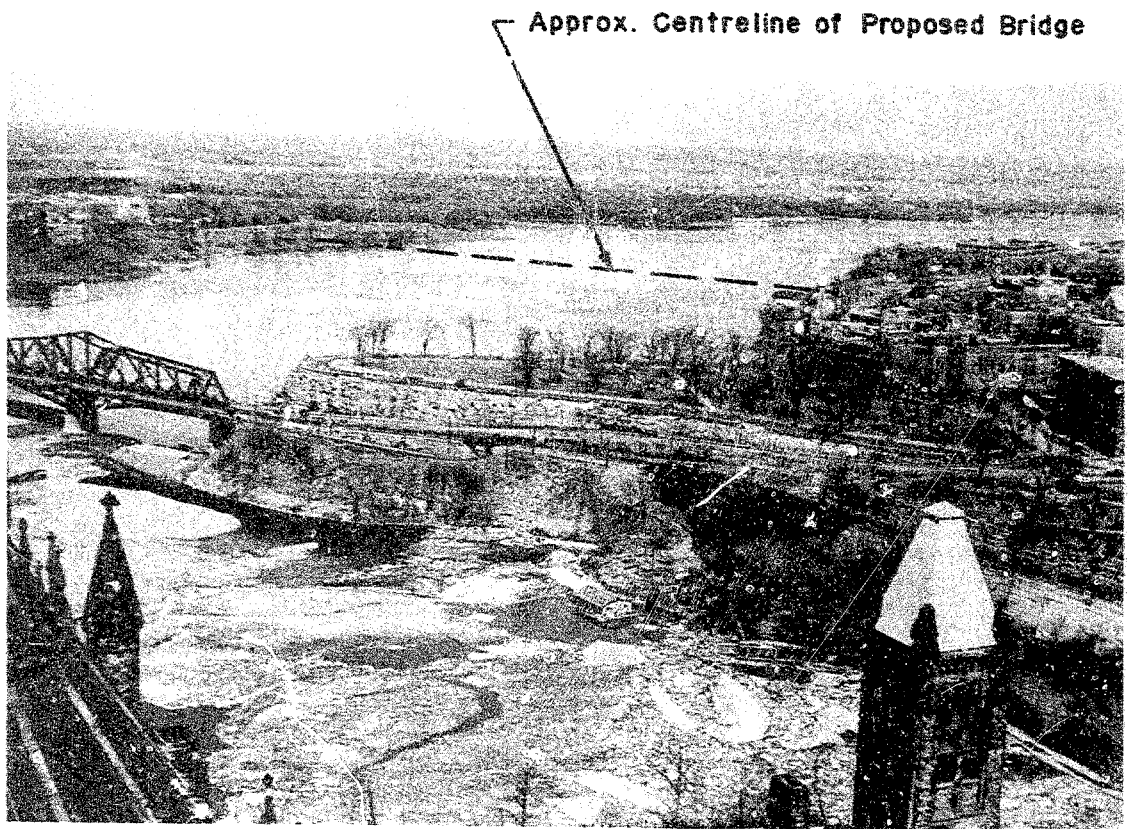
UNDRAINED SHEAR STRENGTH PROFILE

SILTY CLAY STRATUM

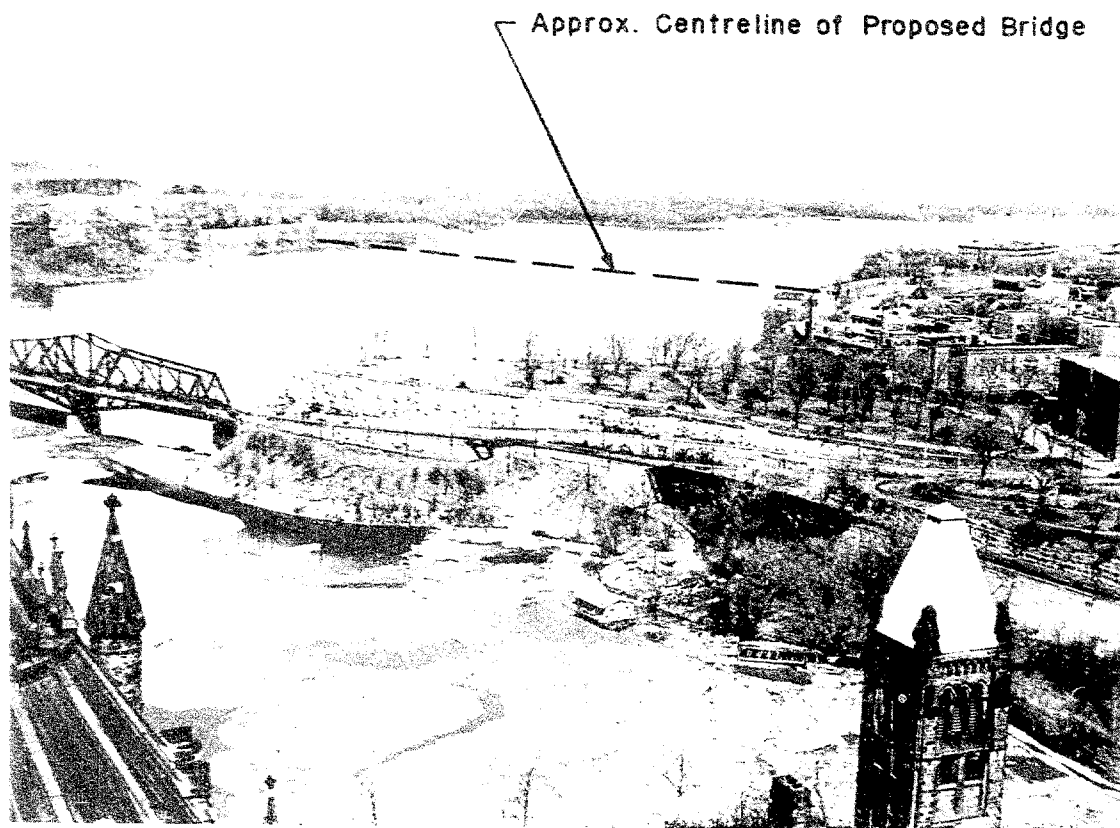
HULL ABUTMENT

FIGURE 9





View of Site looking Downstream from Ottawa side of River
Existing Interprovincial Bridge on the Left.



View of Site looking Downstream from Ottawa side of River
Existing Interprovincial Bridge on the Left.

H. Q. GOLDER & ASSOCIATES LTD.
CONSULTING CIVIL ENGINEERS

H. Q. GOLDER
V. MILLIGAN

2444 BLOOR ST. W.
TORONTO 9
RO. 7-9201



REPORT

TO

CONSULTING ENGINEERS - MACDONALD-CARTIER BRIDGE

ON

PROPOSED MACDONALD-CARTIER BRIDGE

OTTAWA-HULL

CANADA

Distribution:

20 copies - Consulting Engineers - Macdonald-Cartier Bridge,
Ottawa, Ontario.

2 copies - H. Q. Golder & Associates Ltd.,
Toronto, Ontario.

December, 1961

6135

ABSTRACT

The results of a site investigation carried out for the proposed Macdonald-Cartier Bridge on the Ottawa River between Ottawa, Ontario, and Hull, Quebec, are reported.

It was found that river bottom, towards the Hull shore, is covered by about 1 to 30 feet of very loose woodchips and sawdust fill or very loose organic silt. The river bottom near the Ottawa shore is generally underlain directly by bedrock and in some places by a few feet of cobbles and boulders resting on the bedrock.

On the Ottawa side of the river, the land portion of the site is covered by 1 to 2 feet of loose to compact sand fill which rests on bedrock. Similarly, on the Hull side of the river, a layer of generally compact granular fill, from 5 to 16 feet thick, provides the surface cover on the land portion of the site. The granular fill is underlain by a stratum of stiff marine clay, 30 to 35 feet thick, which extends down to elevation 131. The marine clay in the land borings and the recent deposits of woodchips fill and organic silt in the river immediately adjacent to the Hull shore are underlain by a stratum of compact to dense glacial till about 7 feet thick.

Beneath the glacial till on the Hull side of the river and the recent deposits of fill elsewhere, the site is completely underlain by limestone bedrock. The bedrock at some locations is overlain by a layer of cobbles and boulders 1 to 8 feet thick. The upper portion of the bedrock to a depth of about 10 feet is

generally partially fractured. Below this upper fractured zone the bedrock is sound but contains some healed and occasional open fractures.

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
PROCEDURE	1
GENERAL SITE DESCRIPTION	4
PHYSIOGRAPHY AND GENERAL GEOLOGY	5
GLACIAL GEOLOGY	6
SOIL CONDITIONS	7
Woodchips and Sawdust Fill	8
Organic Silt	8
Granular Fill	9
Silty Clay	11
Silty Sand and Gravel	15
Cobbles and Boulders	17
BEDROCK CONDITIONS	18
A Zone	18
B Zone	20
C Zone	22
Bedrock Structure	23
WATER CONDITIONS	25
REFERENCES	28
ABBREVIATIONS	29
Records of Boreholes	In Order
Figure 1 - Site and Boring Plan	Following
Figure 2 - Soil and Rock Stratigraphy Profiles	Page 29
Figure 3 - Site Photographs	
Figures 4 to 23 - Laboratory Test Results - Overburden	
Figures 24 to 30 - Rock Core Photographs	
Figures 31 to 32 - Laboratory Test Results - Bedrock	

INTRODUCTION

H. Q. Golder & Associates Ltd. has been retained by the Consulting Engineers for the Macdonald-Cartier Bridge to carry out a site investigation for the proposed Macdonald-Cartier Bridge between Ottawa, Ontario and Hull, Quebec.

The purpose of the investigation was to determine and interpret the soil and rock conditions at the site in relation to preliminary foundation design for the proposed structure.

This report covers in detail the factual information obtained on the soil and rock conditions from the site investigation.

PROCEDURE

The field work for the investigation which consisted of borings over water and on land was carried out during the period August 1st, 1961 to September 28th, 1961 inclusive. The land work followed the overwater work which was completed on September 8th, 1961.

For the river work a standard machine drillrig mounted on a steel barge about 40 feet long and 25 feet wide and equipped with power operated spuds 60 feet in length was used. A photograph showing the marine drilling equipment is given on Figure 3.

A total of sixteen sampled boreholes, numbered 1 to 16, with accompanying dynamic penetration tests were put down in the river. The dynamic penetration tests were only carried out at the borehole locations where overburden was present at river bottom. In addition seven further dynamic penetration tests, numbered 17 to 23, were attempted between the boring locations to determine the elevation of bedrock surface. Two of these penetration tests, Nos. 18 and 23, were not carried out as the spuds of the barge did not obtain a proper anchorage on river bottom at these locations.

The boreholes in the river were put down in 4 inch size through the overburden and the bedrock was core drilled in BXT size (approx. $1\frac{1}{2}$ inches diameter) in each borehole. In general, the bedrock was cored for a minimum distance of about 40 feet.

After completion of the river borings a total of six sampled boreholes with adjacent dynamic penetration tests were put down on land. Three of the boreholes, numbered 24 to 26, were located on the Hull side of the river and the remaining three, numbered 27 to 29, on the Ottawa side of the river. The land boreholes were put down using both standard machine drill-rig and continuous flight auger boring equipment. Samples of the overburden were taken at about 5 foot intervals of depth and the bedrock was core drilled in each borehole in BXT size for distances of from 20 to 140 feet.

Porous pot piezometers were installed at various elevations in the bedrock in four river boreholes (Nos. 13, 14, 15 and 16) after their completion, for ground water level observations. The plastic tubing connection to the piezometer was encased with 3/4 inch black steel protective pipe and fixed to a float at river water level. Following completion of each land borehole a piezometer was similarly installed in the bedrock and in some cases in the overburden for ground water level observation.

The locations of all the borings put down in this investigation are shown on Figure 1. Sections of the inferred soil and rock stratigraphy are given on Figure 2. A detailed log for each boring is given on the Records of Boreholes.

The samples obtained during the investigation were dispatched to our laboratory for examination and testing. Representative samples of those remaining after testing will be stored until February 1st, 1962 at which time they will be disposed of in accordance with your instructions.

The results of the laboratory testing are plotted on the Records of Boreholes and on the figures.

The elevations given in the report are referred to Geodetic datum. All the survey work connected with the investigation was carried out by the Consulting Engineers.

GENERAL SITE DESCRIPTION

The site of the proposed Macdonald-Cartier Bridge on the Ottawa River is situated approximately 2,000 feet downstream or north of the existing Alexandra or Interprovincial Bridge between Hull, Quebec and Ottawa, Ontario. The width of the Ottawa River at the proposed crossing is about 1,900 feet.

West of the relatively flat area around Sussex Street in Ottawa the ground surface drops about 40 feet over nearly vertical limestone bluffs to the narrow floodplain of the Ottawa River. From here the rock surface plunges steeply for about 60 feet to the deep channel which lies close to the Ottawa bank of the river. West of the main channel the river bed rises gently toward the Hull side and forms a swampy area near the west shore. The river bank on the Hull side is composed mainly of overburden and rises 20 to 40 feet in a moderate slope above the narrow western floodplain.

The depth of water in the main channel near the Ottawa bank of the river is about 50 feet. At the centre of the river the water depth is about 30 feet and gradually decreases towards the Hull side of the river.

Photographs of the site are shown on Figure 3.

PHYSIOGRAPHY AND GENERAL GEOLOGY

The city of Ottawa occupies a small plateau within the St. Lawrence Lowlands physiographic province. This plateau, which rises to nearly 300 feet above sea level at Parliament Hill, is bounded on the north and west by the steep bluffs which form the banks of the Ottawa River. The Ottawa River, at an altitude of about 130 feet above sea level is the lowest part of the lowlands in the Ottawa region. The lowlands are bordered on the north by the Canadian Shield, an upland area seen across the river from Ottawa.

The area is drained by Ottawa River and its tributaries. The Ottawa River flows in a general easterly direction in the vicinity of Ottawa but at the site flows in a northerly direction. At Chaudiere Falls, approximately 6,000 feet upstream from the bridge site, it drops 25 to 30 feet over flat-lying limestone in a series of rapids and cataracts. Below the existing Interprovincial bridge the river gradient is low. The Gatineau River enters the Ottawa River through a broad valley about 6,000 feet downstream from the proposed bridge site, and the Rideau River plunges over a 50 foot cliff to join the Ottawa River about 2,500 feet downstream from the site.

The Macdonald-Cartier bridge site is underlain by limestone of Ordovician age. This bedrock is overlain, in most places, by a thin veneer of Pleistocene till. Overlying the till or resting directly on bedrock are relatively thin deposits of marine clay, silt, and sand. Recent deposits of sawdust and

fluvial sediments up to 30 feet thick occur in the bed of the Ottawa River.

GLACIAL GEOLOGY

Continental glaciers covered the Ottawa region several times during the Pleistocene epoch. The deposits of the early ice sheets were removed or covered by the final glacial advance, hence only the work of the last of the glaciers, the Wisconsin, is recognized. The pre-glacial topography was probably not very different from the topography of today. The glaciers generally followed pre-existing valleys, excavating them deeper in places, filling them with deposits in other places. A thin veneer of till, varying from a few inches to several feet in thickness, was deposited at the base of the glacier as ground moraine. This till covers the bedrock in most places within the Ottawa region. It is exposed at the surface on the Ottawa side of the river but in the river bed and on the Hull side the till is covered by marine and recent deposits. The till varies considerably in composition and reflects the material over-ridden by the last ice advance; where the material under the ice was bedrock, the till is generally a bouldery silt and clay; where the material was clay, silt, or sand the till is composed mainly of material of these particle sizes.

The Ottawa region was depressed several hundred feet by the weight of the Wisconsin glacier, consequently when the ice melted back from the area, which was below sea level at this

time, an arm of the ocean, known as the Champlain Sea, invaded the land. Thick deposits of sand, silt, and clay were deposited in this marine environment. At the site these marine sediments occur only on the Hull side of the Ottawa River where they reach a maximum thickness of about 30 feet near Laurier Boulevard in Hull. The sediments resemble varved clay in composition but lack the characteristic banding of varves. Horizontal stratification is present but not pronounced, hence the separation into distinct clay layers and silt layers is absent. The marine sediments are best described as a uniform silty clay, usually oxidized to a brown colour in the upper part, and grey in the lower part. Sand layers, silt layers, and fossil shells are common in some zones of the marine sediments.

Recent uplift of the land brought an end to the Champlain Sea and began the dissection of the glacial and marine deposits by subaerial agents. Dissection of bedrock during recent times has been negligible. An exception to this may occur in the deep channel of the Ottawa River which could have resulted from stream erosion at the base of the Chaudiere Falls when the falls were further downstream. However, it is more likely that the channel is the result of overdeepening by glacial scour.

SOIL CONDITIONS

The main soil strata encountered by the borings put down at the site are as follows:

Woodchips and Sawdust Fill

A layer of woodchips and sawdust was encountered at river bottom in most of the boreholes and penetration tests put down in the center of the river and towards the Hull shore. The layer varies from about 1 foot in thickness at dynamic penetration test 20 and borehole 14 to as much as 30 feet in thickness at borehole 10, and is generally about 5 to 10 feet thick. The layer is essentially comprised of grey to brown woodchips and coarse sawdust in varying proportions with occasional logs. This material is fill obtained from the pulpwood operations located upstream of the existing Interprovincial Bridge. In borehole 3, 5, 8, 9 and 15 the woodchips and sawdust layer contains a trace of organic silt and silty fine sand.

Standard and dynamic penetration tests carried out in the layer gave generally manual push resistance values. Several standard penetration or 'N' values of up to 9 blows per foot were obtained. Based on the penetration test results the woodchips and sawdust layer is estimated to be very loose.

An estimated average submerged unit weight of 10 pounds per cubic foot may be used for design.

Organic Silt

A layer of organic silt was encountered at river bottom in boreholes 1, 2 and 16 put down near the Hull shore.

The thickness of the layer is about 6 to 7 feet at boreholes 1 and 16 and about 15 feet at borehole 2. The layer is essentially comprised of dark grey to dark brown sandy silt with decomposed organic matter and contains some wood-chips and sawdust throughout. In borehole 2, the layer is predominantly a silty sand.

Two grain size distribution curves on typical samples from the layer are shown on Figure 4.

Three natural water content determinations on samples from the layer gave values of 24, 53 and 363 percent, this last high value indicating the presence of organic matter.

Two organic content determinations gave values of 6 and 33 percent, respectively, by dry weight.

Standard and dynamic penetration tests carried out in the layer gave resistance values of manual push throughout, indicating that the organic silt is very loose.

For design an estimated submerged unit weight and angle of internal friction of 35 pounds per cubic foot and 15 degrees, respectively, may be used.

Granular Fill

At ground surface in boreholes 28 and 29 on the Ottawa bank of the river and in boreholes 24, 25 and 26 on the Hull side of the river, a layer of granular fill was

encountered. The fill which rests on bedrock in boreholes 28 and 29 is about 1 and 2 feet thick, respectively, and is comprised mainly of dark brown silty sand. On the Hull side the fill, which overlies a marine clay stratum, is about 5 feet thick at boreholes 24 and 26 and about 16 feet thick at borehole 25. At borehole 24, located on the bank of the river, the fill consists mainly of brown silty sand with a trace of gravel. In boreholes 25 and 26 the fill is comprised of a generally heterogeneous mixture of particle sizes ranging from silt to boulders. The limestone and granitic boulders in the layer are up to about 4 feet in size.

Three grain size distribution curves on typical samples from the layer obtained using $1\frac{1}{2}$ inch diameter sampling equipment are shown on Figure 5.

Three natural water content determinations gave values of 1, 7 and 9 percent.

Two organic content determinations on samples from the fill gave values of 5 and 7 percent, by dry weight.

Standard penetration tests carried out in the fill gave representative 'N' values ranging from about 10 to 22 blows per foot. One value of 90 blows per foot and two values greater than 100 blows per foot were obtained in borehole 25 where boulders are predominant. Based on these results together with the dynamic penetration test results, it is estimated that the fill varies from loose to very dense and is generally compact.

For design an estimated average total unit weight and angle of internal friction of 110 pounds per cubic foot and 30 degrees, respectively, may be used.

Silty Clay

Underlying the surface cover of granular fill in boreholes 24, 25 and 26 on the Hull side of the river is a stratum of marine clay, ranging from 30 to 35 feet in thickness. The surface of the clay was encountered at about elevation 163 in boreholes 24 and 26 and at about elevation 167 in borehole 25. The base of the stratum, which rests on glacial till, is at about elevation 131 in all three boreholes. The colour of the clay is generally grey, but the upper portion of the stratum has been desiccated and weathered to a mottled brown and grey in about the upper 8 and 15 feet in boreholes 26 and 24, respectively. In borehole 25, the zone of weathering extends to a depth of approximately 4 feet from the surface of the stratum, but the colour of the clay is generally grey throughout.

The clay is relatively homogeneous in structure and composition but in a few samples is stratified with alternating layers of silty clay and clayey silt which are inclined up to about 20 degrees from the horizontal. The clay contains occasional thin layers of silt and sand and concentrations of shells. Traces of black organic material and rust coloured small pockets of fine sand are also present

within the clay. In about the lower 3 feet in boreholes 25 and 26, the stratum grades into essentially a clayey silt to silt. The stratum in about the upper 20 feet has a fissured structure.

Nine typical grain size distribution curves on samples from the stratum are shown on Figures 6 and 7. These show that the clay size material generally predominates with some silt and fine to medium sand. Near the base of the stratum, as shown by the grain size curve for borehole 25 sample 16, the material is essentially silt.

Atterberg limit determinations were carried out on samples from the stratum and these results together with the results of natural water content determinations are plotted on Figure 8. The liquid limit generally decreased from about 70 at elevation 165 to about 40 at elevation 150. Below elevation 150 the liquid limit ranged between about 40 and 50, except near the base of the stratum which is essentially a clayey silt where the liquid limit is about 25. The plasticity index above the lower clayey silt portion of the stratum at about elevation 135, ranged between about 20 and 35. The liquidity index, which is the ratio of natural water content minus the plastic limit to the plasticity index, ranged between about 0.1 to 0.4 in the upper desiccated crust and between about 0.8 and 1.2 with depth. A plot of the liquidity index values versus elevation is also shown on Figure 8.

The Atterberg limit test results for the stratum are also plotted on the plasticity chart in Figure 9. Based on the plasticity chart classification the stratum, with the exception of the lower clayey silt portion, is an inorganic silty clay of medium to high plasticity.

The activity of the silty clay, which is the ratio of the plasticity index to the clay fraction, ranges from about 0.5 to 0.7 with an average value of about 0.6. This is in the inactive zone for clays.

Twelve unit weight determinations on samples of the silty clay gave an average value of 110 pounds per cubic foot, with an average of about 114 for the upper crust and an average of about 108 for the lower portion of the stratum.

By visual examination the clay was judged to be of medium sensitivity but no field measurements of sensitivity were carried out.

Undrained triaxial compression tests were carried out on samples of the silty clay. The results of these tests are plotted on the Records of Boreholes and on Figure 10. Typical stress strain curves for the triaxial tests are shown on Figure 11. The shear strength results obtained, as shown on Figure 10, vary from about 4,500 pounds in the upper crust to as low as 750 pounds per square foot above elevation 145. Below this elevation the shear strength obtained is in the vicinity of 1,250 pounds per square foot. The sensitivity of

the silty clay below the crust leads to unavoidable disturbance during sampling by normal methods and accounts for the low shear strength obtained in borehole 25 near the surface of the stratum where no desiccation has taken place. Reference to the shear strength data plotted on the Records of Boreholes shows that in general these low strengths were obtained at relatively high failure strains which is indicative of sample disturbance. The suggested shear strength profile for design shown on Figure 10 is therefore partly based on previous strength information on the marine clay in the Ottawa area where samples of the clay were obtained using highly specialized sampling equipment which reduces disturbance to a minimum.

Eight consolidation tests were carried out on samples of this clay and the resulting log pressure-void ratio curves are presented on Figures 12 to 19 inclusive. As in the case of the strength tests it is evident that the sensitivity of the clay and subsequent sample disturbance has affected the results. However, a slight overconsolidation is indicated by the curves and the most probable preconsolidation pressure has been computed by means of the Casagrande construction and is plotted on Figure 20. Also shown on this figure is a range of preconsolidation pressures for the marine clay in the Ottawa area reported by Crawford (1961) plotted against elevation. The range of values shown is not so much representative of the possible variation in preconsolidation pressure

at a particular elevation as it is indicative of the difficulty of measuring the preconsolidation load in the laboratory on the sensitive marine clay. From the results obtained in this investigation and disregarding values from tests on obviously relatively disturbed samples, it would appear reasonable to accept the upper limit of the range of preconsolidation pressure on Figure 20 for design purposes.

The consolidation parameters obtained from the log pressure-void ratio curves are shown on Figure 21. The initial void ratio (e_0), compression index (C_c) and recompression index (C_{cr}) for each consolidation sample has been plotted against the liquidity index. The resulting curves give a relatively good correlation. The compression index is a measure of the slope of the straight line portion of the log pressure-void ratio curve and the recompression index is a measure of the slope of the rebound and reload cycle of the curve when the pressure is reduced to 1/4 ton per square foot.

Silty Sand and Gravel

Underlying the silty clay in boreholes 24, 25 and 26 and the organic silt or woodchips and sawdust fill in boreholes 1, 5, 8, 14 and 16 near the Hull shore of the river, a stratum of grey silty sand and gravel was encountered. The stratum ranges from about 2 feet in thickness at borehole 25 to about 14 feet thickness at borehole 8 and has an average thickness of about 7 feet. The texture, colour and relative

density of the material is typical of the basal till sheet overlying the bedrock in the Ottawa area. Examination of soil samples obtained from the stratum supplemented by laboratory grain size analyses shows the material to be essentially well graded, the particles sizes ranging from clay to gravel. The stratum contains cobbles and boulders although these were not obtained in the soil sampler due to its limited size ($1\frac{1}{2}$ inches I.D.). In general, the matrix of the stratum is comprised of up to about 10 percent clay, 10 to 20 percent silt, 30 to 45 percent sand and 60 to 25 percent gravel. The predominance of sand and gravel sizes allows classification as a sandy till sensibly non-plastic. The individual sand and gravel particles are generally sub-angular in shape.

Nine typical grain size distribution curves on samples from the stratum are shown on Figures 22 and 23.

Nine natural water content determinations gave values ranging from about 5 to 11 percent with an average value of about 7 percent.

Standard penetration tests carried out in the stratum gave a general range of 'N' values from about 15 to 54 blows per foot with an average representative value of about 30 blows per foot. Three values of about 5 blows per foot were obtained near the surface of the stratum and one value of 90 blows per foot and two values greater than 100 blows per foot were also obtained in the stratum. Based on the 'N'

values together with the results of the dynamic penetration tests, the stratum ranges from loose near surface to very dense and is generally compact to dense.

For design a submerged unit weight and angle of internal friction of 70 pounds per cubic foot and 35 degrees, respectively, may be used.

Cobbles and Boulders

Beneath the glacial till in boreholes 1, 5, 8 and 14 near the Hull shore of the river and beneath the woodchips or at river bottom in boreholes 4, 7, 10 and 12 near the Ottawa shore, a layer of cobbles and boulders was encountered above the bedrock. The thickness of this layer varies from about 1 foot in borehole 12 to about 8 feet in boreholes 5 and 14. The layer is comprised mainly of limestone cobbles and boulders with the bedding planes horizontal from several inches to several feet in size. Occasionally, as in boreholes 5 and 14, the layer contains a few granitic and sandstone coarse gravel sizes. Several sand seams up to about 8 inches in thickness were encountered within the layer in boreholes 1 and 5.

The layer was penetrated by core drilling in BXT size. The core recovery obtained ranged from about 10 percent in borehole 7 to about 90 percent in borehole 1 and was generally about 50 percent.

Examination of the core obtained from this layer shows that the limestone fragments are of the same type as the underlying bedrock. This indicates that the cobbles and boulders in the layer could, at several borehole locations, be either the upper portion of bedrock which is broken and shattered or large tabular slabs of the underlying limestone which have been moved to their present locations by stream action. However, for engineering purposes, based on the behaviour of the drill during drilling operations and core recovery, the layer has been classified as cobbles and boulders.

BEDROCK CONDITIONS

Bedrock was encountered beneath the overburden or at river bottom and was core drilled in each borehole put down in this investigation. The local bedrock is composed of limestone, shaly limestone, and shale of the Cobourg member, the uppermost part of the Ottawa formation of Ordovician age. The rock encountered by drilling may be conveniently divided into three zones which are described separately below. Photographs of typical core samples from each zone are shown on Figure 24.

A Zone

This zone forms the upper portion of the bedrock over most of the bridge site. It is dominantly limestone, fine to medium grained in size and dark grey brown in colour as shown on the photographs in Figure 25. Black

shale occurs as thin partings and minor laminae throughout the limestone (See Figure 26). The individual shale beds do not generally exceed three inches in thickness. Zone A is characterized by a breccia or intra-formational conglomerate interspersed through the section (See Figure 27). The probable origin of this conglomerate was due to a stirring up of the sea floor prior to induration of the sediments, followed by redeposition of the fragments together with muds and calcium carbonate.

On the Ottawa side the A zone is at least 145 feet thick as shown by borehole 28 put down on Lady Gray Drive. At borehole 10 in the deepest part of the channel it is entirely missing, the result of erosion. It is also absent in borehole 26, but comprises the upper part of the bedrock in the remaining boreholes. In general zone A occurs above about elevation 50 on the Ottawa side of the river and above about elevation 120 on the Hull side of the river.

In the majority of boreholes put down, the rock core recovery in about the upper 5 feet of zone A ranged from approximately 25 to 95 percent. Below this upper portion, which was characterized by poor recovery and loss of water during drilling, the core recovery in the remainder of zone A was generally 100 percent and no loss of water was observed (loss of water would indicate open jointing, fissuring, or the like), except in borehole 4 where there was a complete loss of wash water throughout in zone A. Also during

drilling in borehole 28, wash water was observed to flow out along a crack in the bedrock at about elevation 150 on the Ottawa bank of the river.

A total of nine core samples from varying depths in the zone A portion of the bedrock was selected for strength testing. Each individual sample was at least 4 inches in length and represented a sound portion of the bedrock. The 1.6 inch diameter samples were trimmed to give approximately a 2 to 1 length to diameter ratio and tested to failure in compression. The results of the strength testing are given in Figure 31. From the nine compression tests, a failure stress ranging from 11,000 to 22,000 pounds per square inch with an average value of about 16,000 pounds per square inch was obtained. These test results indicate the ultimate vertical strength of the sound portion of the zone A bedrock.

B Zone

This zone underlies the A zone and is marked by a well defined lower contact usually ascertained during drilling by loss of water in most of the boreholes. The upper contact is gradational, and whereas in some drill cores the upper limit can be fixed with some certainty, in other cores it is arbitrary. The material is intermixed medium to fine grained, dark grey brown limestone and black shale. The shale makes up approximately 50 percent of this zone of the bedrock, which is about 10 feet thick, and does

not occur as discrete beds but as blobs or nodules in the limestone. This intermixing gives the rock a mottled appearance as shown on the photographs in Figure 28.

Boreholes 4, 28 and 29 were not put down deep enough to reach the B zone. Boreholes 12 and 27 both penetrated about 4 feet of the upper part of the B zone. In boreholes 10 and 26 the B zone is absent due to erosion, but was completely penetrated in the remaining boreholes.

The rock core recovery in the zone B portion of the bedrock was generally 100 percent throughout. Where recovery of less than this was obtained, the lower recovery may be attributed to dry blocking at the end of a coring run. This results in some mechanical shattering of the shale nodules in the limestone at the base of each coring run and thus complete core recovery is not obtained. No loss of water was observed while drilling through zone B but, in general the drilling water was lost completely at the base of zone B.

A total of two strength tests was carried out on representative core samples of the zone B portion of the bedrock. A third test was planned but the rock core broke during saw trimming operations. The results of the compression tests are given on Figure 32. Ultimate compressive strengths of 7,600 and 9,500 pounds per square inch, respectively, were obtained from the tests.

C Zone

This zone is defined as that which underlies the B zone. The upper contact is well marked as noted above. The lower contact is not described as no borehole was carried down deep enough to indicate any recognizable change in lithology. The rock is a medium to coarse grained crystalline limestone, dark grey brown in colour and well stratified. Photographs of typical cores from this zone are given in Figure 29. Thin partings of black shale (Figures 29(b) and 30) and beds of intra-formational conglomerate are also present. This zone of the bedrock is somewhat similar to the A zone except that it contains less shale and conglomerate and thicker limestone beds.

The C zone forms the uppermost bedrock in boreholes 10 and 26. It was not reached in boreholes 4, 12, 27, 28 and 29. In the remainder of the boreholes it underlies the B zone and was penetrated for a maximum distance of 43 feet in borehole 10.

The rock core recovery in the zone C portion of the bedrock was generally 100 percent throughout. The water return during drilling in boreholes 11 and 13 was generally poor throughout the zone. In boreholes 10 and 26 there was a complete water loss in a crack within the bedrock. The water return in the remainder of the holes was generally good.

Seven compression tests were carried out on representative core samples from the zone C portion of the bedrock.

GOLDER & ASSOCIATES

The results of the testing are presented on Figure 32. The compressive strengths obtained ranged from 12,400 to 18,000 pounds per square inch with an average value of about 15,000 pounds per square inch.

Bedrock Structure

The Ottawa area is marked by several major east-west faults which have resulted in a down-dropped block, called a graben, on which most of the City of Ottawa is located. The recognized faults responsible for the graben lie at some distance from the bridge site and no faults have been outlined for the immediate area surrounding the bridge site. The faults are considered to be ancient and all are older than the Pleistocene period. Examination of the rock core obtained from the borings does not indicate the presence of any faulting of recent origin.

The limestones of the A zone outcropping on the east bank of the Ottawa River appear to be horizontal. The base of the B zone, however, is tilted down towards the north-east. From calculations of strike and dip of this lower contact the average strike is about N15°W and the average dip is about 4 percent to the ENE. The elevation of the base of zone B is about 45 at the Ottawa bank of the river and about 110 at the Hull bank of the river along the line of the proposed crossing.

Examination of the core obtained shows that the rock is marked by vertical and inclined fractures in many cores.

These fractures are most common in the C zone and upper portion of the A zone and occur only rarely in the remainder of the A zone and in the B zone. The fractures have in most cases been healed by calcite as shown in the photographs on Figures 26(a) and 30(b). In a few cases, particularly in zone C, the fractures are not healed and are open.

Because of the excellent cleavage of the calcite, some cores during drilling have broken along the healed fractures. Where these healed fractures are not present, horizontal breakage of the drill cores has generally taken place due to the drilling operations causing shear between limestone and shale bands. While the horizontal stratification has generally resulted in broken cores in the boxes, this may not represent the condition of the bedrock in-situ as the lenticular nature of the shale partings and laminae would prohibit horizontal weakness from extending any great distance. In general the strength of the mass bedrock would be greater in the vertical direction than in the horizontal direction due to the horizontal bedding of the bedrock.

Based on the rock core recovery and compression test results the zone C portion of the bedrock is generally sound but contains healed and in some cases open fractures. The bedrock in zone B is generally sound throughout and contains only occasional fractures which are well healed.

In the upper portion of zone A, the bedrock up to a depth of 22 feet from surface in borehole 4 and about 2 to 10 feet in the majority of the other boreholes is characterized by open fractures and poor rock core recovery. Below this partially fractured upper portion, the bedrock in the lower portion of zone A is generally sound but contains some healed fractures.

At borehole 4, which was put down on the steep rock slope forming the east bank of the Ottawa River, a few sand seams up to 6 inches in thickness were found in the upper portion of zone A to a depth of 18 feet from rock surface. In this same borehole, between an 18 and 22 foot depth from surface, a portion of the bedrock kept sliding into the borehole. This eventually resulted in complete blocking of the borehole which could not be completed.

Based on observation of water return during drilling, the zone B portion of the bedrock is relatively impervious. Because of the presence of fractures the bedrock in the A and C zones is not impervious throughout.

WATER CONDITIONS

The river water level at the site during the period of the investigation generally ranged between about elevation 130 and 132 during the week days. A feature of the normal river flow is the weekend fall of about 1 to 2 feet in the river level caused by control for water storage.

During drilling in borehole 1 put down in the river near the Hull shore, artesian water was encountered in the C zone of the bedrock. The water level rose in the casing 4.5 feet above river water level. To check on the lateral extent of the artesian condition, borehole 16 was put down in the proximity of borehole 1. Artesian water was also encountered in this borehole at about the same elevation as in borehole 1. The water level in the casing rose 2 feet above river level. A piezometer was installed in the borehole at the depth where the artesian condition was noticed. Readings taken in this piezometer over a period of about two months show that the water level in the zone C portion of the bedrock at borehole 16 varied between about elevation 134 and 135. Over the period of the readings this corresponded to a variation of from 3 to 6 feet above river water level, which fluctuates. There is no apparent relationship between the artesian pressure and river water level.

To determine the water conditions in the bedrock across the river a further 3 piezometers were installed at boreholes 13, 14 and 15. The piezometer in borehole 13 was installed in the C zone, in borehole 15 near the base of the A zone and in borehole 14 at the contact between the B and C zone of the bedrock. Periodic readings taken in these piezometers over a period of about 1 month show that the water level in the bedrock fluctuates with the river water level. These readings indicate that, except for the artesian water conditions at boreholes 1 and 16, the water in the bedrock is apparently in communication with the river water through cracks and fractures in the bedrock.

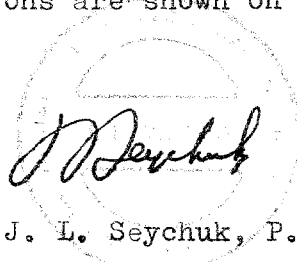
A piezometer was installed in five of the boreholes put down on land. In the three boreholes on the Ottawa side of the river, the piezometers were placed in the bedrock. At boreholes 24 and 26 on the Hull side the piezometers were placed in the bedrock and the glacial till overlying the bedrock, respectively. In borehole 25, the casing used for drilling was left seated several feet in the bedrock.

Readings taken in these piezometers over a period of about a month show that the water level in the bedrock at boreholes 27 and 28 on the Ottawa Bank is at river level. In borehole 29 the water level is at about elevation 185. It is considered that the water level in this borehole is affected by the drilling wash water, which because of the sound condition of the bedrock is not readily able to dissipate. At boreholes 24 and 26, the stabilized piezometric water level is at about elevation 136 which is above the base of the silty clay overlying the glacial till. The stabilized water level in borehole 25 is at about elevation 160.

The depth of installation for each piezometer together with the stabilized water conditions are shown on the Records of Boreholes.

JLS/jb
6135

December, 1961



J. L. Seychuk
J. L. Seychuk, P. Eng.

V. Milligan
V. Milligan, P. Eng.

REFERENCES

- Johnston, W.A. (1915), "Pleistocene and Recent Deposits in the Vicinity of Ottawa with a Description of the Soils", Geological Survey of Canada, Memoir 101.
- Wilson, A.E. (1946), "Geology of the Ottawa-St. Lawrence Lowland, Ontario and Quebec", Geological Survey of Canada, Memoir 241.
- Crawford, C.B. (1961,) "Engineering Studies of Leda Clay", Article in "Soils in Canada" edited by R.F. Legget, University of Toronto Press.

LIST OF STANDARD ABBREVIATIONS

The standard abbreviations commonly employed on each "Record of Borehole", on the figures, and in the text of the report are as follows:

SAMPLE TYPES

A.S. - Auger Sample	R.C. - Rock Core
C.S. - Chunk Sample	S.T. - Slotted Tube
D.O. - Drive Open	T.O. - Thin-walled, Open
D.S. - Denison Type Sample	T.P. - Thin-walled, Piston
F.S. - Foil Sample	W.S. - Wash Sample

PENETRATION RESISTANCES

Dynamic Penetration Resistance - The energy required to drive a 2 inch diameter, 60 degree cone attached to the end of the drilling rods into the ground: expressed in blows per foot, where each blow represents 4,200 inch-pounds of energy.

Standard Penetration Resistance, N - The number of blows by a 140 pound hammer dropped 30 inches required to drive a 2 inch drive open sampler one foot into the ground.

Sampler advanced by static weight	- weight, hammer	- Wh
Sampler advanced by pressure	- pressure, hydraulic	- Ph
Sampler advanced by pressure	- pressure, manual	- Pm

SOIL DESCRIPTION

The standard terminology for the descriptions of the relative density of cohesionless soils and the consistency of cohesive soils is as follows:

<u>Relative Density</u>	<u>N, Blows/ft.</u>	<u>Consistency</u>	<u>c, lb/sq. ft.</u>
Very Loose	0 to 4	Very Soft	Less than 250
Loose	4 to 10	Soft	250 to 500
Compact	10 to 30	Firm	500 to 1,000
Dense	30 to 50	Stiff	1,000 to 2,000
Very Dense	over 50	Very Stiff	2,000 to 4,000
		Hard	over 4,000

SOIL TESTS

C - Consolidation Test	Q - Undrained Triaxial
H - Hydrometer Analysis	Qc - Consolidated Undrained Triaxial
M - Sieve Analysis	S - Drained Triaxial
MH - Combined Analysis, Sieve and Hydrometer	U - Unconfined Compression
	V - Field Vane Test

Note: Undrained triaxial tests in which pore pressures are measured are shown as Q' or Q'c.

SOIL PROPERTIES

γ - Total Unit Weight	K - Coefficient of Permeability
γ_d - Dry Unit Weight	c - Undrained Shear Strength ($\frac{1}{2}$ Compressive Strength)
γ_b - Submerged Unit Weight	St - Sensitivity
L_L - Liquid Limit	ϕ' - Effective Angle of Shearing Resistance
P_L - Plastic Limit	c' - Effective Cohesion Intercept
W - Natural Water Content	Cc - Compression Index
G - Specific Gravity	Cv - Coefficient of Consolidation
e - Void Ratio	

3465-50

GEOCKES No.

RECORD OF BOREHOLE

LOCATION SEE FIGURE 1 BORING DATE AUG. 2-4, 1961 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{1}{2}$ BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _i PLASTIC LIMIT P _L P_L W L_L				LAB. TESTING	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FT						WATER CONTENT W				
							SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT, PER CENT				
						20	40	60	80	100	20	40	60	80		
132.7	RIVER LEVEL					140										
129.7	RIVER BOTTOM					130										
121.7	VERY LOOSE GREY - BROWN ORGANIC SILT WITH SOME SAND SAWDUST AND WOODCHIPS		1	PM	1											
111.0	COMPACT TO DENSE GREY SILTY SAND AND GRAVEL WITH COBBLES & BOULDERS		2	"	2											
114.6	GREY LIMESTONE COBBLES AND BOULDERS		3	"	3											
104.0	0.7' SILTY SAND SEAM		4	"	4											
95.5	ZONE "A"		5	"	5											
86.7	DARK GREY LIMESTONE BED ROCK		6	"	6											
76.0	ZONE "B" SOUND BELOW EL. 114		7	"	7											
66.7	ZONE "C"		8	"	8											
46.0	END OF HOLE		9	"	9											

VERTICAL SCALE
 1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.
 CHECKED JKS

3065-50

GEOCRES No.

RECORD OF BOREHOLE 2

LOCATION	SEE FIGURE 1	BORING DATE	AUG 4, 1961	DATUM	GEODETIC
BOREHOLE TYPE	WASH BORING	BOREHOLE DIAMETER	4" & 8X CASING		
SAMPLER HAMMER WEIGHT 140 LB.	DROP 30 INCHES	PEN. TEST HAMMER WEIGHT 140 LB.	DROP 30 INCHES		

[illegible]

3465-50
GEOGRAPHY

RECORD OF BOREHOLE 3

LOCATION SEE FIGURE 1 BORING DATE AUG. 8, 1961 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{1}{2}$ BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT L _L		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FOOT					PL	W	L
						20	40	60	80	100	WATER CONTENT W		
						SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT, PER CENT		
131.4	RIVER LEVEL				140								
90.0					130								
					120								
					110								
					100								
95.4	RIVER BOTTOM				90								
36.0			1	Pm									
	VERY LOOSE		2	Pm									
	GREY-BROWN		3	9									
	WOODCHIPS AND		4	3									
	COARSE SAWDUST												
	TRACE OF SILT												
83.9			5	BX									
47.5	ZONE "A"		6	1									
74.0													
57.4	ZONE "B"												
	SOUND												
65.6	DARK-GRAY												
65.8	LIMESTONE												
	BEDROCK												
	ZONE "C"												
43.4													
83.0	END OF HOLE												

WEIGHT OF RODS

END OF PEN. TEST @ EL 83.9
60 BLOWS FOR NO ADVANCE

WATER RETURN

COMPLETE WATER LOSS DURING
DRILLING AT EL. 67.0

PERCENT CORE RECOVERY

3465-50

RECORD OF BOREHOLE 4

LOCATION SEE FIGURE 1 BORING DATE AUG. 9-10, 1961 DATUM GEODETTIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 8X CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT				LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB./SQ.FT.				WATER CONTENT, PER CENT			
131.5 0.0	RIVER LEVEL				140								
125.7 5.8	RIVER BOTTOM				130								
118.5 13.0	GREY LIMESTONE COBBLES AND BOULDERS		1	PR	120	16							
			2			45							
108.8 22.7	2' SAND SEAM		3		110	61							
101.0 30.5	6" SAND SEAM		4			100							
	ZONE "A"		5		100	60							
	GREY LIMESTONE BEDROCK		6		90	100							
	SOUND BELOW EL. 97		7		80	100							
76.5 55.0	END OF BORE				70								

WATER RETURN

COMPLETE WATER LOSS DURING
DRILLING IN BEDROCK

PERCENT CORE RECOVERY

34 65-56

RECORD OF BOREHOLE 5

LOCATION SEE FIGURE 1

BORING DATE

AUG. 10-14, 1961

DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

4" $\frac{1}{2}$ BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT -----					LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W				LAB. TESTING	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FT.						WATER CONTENT, PER CENT				
							20	40	60	80	100	20	40	60		80
						SHEAR STRENGTH C , LB. / SQ. FT.										

PERCENT CORE RECOVERY

83
50
95
100
73
95
95
100
50
97
100
100

END OF PEN. TEST @ EL. 113.9
125 BLOWS FOR NO ADVANCE

WATER RETURN
COMPLETE WATER LOSS DURING DRILLING AT EL. 83.9

P_L W L_L

34 65-50

3465-50

RECORD OF BOREHOLE 7

LOCATION SEE FIGURE 1 BORING DATE AUG. 15-16, 1961 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W		
ELEV. / DEPTH	DESCRIPTION	STRAT. PL. T	NUMBER	TYPE		SHEAR STRENGTH C , LB./SQ.FT.					WATER CONTENT, PER CENT P_L W L_L		
130.7	RIVER LEVEL				130								
0.0					120								
					110								
					100								
					90								
83.7	RIVER BOTTOM				80								
47.0	BROKEN BLOCKS OF LIMESTONE OR BOULDER		1	BX RC	75								
79.7					70								
51.0			2	"	65								
	ZONE "A"		3	"	60								
	DARK GREY LIMESTONE BEDROCK		4	"	55								
	SOUND BELOW EL. 77		5	"	50								
57.5			6	"	45								
73.2	ZONE "B"		7	"	40								
47.5													
83.2	ZONE "C"												
38.7													
92.0	END OF HOLE												

WATER RETURN

COMPLETE WATER LOSS DURING
DRILLING AT EL. 47.5

PERCENT CORE RECOVERY

3465-50

RECORD OF BOREHOLE 8

LOCATION SEE FIGURE 1

BORING DATE AUG. 17-18, 1961

DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

4" E BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

[illegible]

3465-50

GEOCRES No.

RECORD OF BOREHOLE 9

LOCATION

SEE FIGURE 1

BORING DATE

AUG. 18-21, 1961

DATUM

GEODETIC

BOREHOLE TYPE

WATER SPRING

BOREHOLE DIAMETER

4" EX CASING

SAMPLER HAMMER WEIGHT 140 LB.

DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W				
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER TYPE		20	40	60	80	100	P_L W L_L				
				BLOWS / FT.	SHEAR STRENGTH C , LB./SQ.FT.					WATER CONTENT, PER CENT				
130.7	RIVER LEVEL													
100.0														
104.7	RIVER BOTTOM													
97.5	VERY LOOSE BROWN SAWDUST AND WOODCHIPS WITH SOME DARK BROWN ORGANIC SILT		I											
97.5														
83.2	ZONE "A"		II											
83.2														
42.2	ZONE "B"		III											
42.2	SOUND DARK GREY LIMESTONE BEDROCK													
78.2														
52.5	ZONE "C"		IV											
52.5														
67.5														
63.2	END OF HOLE													

MANUAL PUSH

END OF PEN. TEST @ EL. 97.5
REFUSAL

WATER RETURN

COMPLETE WATER LOSS DURING
DRILLING AT EL. 78.2

PERCENT CORE RECOVERY

98
90
100
100

3165-50

3165-50

3165-50

LOCATION	SEE FIGURE 1	BORING DATE	AUG 21-22, 1961	DATUM	GEODETIC
BOREHOLE TYPE	WASH BORING	BOREHOLE DIAMETER	4" $\frac{1}{8}$ BX CASING		
SAMPLER HAMMER WEIGHT 140 LB.	DROP 30 INCHES	PEN. TEST HAMMER WEIGHT 140 LB.	DROP 30 INCHES		

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT ----- 20 40 60 80 100			LIQUID LIMIT L _L PLASTIC LIMIT P _L P _L W L _L WATER CONTENT W		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.		SHEAR STRENGTH C, LB./SQ.FT.			WATER CONTENT, PER CENT		
						140						
130.8 0.0	RIVER LEVEL					130						
						120						
						110						
						100						
88.8	RIVER BOTTOM					90						
41.3	VERY LOOSE TO LOOSE BROWN FRESH WOODCHIPS AND COARSE SAWDUST WITH TRACE OF DARK BROWN BARK		1	DF Wh	WEIGHT OF RODS	80						
			2	" P _m								
			3	"								
			4	"								
			5	"								
			6	"								
			7	"								
58.8						70						
71.5	LIMESTONE BOULDER		8	DF		60						
73.0			9	"		50						
			10	"		40						
			11	"		30						
			12	"		20						
			13	"		10						
			14	"		0						
			15	"								
			16	"								
			17	"								
			18	"								
			19	"								
			20	"								
			21	"								
			22	"								
			23	"								
			24	"								
			25	"								
			26	"								
			27	"								
			28	"								
			29	"								
			30	"								
			31	"								
			32	"								
			33	"								
			34	"								
			35	"								
			36	"								
			37	"								
			38	"								
			39	"								
			40	"								
			41	"								
			42	"								
			43	"								
			44	"								
			45	"								
			46	"								
			47	"								
			48	"								
			49	"								
			50	"								
			51	"								
			52	"								
			53	"								
			54	"								
			55	"								
			56	"								
			57	"								
			58	"								
			59	"								
			60	"								
			61	"								
			62	"								
			63	"								
			64	"								
			65	"								
			66	"								
			67	"								
			68	"								
			69	"								
			70	"								
			71	"								
			72	"								
			73	"								
			74	"								
			75	"								
			76	"								
			77	"								
			78	"								
			79	"								
			80	"								
			81	"								
			82	"								
			83	"								
			84	"								
			85	"								
			86	"								
			87	"								
			88	"								
			89	"								
			90	"								
			91	"								
			92	"								
			93	"								
			94	"								
			95	"								
			96	"								
			97	"								
			98	"								
			99	"								
			100	"								
			101	"								
			102	"								
			103	"								
			104	"								
			105	"								
			106	"								
			107	"								
			108	"								
			109	"								
			110	"								
			111	"								
			112	"								
			113	"								
			114	"								
			115	"								
			116	"								
			117	"								
			118	"								
			119	"								
			120	"								
			121	"								
			122	"								
			123	"								
			124	"								
			125	"								
			126	"								
			127	"								
			128	"								
			129	"								
			130	"								
			131	"								
			132	"								
			133	"								
			134	"								
			135	"								
			136	"								
			137	"								
			138	"								
			139	"								
			140	"								
			141	"								
			142	"								
			143	"								
			144	"								
			145	"								
			146	"								
			147	"								
			148	"								
			149	"								
			150	"								
			151	"								
			152	"								
			153	"								
			154	"								
			155	"								
			156	"								
			157	"								
			158	"								
			159	"								
			160	"								
			161	"								
			162	"								
			163	"								
			164	"								
			165	"								
			166	"								
			167	"								
			168	"								
			169	"								
			170	"								
			171	"								
			172	"								
			173	"								
			174	"								
			175	"								
			176	"								
			177	"								
			178	"								
			179	"								
			180	"								
			181	"								
			182	"								
			183	"								
			184	"								
			185	"								
			186	"								
			187	"								
			188	"								
			189	"								
			190	"								
			191	"								
			192	"								

ELEV. DEPTH	DESCRIPTION	STRAT. PLC	NUMBER	TYPE	BLOWS / F	ELEVATION	SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT W			
						140									
130.8	RIVER LEVEL					130									
0.0						120									
						110									
						100									
88.8	RIVER BOTTOM					90									
41.5			1	2" DF Wh		80									
			2	" Pm											
	VERY LOOSE TO LOOSE BROWN FRESH WOODCHIPS AND COARSE SAWDUST WITH TRACE OF DARK BROWN BARK		3	"											
			4	2" DF		70									
			5	2" DF											
			6	"											
58.8			7	2" DF		60									
71.5	LIMESTONE BOULDER		8	2" DF											
73.0			9	"											
			10	"											
			11	"											
	DARK GREY ZONE 'C' LIMESTONE BEDROCK SOUND BELOW EL. 55		12	"											
			13	"											
11.5	END OF HOLE														

WEIGHT OF RODS

END OF PEN TEST @ EL. 58.8
125 BLOWS FOR NO ADVANCE

WATER RETURN
COMPLETE WATER LOSS DURING DRILLING AT EL. 36.3

PERCENT CORE RECOVERY

31
3065-50

RECORD OF BOREHOLE 11

SEE FIGURE 1

AUG. 23 - 24 1961

DATUM

GEODETIC

WASH BORING

BOREHOLE DIAMETER

4" E BX CASING

DROP 30 INCHES

PEN. TEST HAMMER WEIGHT

LB. DROP

INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB. / SQ. FT.		WATER CONTENT, PER CENT	
130.8 0.0	RIVER LEVEL				130				
80.3 50.5	RIVER BOTTOM				120				
	ZONE "A"		1	PX RC	110				
59.8 71.0	SOUND DARK GREY LIMESTONE BEDROCK		2		100				
	ZONE "B"		3		90				
50.2 80.6	ZONE "C"		4		80				
40.3 90.5	END OF HOLE				70				

31
3a 65-50

RECORD OF BOREHOLE LOG

LOCATION SEE FIGURE 1 BORING DATE AUG 24-25, 1961 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" $\frac{1}{2}$ BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT				LIQUID LIMIT LL PLASTIC LIMIT PL $\frac{PL}{W}$ LL WATER CONTENT W WATER CONTENT, PER CENT			
ELEVATION DEPTH	DESCRIPTION	STRAT PLOT	NUMBER TYPE		SHEAR STRENGTH C , LB/SQ.FT.							
130.7	RIVER LEVEL		1	130								
0.0				120								
				110								
99.2	RIVER BOTTOM			100								
51.5	LIMESTONE BOULDER		1	75					WATER RETURN			
32.5			IV	100					FAIR WATER RETURN DURING DRILLING IN BEDROCK BELOW EL. 98.2			
			III	90								
			III	80								
			4	70								
			5	60								
			6	50								
53.0												
77.7	ZONE "B"											
48.0												
32.5												

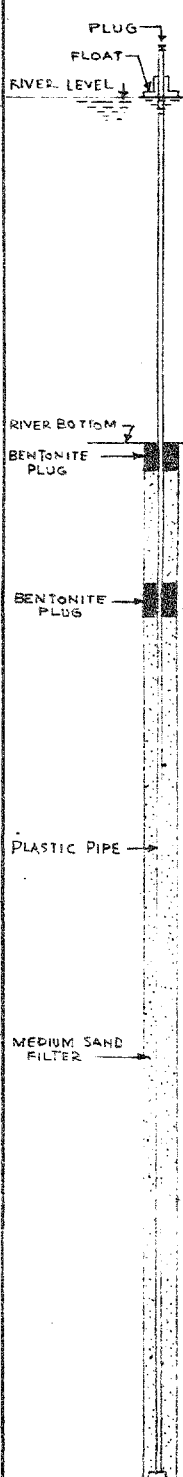
PERCENT CORE RECOVERY

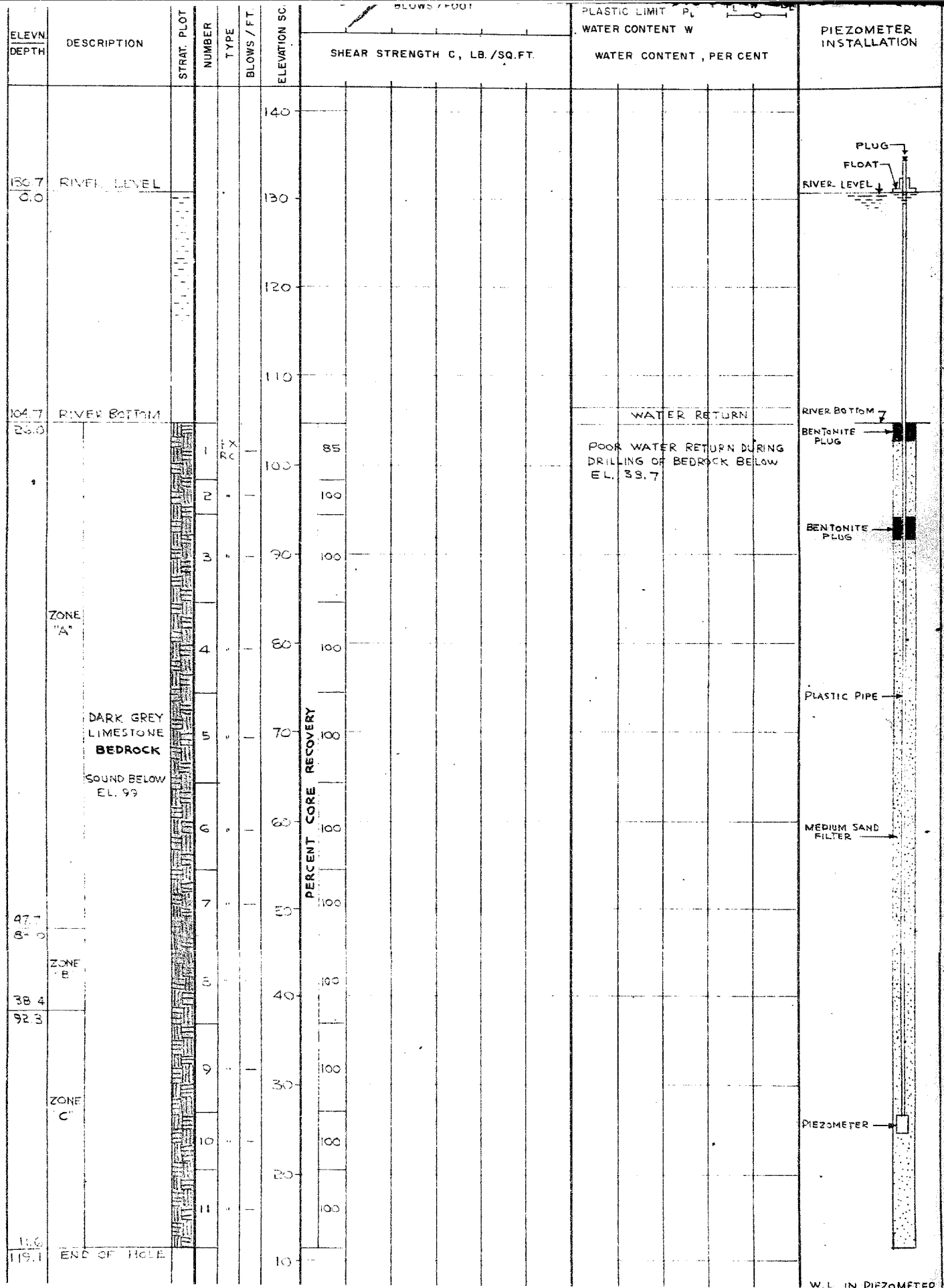
ZONE "A"
 SOUND DARK GREY
 LIMESTONE
 BEDROCK

34 65-50

GEOCRES No.

LOCATION	SEE FIGURE	BORING DATE	AUG 25 - 29 1961	DATUM	GEODETIC
BOREHOLE TYPE		WATER BORING	BOREHOLE DIAMETER		4 1/2 BX CASING
SAMPLER HAMMER WEIGHT	LB.	DROP - INCHES	PEN. TEST HAMMER WEIGHT	LB.	DROP - INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT LL PLASTIC LIMIT PL WATER CONTENT W		PIEZOMETER INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB./SQ.FT.		WATER CONTENT, PER CENT		
156.7 0.0	RIVER LEVEL				120					
104.7 52.0	RIVER BOTTOM				130					
					120					
					110					
					100	85				
			1	BOX	100	100				
			2		90	100				
			3		80	100				
	ZONE "A"		4		70	100				
	DARK GREY LIMESTONE BEDROCK		5		60	100				
	SOUND BELOW EL. 99		6		50	100				
			7		40	100				
			8		30	100				
	ZONE "B"		9		20	100				
47.4 109.3			10		10	100				
39.4 120.3			11		0	100				
	ZONE "C"		12		0	100				



3165-50

RECORD OF BOREHOLE 14

568 F. J. Beckwith

ASG. 31 - SEPT. 1 1961 DATUM

GEODETIC

W. H. R. S.

BOREHOLE DIAMETER

4" @ BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

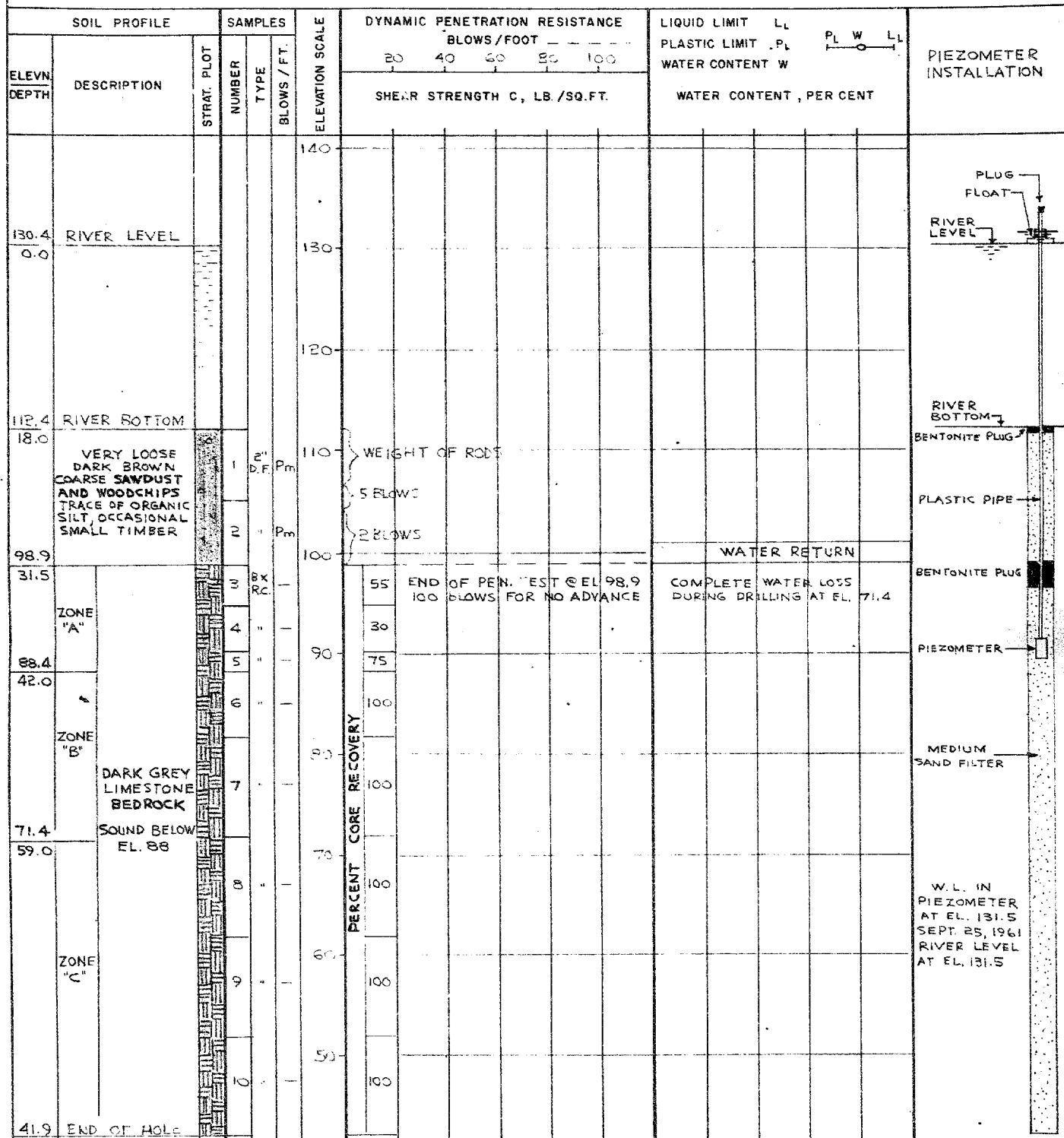
PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

[illegible]

3165-50

RECORD OF BOREHOLE 15

LOCATION SEE FIGURE 1 BORING DATE SEPT 5-6, 1961 DATUM GEODETIC
BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 4" 8 BX CASING
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED JWS

31 65-50

31 65-50

31 65-50

RECORD OF BOREHOLE 16

LOCATION SEE FIGURE 1

BORING DATE SEPT. 6-7, 1961

DATUM

GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

4" & Bx CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT --- LB. DROP --- INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT		LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W		LAB. TESTING	PIEZOMETER INSTALLATION
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH C, LB./SQ.FT.		WATER CONTENT, PER CENT			
								20 40 60 80			
131.0	RIVER LEVEL				140						
0.0					130						
127.0	RIVER BOTTOM										
4.0	VERY LOOSE DARK GREY-GREEN ORGANIC SILT, TRACE OF COARSE SAWDUST AT SURFACE		1	D.O.	P _m						
121.2											
9.8	DENSE TO VERY DENSE GREY SILTY SAND & GRAVEL, V. H. COBBLES AND BOULDERS		2	P _m							
114.0			3	P _m							
17.0			4	P _m							
	ZONE "A"		5	P _m							
102.5			6	P _m							
28.5	ZONE "B"		7	P _m							
	DARK GREY LIMESTONE BEDROCK SOUND BELOW EL. 111		8	P _m							
92.8			9	P _m							
58.2			10	P _m							
	ZONE "C"		11	P _m							
76.0			12	P _m							
55.0	END OF HOLE		13	P _m							
		</									

31 25-50

RECORD OF BOREHOLE 17

LOCATION SEE FIGURE 1

BORING DATE

SEPT. 8, 1961

DATUM

GEODETIC

BOREHOLE TYPE

PENETRATION TEST

BOREHOLE DIAMETER

SAMPLER HAMMER WEIGHT — LB. DROP — INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT L _L			WATER CONTENT, PER CENT
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.		BLOWS / FOOT					PLASTIC LIMIT P _L			
							20	40	60	80	100	WATER CONTENT W			
SHEAR STRENGTH C, LB. / SQ. FT.							WATER CONTENT, PER CENT								
						140									
130.7 0.0	RIVER LEVEL					130									
						120									
						110									
98.9 31.8	RIVER BOTTOM					100									
92.9 37.8	PROBABLY VERY LOOSE SAWDUST AND WOODCHIPS														
	END OF PEN TEST PROBABLY BEDROCK														
						90									
						80									

WEIGHT OF RODS
4 BLOWS

50 BLOWS FOR NO ADVANCE

34 G-5-50

GEOCRES No.

RECORD OF BOREHOLE 19

LOCATION SEE FIGURE 1 BORING DATE SEPT 8, 1961 DATUM GEODETIC
 BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER —
 SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT					LIQUID LIMIT L _L PLASTIC LIMIT P _L WATER CONTENT W		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	BLOWS/FT.	20	40	60	80	100	PL W PL
						SHEAR STRENGTH C, LB./SQ.FT.					WATER CONTENT, PER CENT	
130.7 0.0	RIVER LEVEL				140							
					130							
					120							
					110							
					100							
91.7 39.0	RIVER BOTTOM				90							
	PROBABLY VERY LOOSE SAWDUST AND WOODCHIPS				80							
81.9 49.9	END OF PEN. TEST				70							
	PROBABLY BOULDERS OR BEDROCK				60							

WEIGHT OF ROD

50 BLOWS FOR NO ADVANCE

3165-50

OF PAGES NO.

3165-50

PROJECT NO. _____

BORING DATE SEPT 8, 1961

DATUM GEODETIC

BOREHOLE DIAMETER

PEN. TEST HAMMER WEIGHT 40 LB. DROP 30 INCHES

[illegible]

3165-50

3165-50

RECORD OF BOREHOLE 22

LOCATION SEE FIGURE 1 BORING DATE SEPT. 2, 1961 DATUM GEODETIC
 BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER —
 SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT L_L			
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE					PL	W	LL	
				BLOWS / FT	BLOWS / FOOT — — — — —				PLASTIC LIMIT P_L			
					20 40 60 80 100				WATER CONTENT W			
					SHEAR STRENGTH C , LB./SQ.FT.				WATER CONTENT, PER CENT			
				140								
136.7	RIVER LEVEL											
0.0				130								
				120								
				110								
				100								
95.9	RIVER BOTTOM											
84.9	PROBABLY											
	VERY LOOSE											
	SAWDUST AND											
83.2	WOODCHIPS											
42.5	END OF PEN TEST											
	PROBABLY BEDROCK											
				80								

WEIGHT OF RODS

1 BLOW

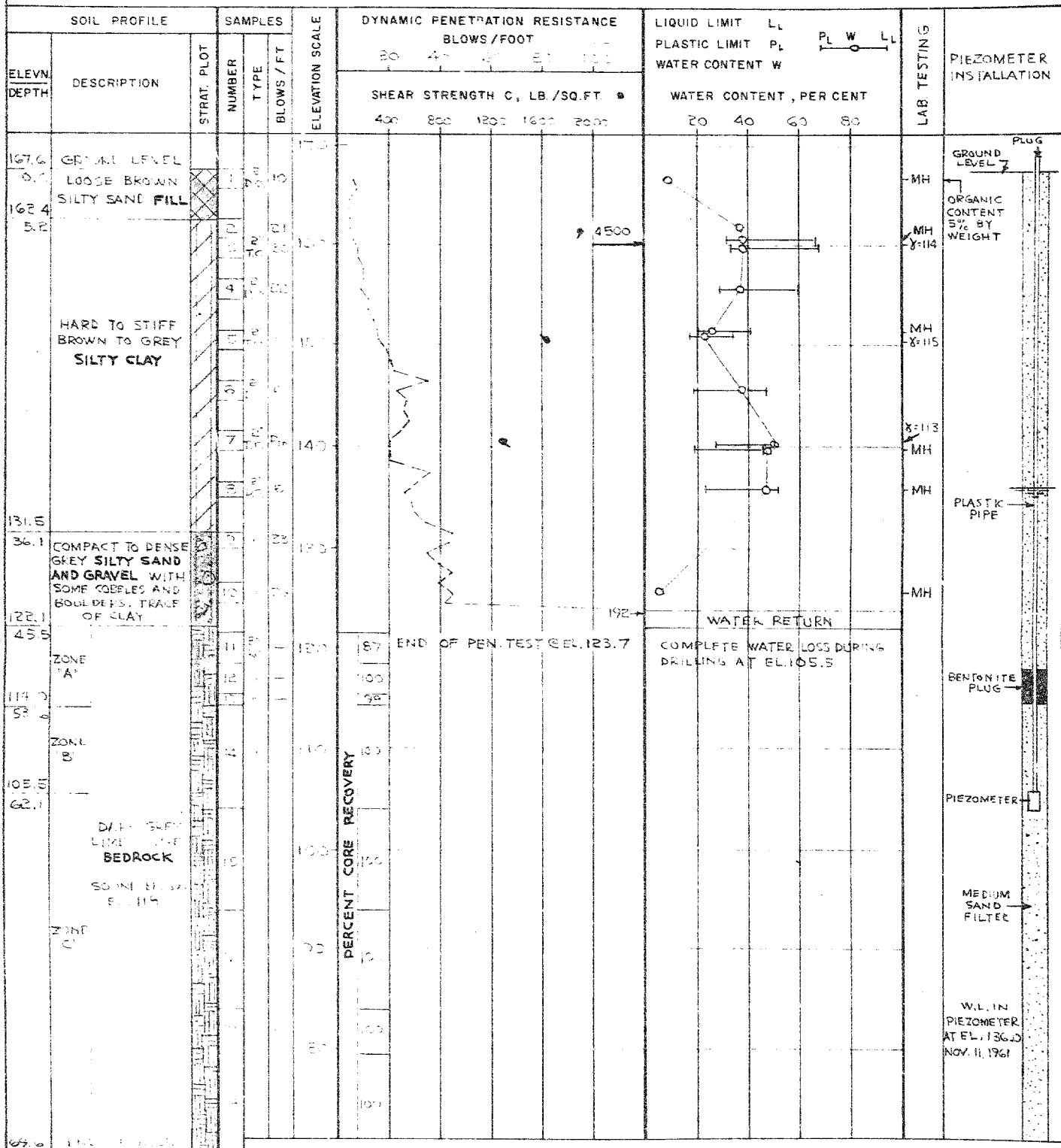
25 BLOWS FOR NO ADVANCE

3165-50
GROVER L.

3165-50

RECORD OF BOREHOLE 24

LOCATION BELT DISTRICT 1 BORING DATE SEP 11-12, 1961 DATUM GEODETIC
 BOREHOLE TYPE WATER BORING BOREHOLE DIAMETER 4" & BX CASING
 SAMPLER HAMMER WEIGHT 45 LB DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE

1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.

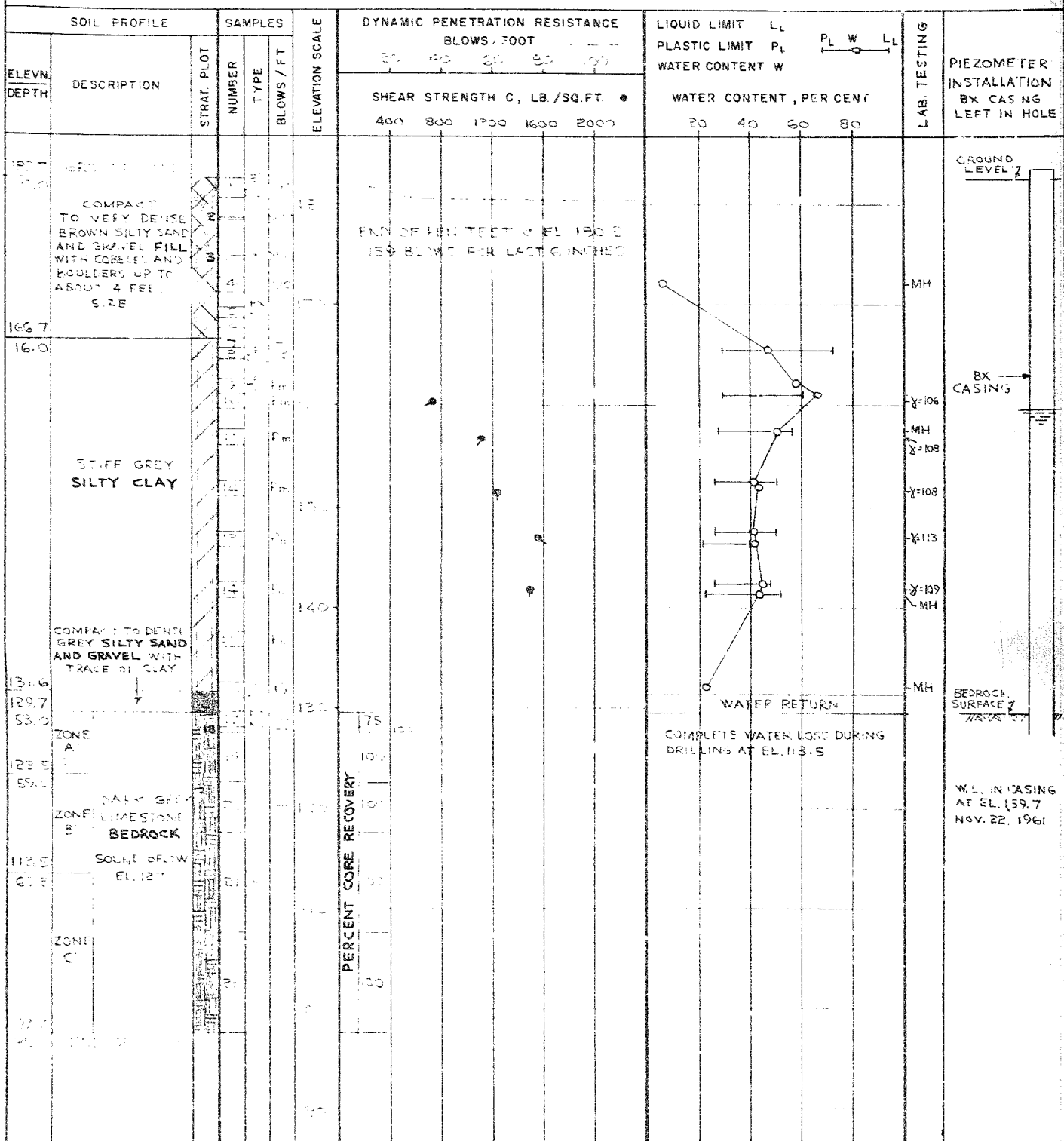
CHECKED JTS

3165-50

3165-50

RECORD OF BOREHOLE 25

LOCATION: DEPT. OF AGRICULTURE BORING DATE: SEP. 14, 1961 DATUM: GEODETIC
 BOREHOLE TYPE: WATER BORING BOREHOLE DIAMETER: 8X CASING
 SAMPLER HAMMER WEIGHT: 47 LB. DROP: 30 INCHES PEN. TEST HAMMER WEIGHT: 140 LB. DROP: 30 INCHES



GOLDER & ASSOCIATES

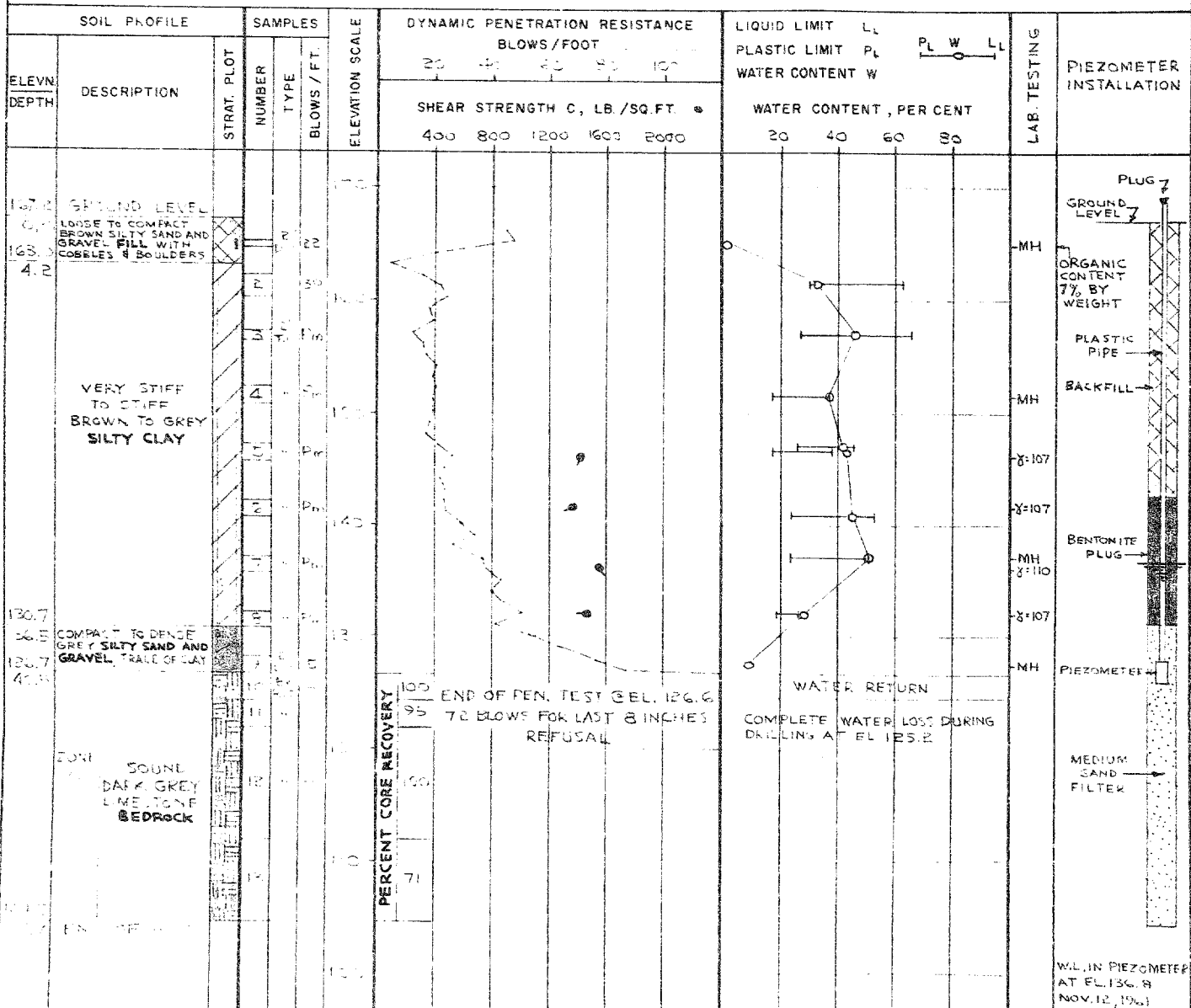
 DRAWN: J.A.
 CHECKED: J.S.

W. A. R.

3165-50

RECORD OF BOREHOLE 26

LOCATION SFL PROJECT 1 BORING DATE SEP 2 1960 DATUM GEODETIC
 BOREHOLE TYPE 1 1/4" BORING BOREHOLE DIAMETER BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



3465-50

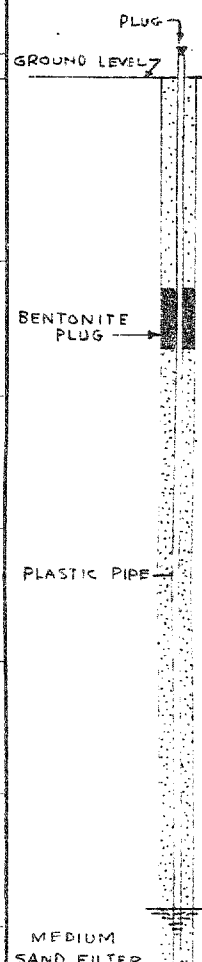
30
GATE
GEOCRES No.

3165-50

RECORD OF BOREHOLE 28

LOCATION SEE FIGURE BORING DATE SEPT. 26-27, 1961 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING
 SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W		PIEZOMETER INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLAT	NUMBER	TYPE		BLWS / FT.	SHEAR STRENGTH C , LB. / SQ. FT.	WATER CONTENT, PER CENT		
193.7	GROUND LEVEL									
0.7	COMPACT DARK BROWN SANDY FILL		1	AN RC	190	75				
			2	BX RC		100				
			3			100				
			4			100				
			5			100				
			6			100				
			7			100				
			8			100				
			9			100				
			10			100				
			11			100				
			12			100				
			13			95				
			14			100				
			15			100				
			16			100				
			17			100				
			18			100				
			19			100				
			20			100				
			21			100				
			22			100				
			23			100				
			24			100				
			25			100				
			26			100				
			27			100				
			28			100				
			29			100				
			30			100				
			31			100				
			32			100				
			33			100				
			34			100				
			35			100				
			36			100				
			37			100				
			38			100				
			39			100				
			40			100				
			41			100				
			42			100				
			43			100				
			44			100				
			45			100				
			46			100				
			47			100				
			48			100				
			49			100				
			50			100				
			51			100				
			52			100				
			53			100				
			54			100				
			55			100				
			56			100				
			57			100				
			58			100				
			59			100				
			60			100				
			61			100				
			62			100				
			63			100				
			64			100				
			65			100				
			66			100				
			67			100				
			68			100				
			69			100				
			70			100				
			71			100				
			72			100				
			73			100				
			74			100				
			75			100				
			76			100				
			77			100				
			78			100				
			79			100				
			80			100				
			81			100				
			82			100				
			83			100				
			84			100				
			85			100				
			86			100				
			87			100				
			88			100				
			89			100				
			90			100				
			91			100				
			92			100				
			93			100				
			94			100				
			95			100				
			96			100				
			97			100				
			98			100				
			99			100				
			100			100				



ZONE
"A"
DARK GREY
LIMESTONE
BEDROCK
SOUND BELOW
EL. 189

WATER RETURN
FAIR WATER RETURN DURING
DRILLING TO EL. 110.6
COMPLETE WATER LOSS DURING
DRILLING BELOW EL. 110.6

PERCENT CORE RECOVERY

ZONE
"A"

DARK GREY
LIMESTONE
BEDROCK
SOUND BELOW
EL. 189

PERCENT CORE RECOVERY

PLASTIC PIPE

MEDIUM
SAND FILTER

PIEZOMETER

48.7
145.0 END OF HOLE

W.L. IN PIEZOMETER
AT EL. 131.4 NOV. 2
1961 - RIVER LEVEL
AT EL. 130.7

VERTICAL SCALE
1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED JKS

31 G5-50

RECORD OF BOREHOLE 29

LOCATION OFF FILED

BORING DATE

[illegible]

DATUM

GENETIC

BORENCE TYPE

WATSON, F. F. -

BOREHOLE DIAMETER

5/ CASING

SAMPLER HAMMER WEIGHT 4 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

[illegible]

BH26

W
A
I
S
O
N
Z
E
J
V
E

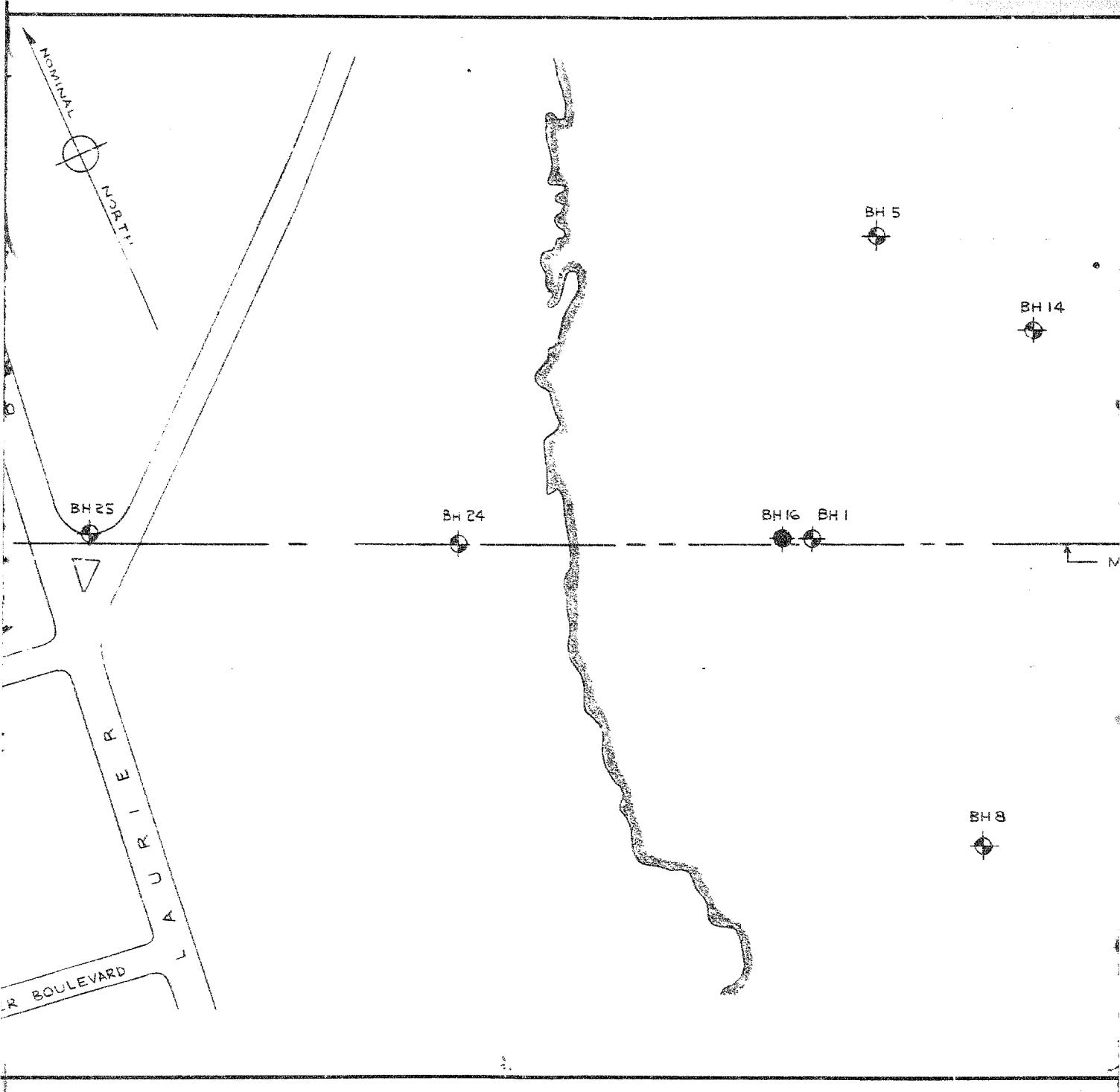
C
H
I
S
P
A
N
I
S
Z

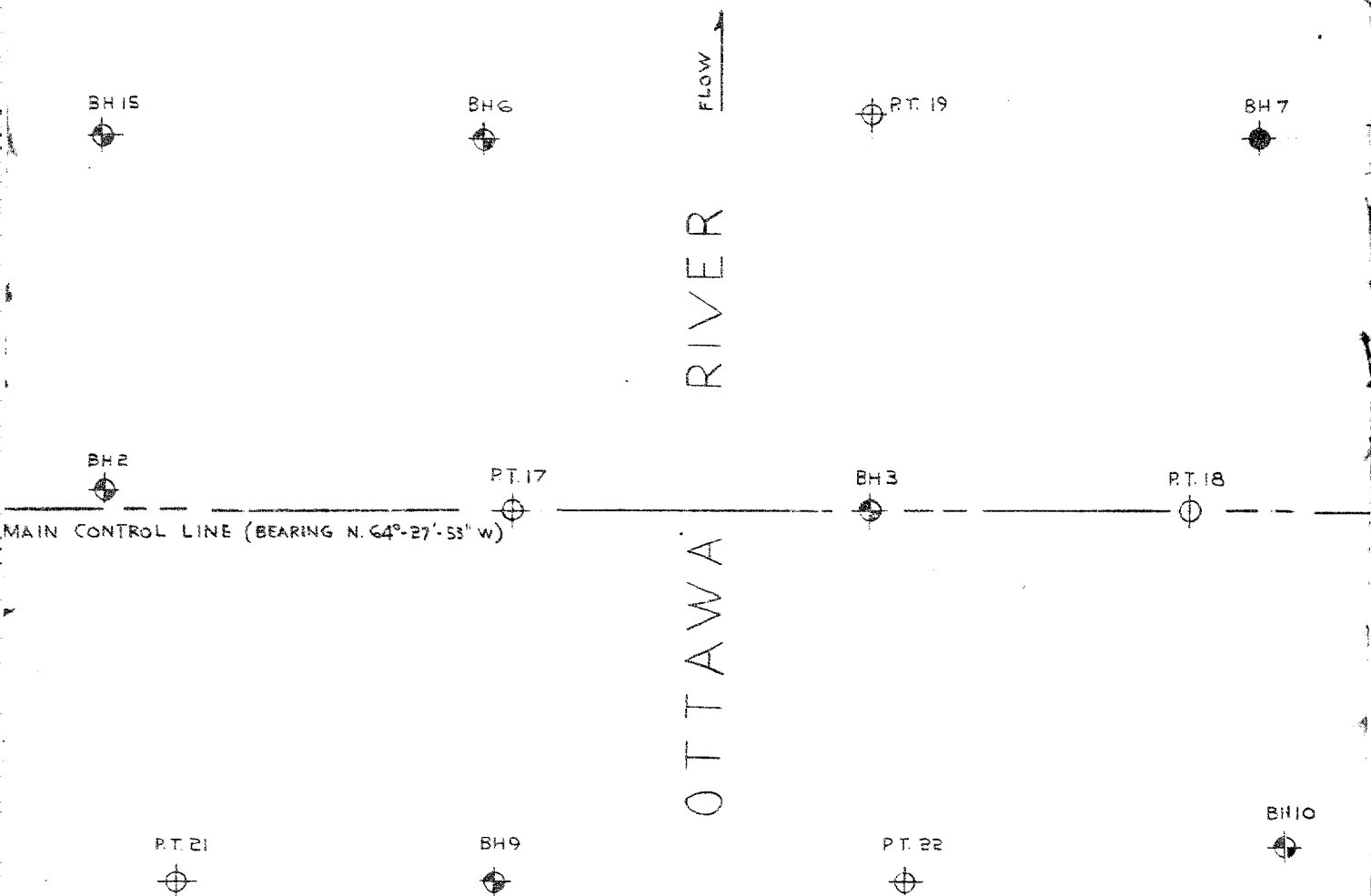
Z
O
T
R
E
M
A
D
E

MARSTON

SACRE COUE

O
J
U
L
E
V
A
R
D





BH15

BH6

PT. 19

BH7

P.T. 20

BH 13

BH 12

BH 28

BH 29

BH 27

BH 11

BH 4

GREY DRIVE

LADY

CO. ORDINATES MAIN
CONTROL LINE AT
SUSSEX DRIVE
9,195 M 12,520 E

SUSSEX DRIVE

P.T. 23

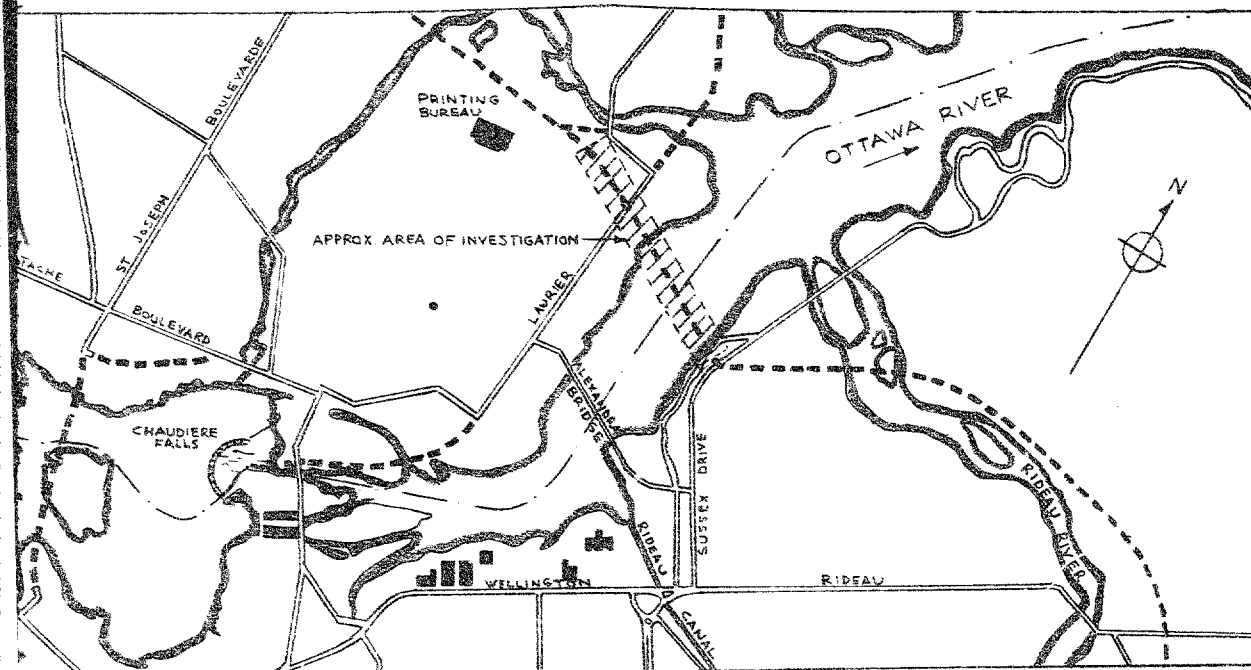


DRWG. No.

TOPOGRAPHY
OF BOREHO
SUPPLIED BY
UNDATED.

3165-50

GEOCRE No.



KEY PLAN

SCALE: 1" TO 2200' (APPROX)

LEGEND

- ⊕ BOREHOLE WITH PENETRATION TEST IN PLAN
- BOREHOLE ONLY IN PLAN
- ⊕ PENETRATION TEST ONLY IN PLAN

RENCE

DESCRIPTION

PLAN SHOWING LOCATIONS
SCALE: 1" TO 100'
CONSULTING ENGINEERS,

CONSULTING ENGINEERS
MACDONALD-CARTIER BRIDGE
OTTAWA ONTARIO
PROPOSED MACDONALD-CARTIER BRIDGE
OTTAWA-HULL CANADA

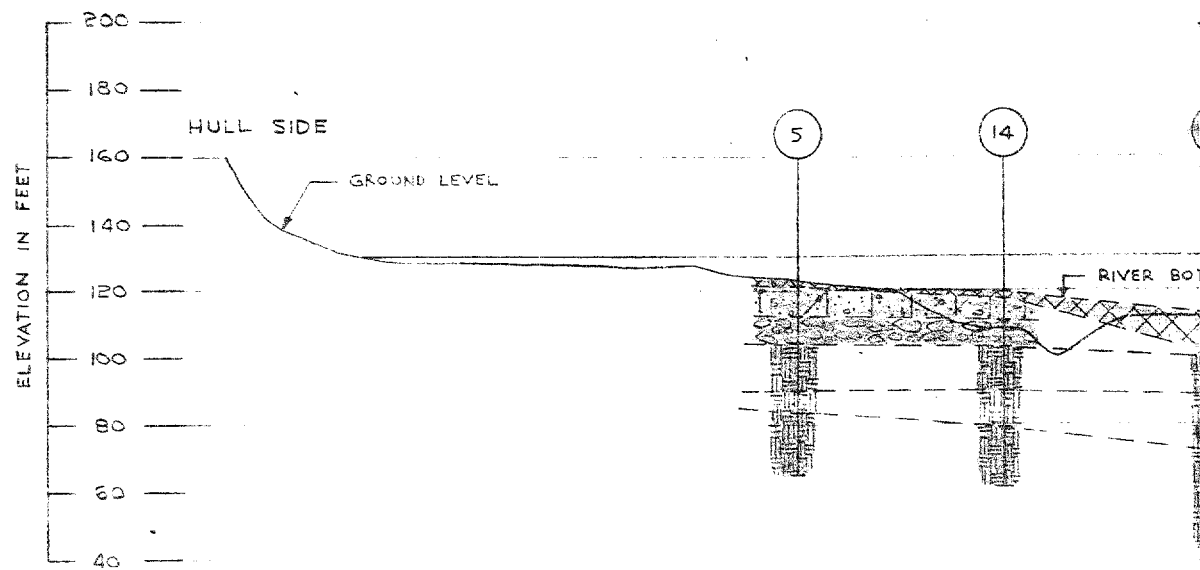
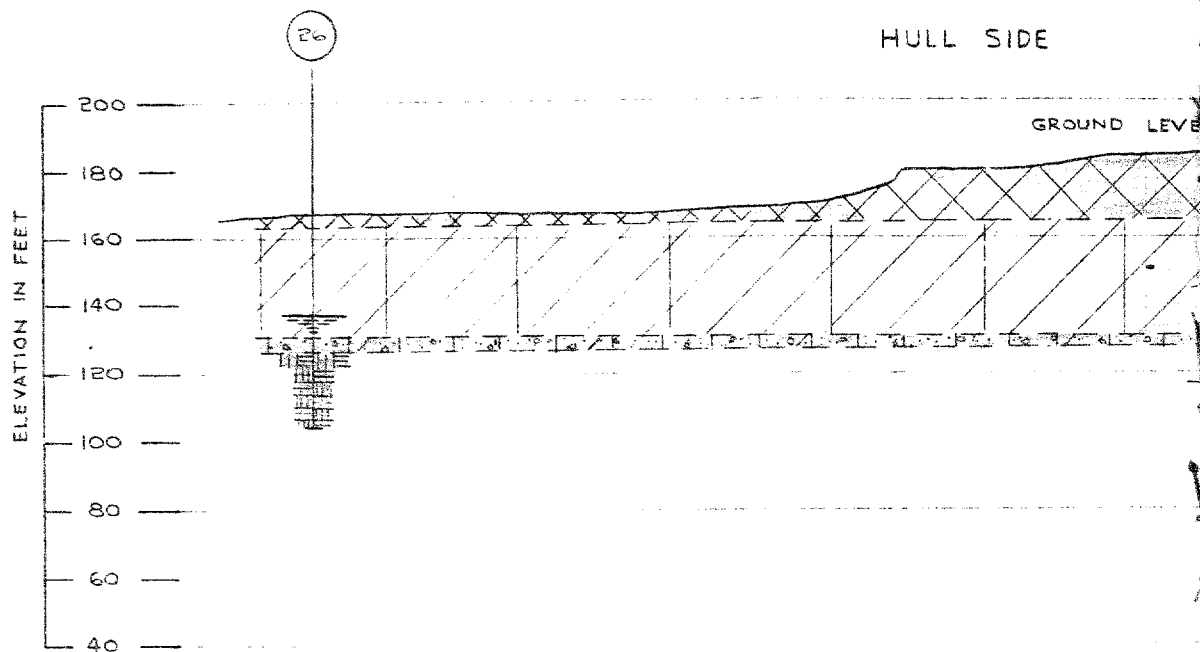
BORING PLAN

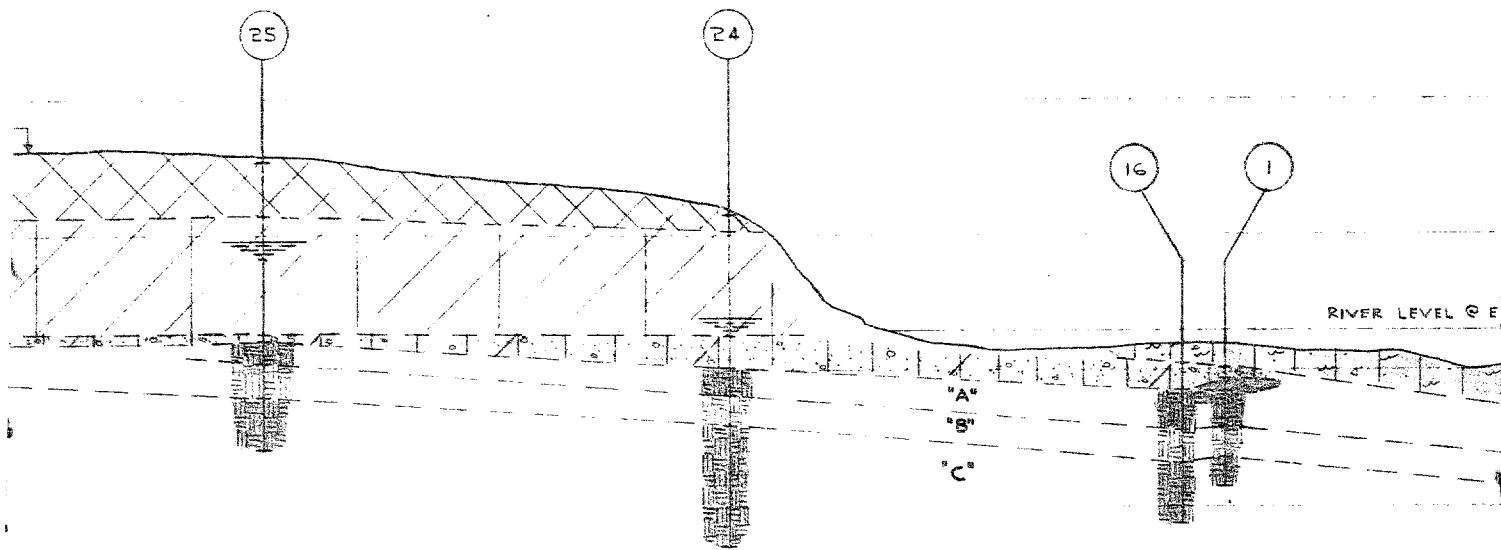
GOLDER & ASSOCIATES
CONSULTING CIVIL ENGINEERS

DATE: DEC. 7, 1961 SCALE: 1" TO 100'

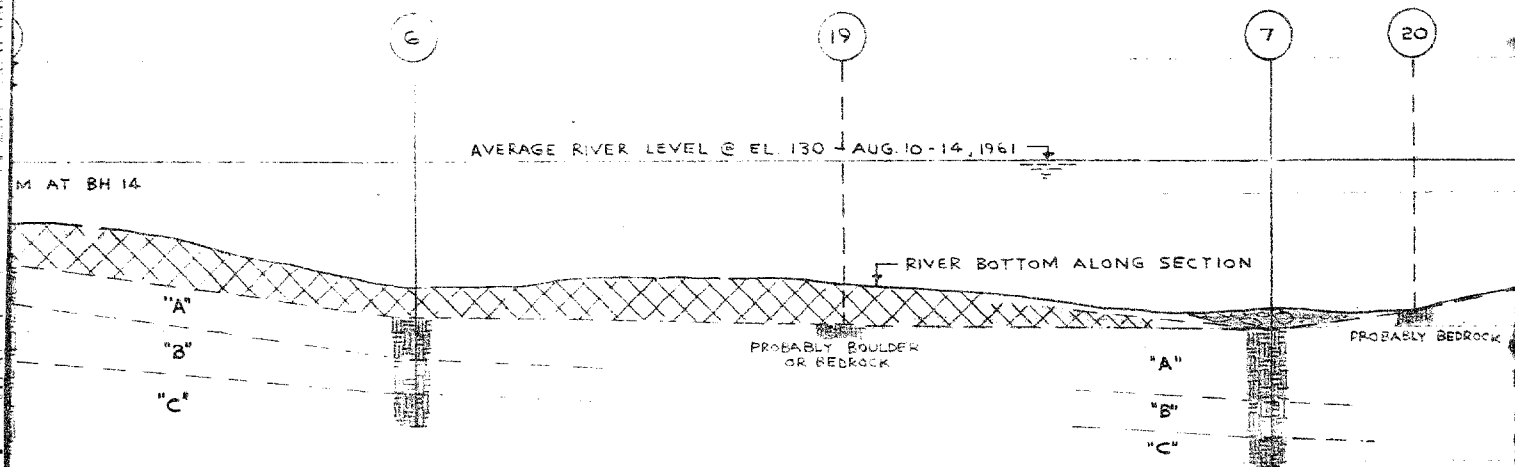
MADE J.A. CHKD. JLS APPD. T.M.

FIGURE 1

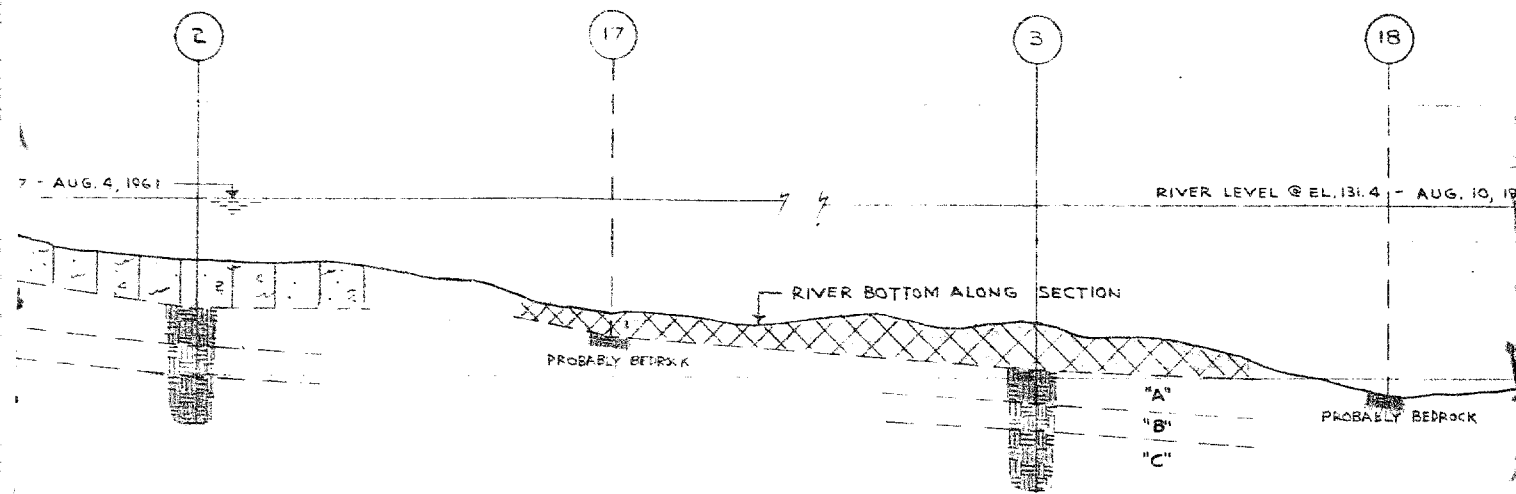




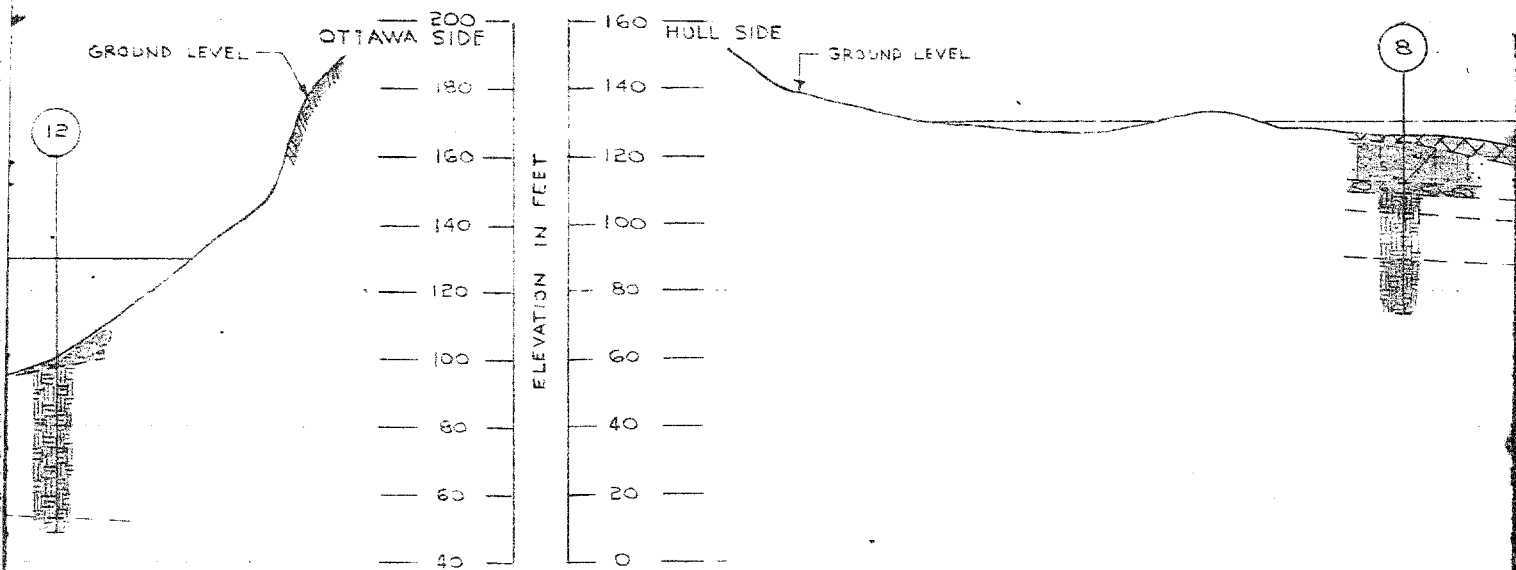
SECTION

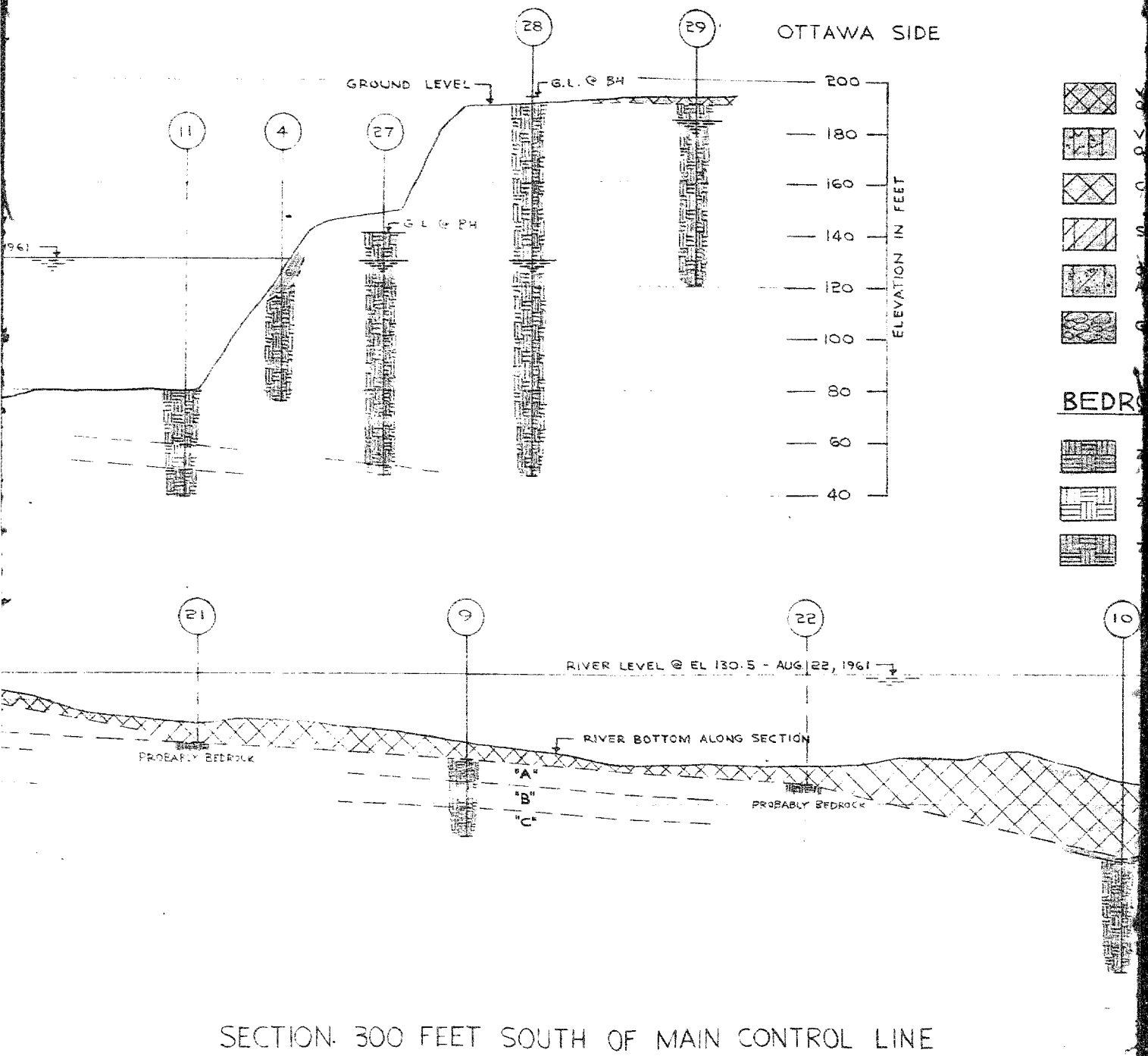


N 300 FEET NORTH OF MAIN CONTROL LINE



ALONG MAIN CONTROL LINE





STRATIGRAPHY

LOOSE GREY TO BROWN WOODCHIPS AND SAWDUST FILL WITH
SIGNAL LOGS AND A TRACE OF ORGANIC SILT AND SAND.

LOOSE DARK BROWN ORGANIC SILT AND SAND WITH A TRACE
WOODCHIPS AND SAWDUST

FACT BROWN GRANULAR FILL

BROWN TO GREY SILTY CLAY

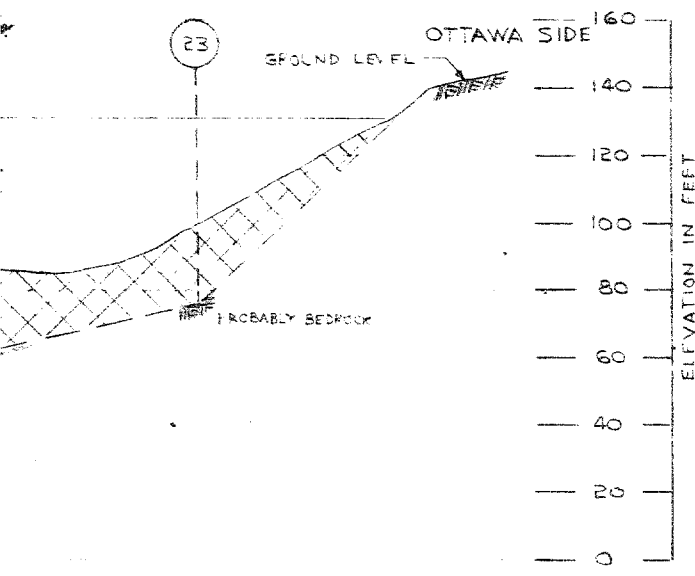
FACT TO DENSE GREY SILTY SAND AND GRAVEL WITH COBBLES
BOULDERS, TRACE OF CLAY

BOULES AND BOULDERS

"A" - PARTLY FRACTURED TO SOUND STRATIFIED LIMESTONE WITH SHALE PARTINGS

"B" - SOUND INTERMIXED LIMESTONE AND SHALE

"C" - SOUND STRATIFIED LIMESTONE



LEGEND



BOREHOLE IN ELEVATION



PENETRATION TEST IN



STABILIZED WATER LEVEL

NOTE

FOR LOCATION OF SECT
TO FIGURE 1

SPECIAL NOTE: DATA CONCERNING THE VARIOUS
BOREHOLE LOGS OBTAINED AT BOREHOLE LOCATIONS
FROM 1957 TO 1960 ARE IN DISCREPANCY BETWEEN
BOREHOLE LOGS OBTAINED FROM GEOLOGICAL
SURVEY AND DATA FROM THE BOREHOLE LOGS

CONSULTING ENGINEERS
MACDONALD - CARTIER BRIDGE
OTTAWA ONTARIO
PROPOSED MACDONALD-CARTIER BRIDGE
OTTAWA - HULL CANADA
SOIL STRATIGRAPHY

GO

DATE:

MADE
J.A.

LEGEND

31 GS-50
STANDARD



BOREHOLE IN ELEVATION



PENETRATION TEST IN ELEVATION



STABILIZED WATER LEVEL IN BOREHOLE

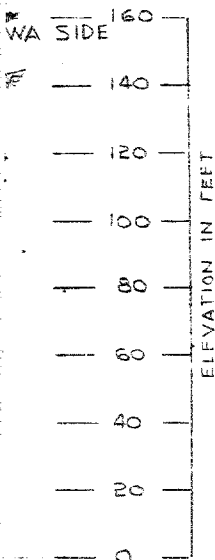
LEVEL WITH COBBLES

IFIED LIMESTONE WITH SHALE PARTINGS

SHALE

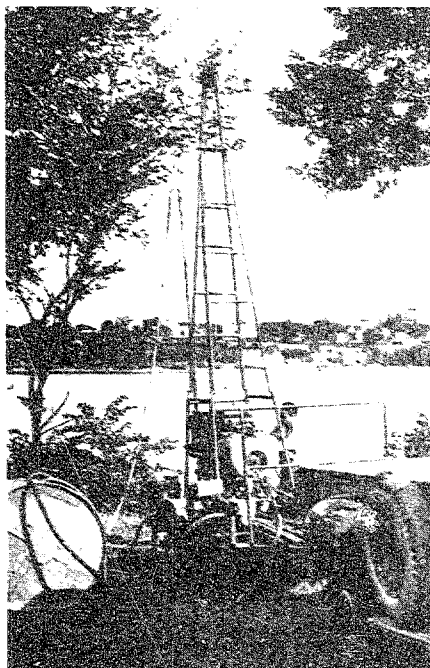
NOTE

FOR LOCATION OF SECTIONS REFER
TO FIGURE 1



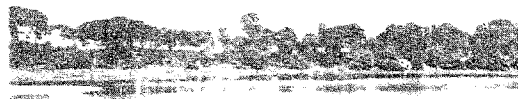
SEE THE NOTE DATA CONCERNING THE VARIOUS
WATER LEVELS AND CORRELATIONS LOCAL
WATER LEVELS AND CORRELATIONS LOCAL
WATER LEVELS AND CORRELATIONS LOCAL
WATER LEVELS AND CORRELATIONS LOCAL
WATER LEVELS AND CORRELATIONS LOCAL
WATER LEVELS AND CORRELATIONS LOCAL

CONSULTING ENGINEERS MACDONALD - CARTIER BRIDGE OTTAWA ONTARIO PROPOSED MACDONALD-CARTIER BRIDGE OTTAWA - HULL CANADA SOIL STRATIGRAPHY		GOLDER & ASSOCIATES CONSULTING CIVIL ENGINEERS DATE: DEC. 7, 1961 SCALE: HORIZ. 1" TO 100' VERT. 1" TO 40' MADE J.A. CHKD. JJA APPD. V.A.	
		FIGURE 2	



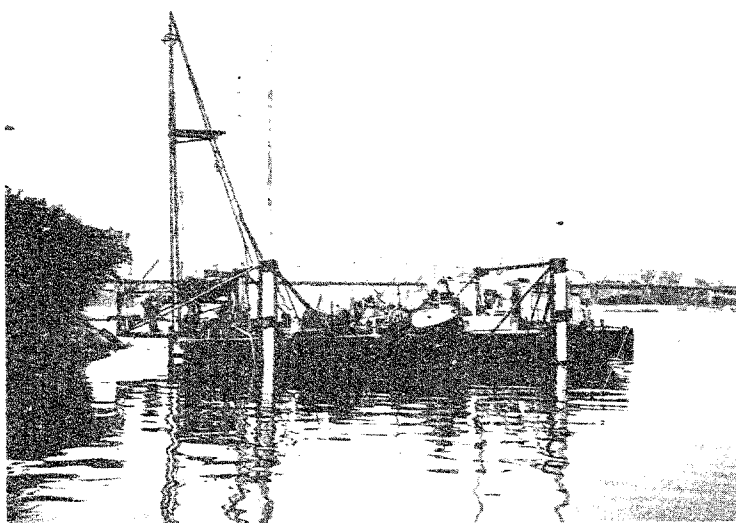
(a)

Looking east from Quebec side of river to Ottawa. Standard trailer mounted drillrig at BH 24



(b)

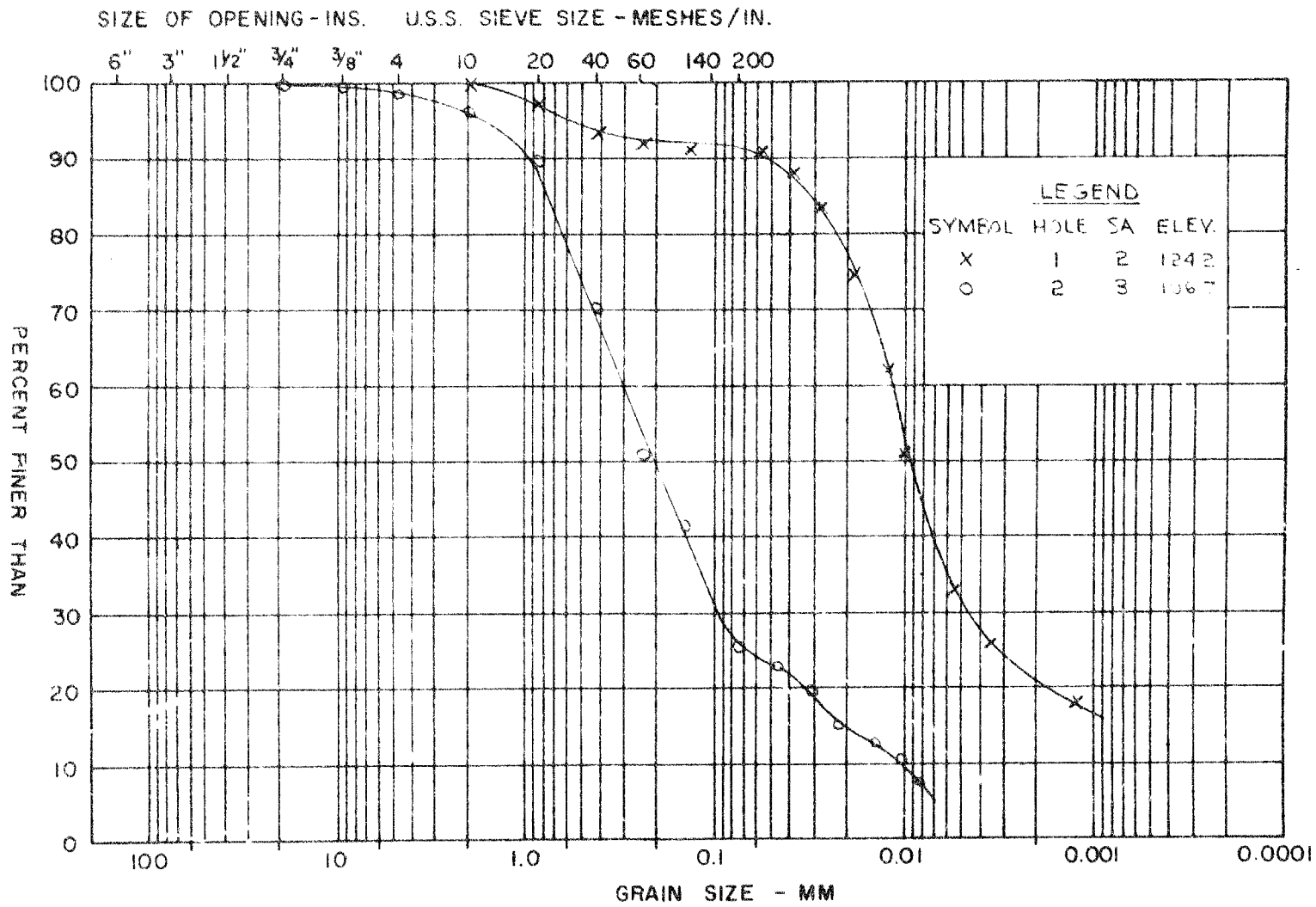
Looking west towards Quebec side of river along approximate proposed centreline from Lady Grey Drive. Marine drilling equipment at BH 4



(c)

Looking south, marine drilling equipment at BH 4 close to Ottawa bank. Alexandra bridge and Hull in background.

M.I.T. GRAIN SIZE SCALE

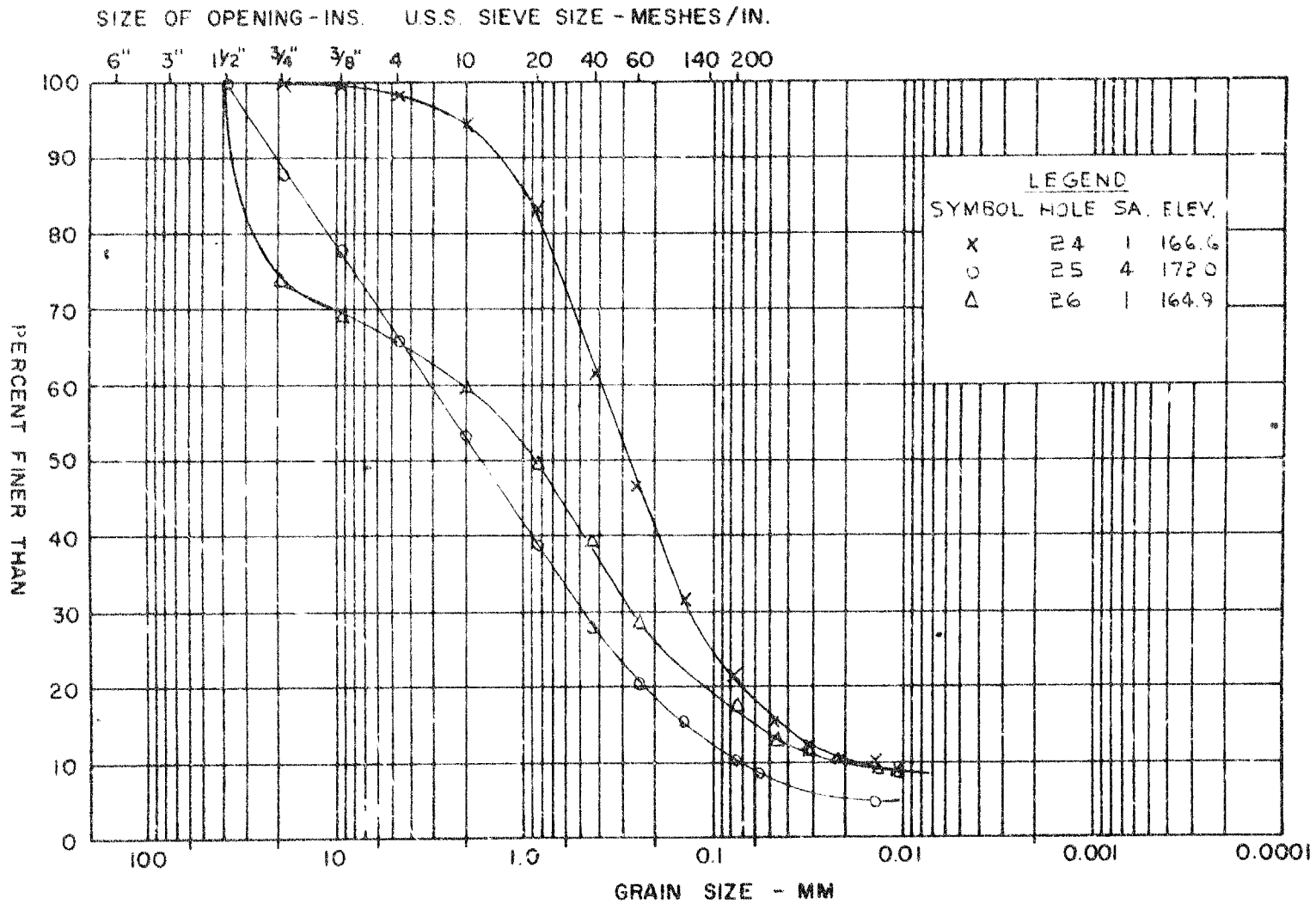


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
(ORGANIC) SILT AND SAND

FIGURE 4

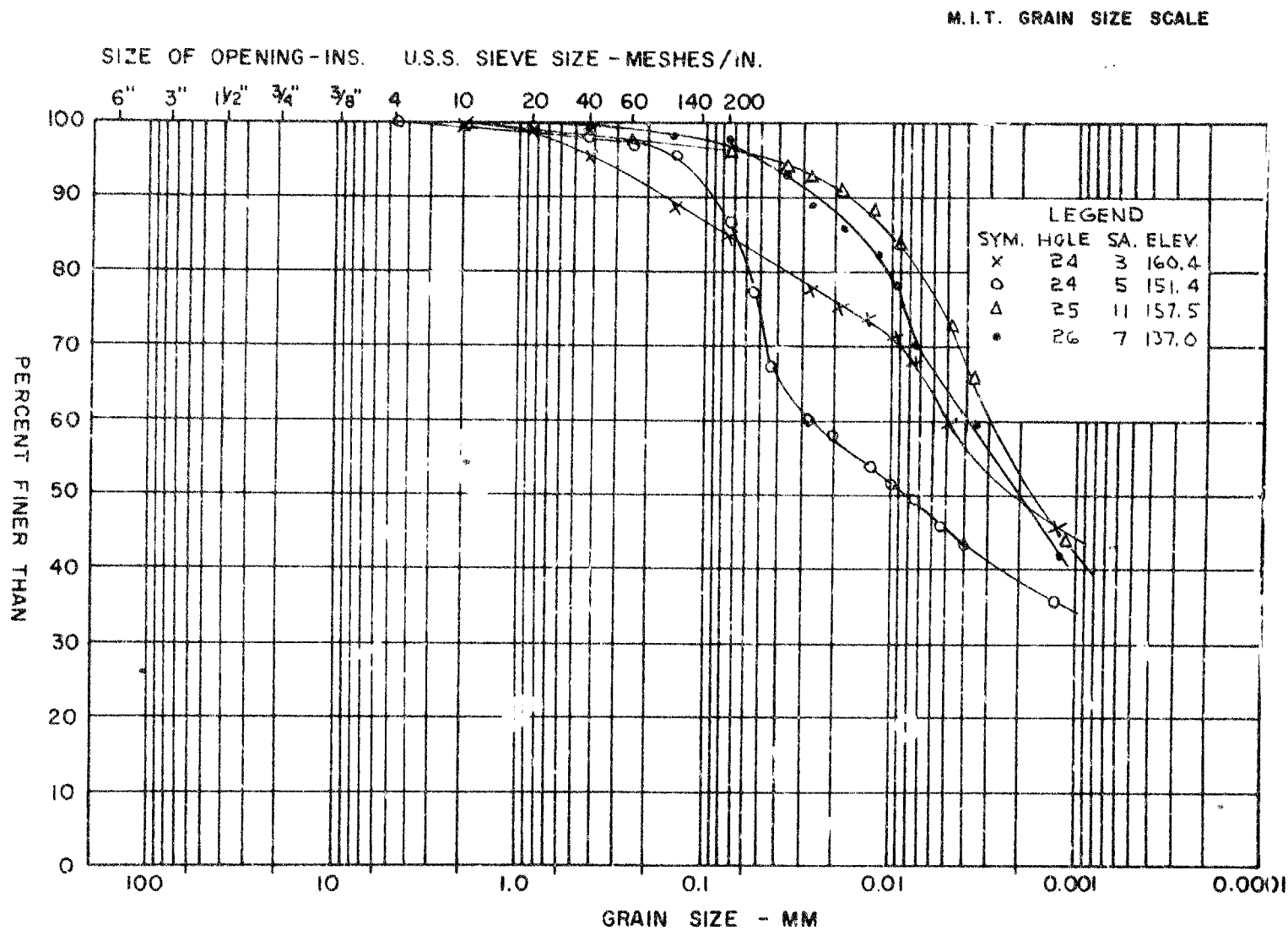
M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
FILL

FIGURE 5



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

GOLDER & ASSOCIATES

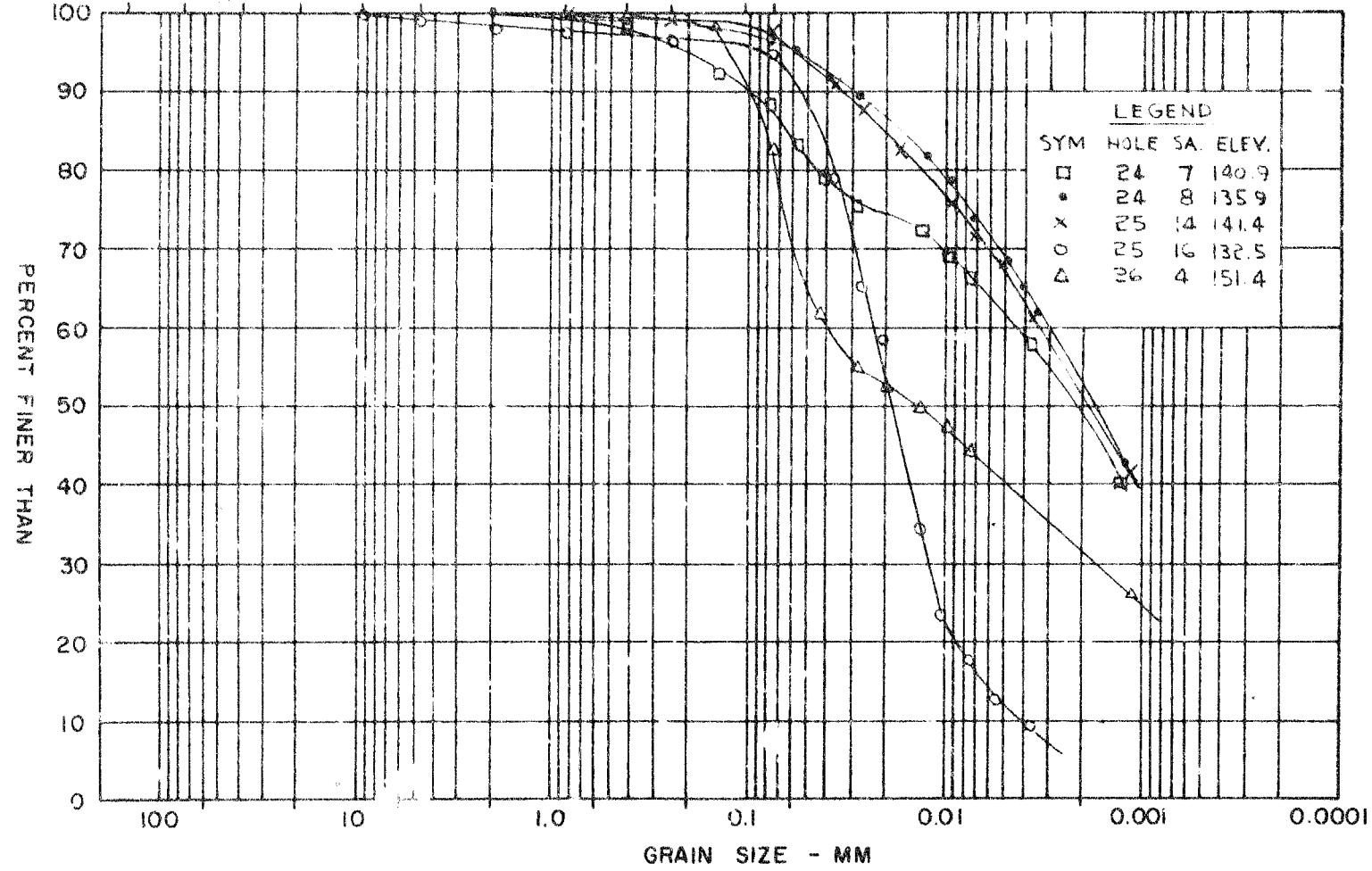
	GRAIN SIZE DISTRIBUTION
SILTY CLAY	

FIGURE 5

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.

6" 3" 1 1/2" 3/4" 3/8" 4 10 20 40 60 140 200



GOLDER & ASSOCIATES

COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED		

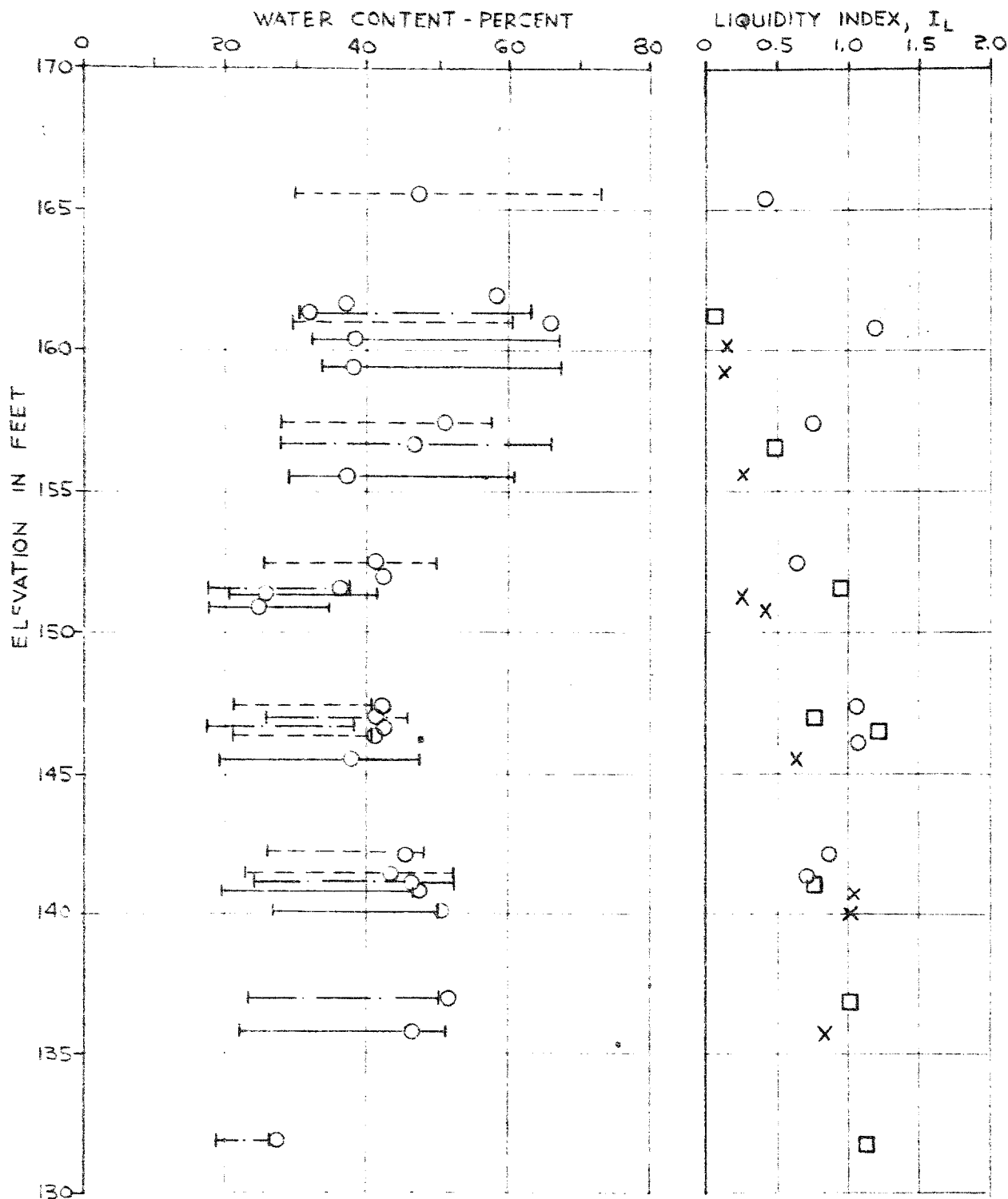
GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIGURE 7

6135

ATTERBERG LIMITS AND LIQUIDITY INDEX SILTY CLAY STRATUM

FIGURE 8



LEGEND
SYMBOL BOREHOLE
— 24
- - - 25
- · - 26

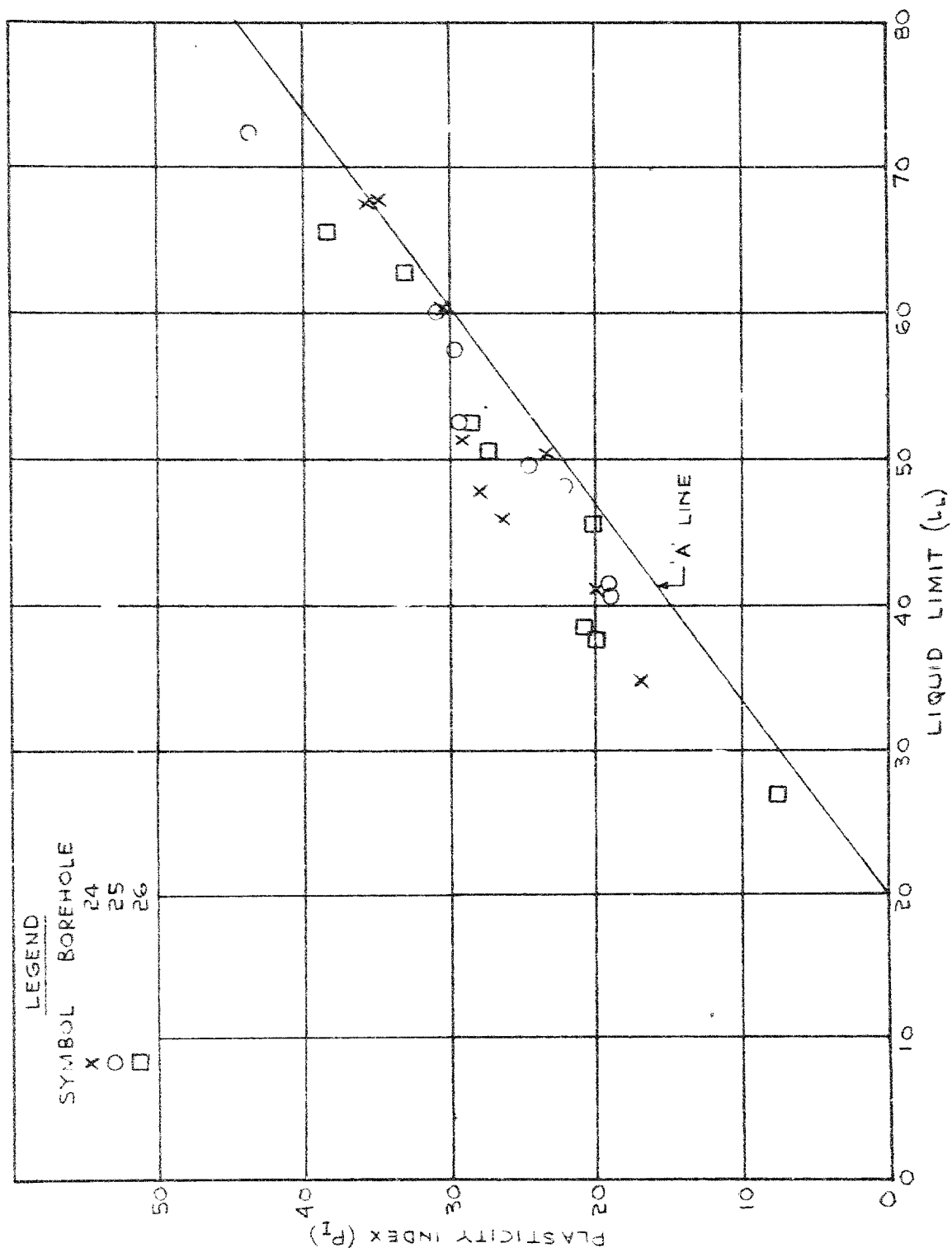
GOLDER & ASSOCIATES

LEGEND
SYMBOL BOREHOLE
x 24
o 25
□ 26

PLASTICITY CHART

SILTY CLAY STRATUM

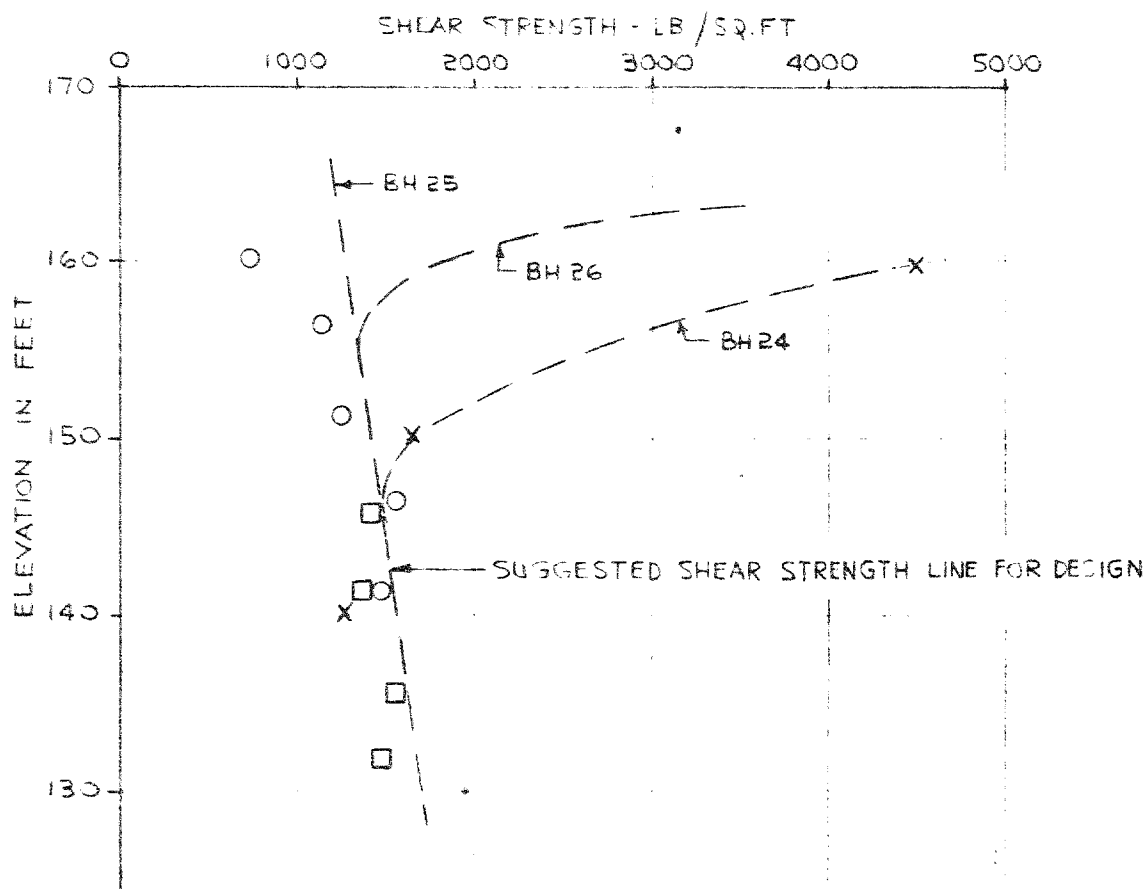
FIGURE 9



GOLDER & ASSOCIATES

UNDRAINED SHEAR STRENGTH PROFILE SILTY CLAY STRATUM

FIGURE 10



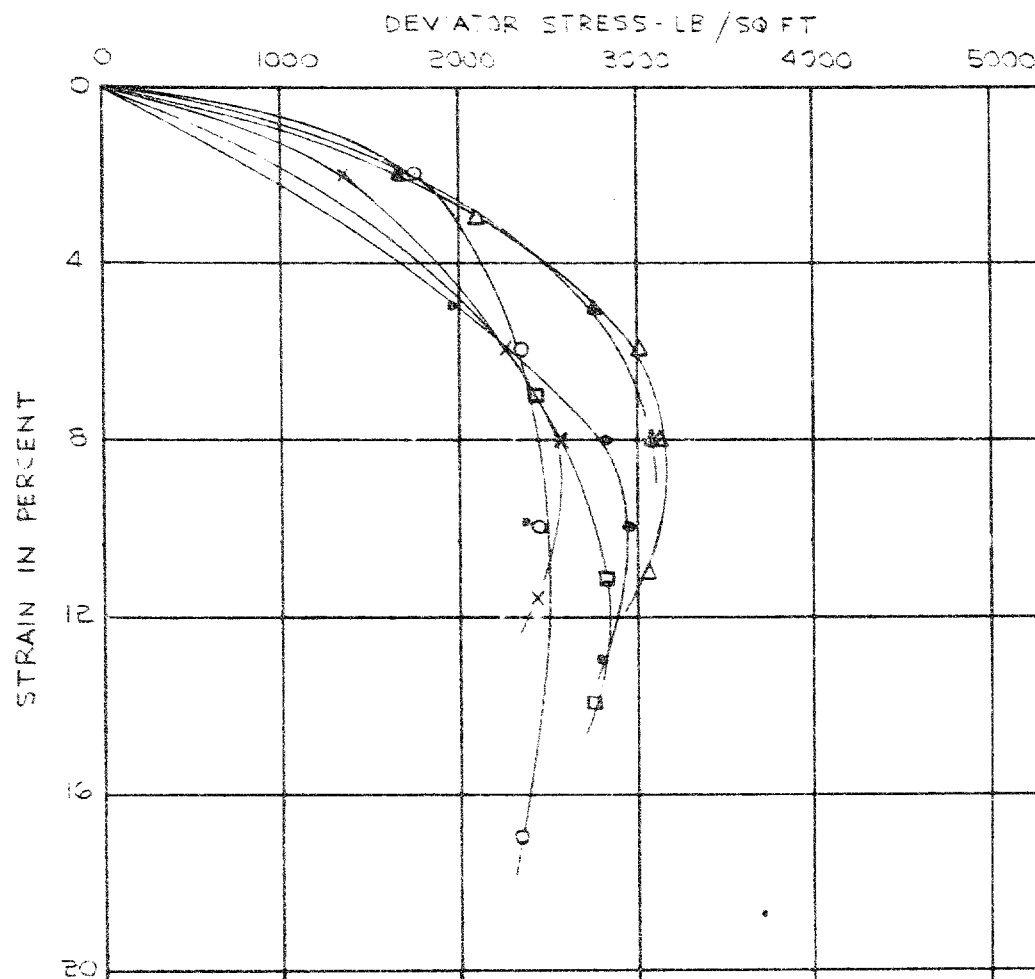
LEGEND

SYMBOL	BORHOLE
x	24
o	25
□	26

GOLDER & ASSOCIATES

UNDRAINED TRIAXIAL COMPRESSION TESTS TYPICAL STRESS-STRAIN CURVES SILTY CLAY

FIGURE 11



LEGEND			
SYMBOL	HOLE	SAMPLE	ELEV.
x	24	7	146.5
o	25	12	151.6
Δ	25	13	146.9
•	25	14	141.8
□	26	5	146.0
▲	26	7	136.1

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

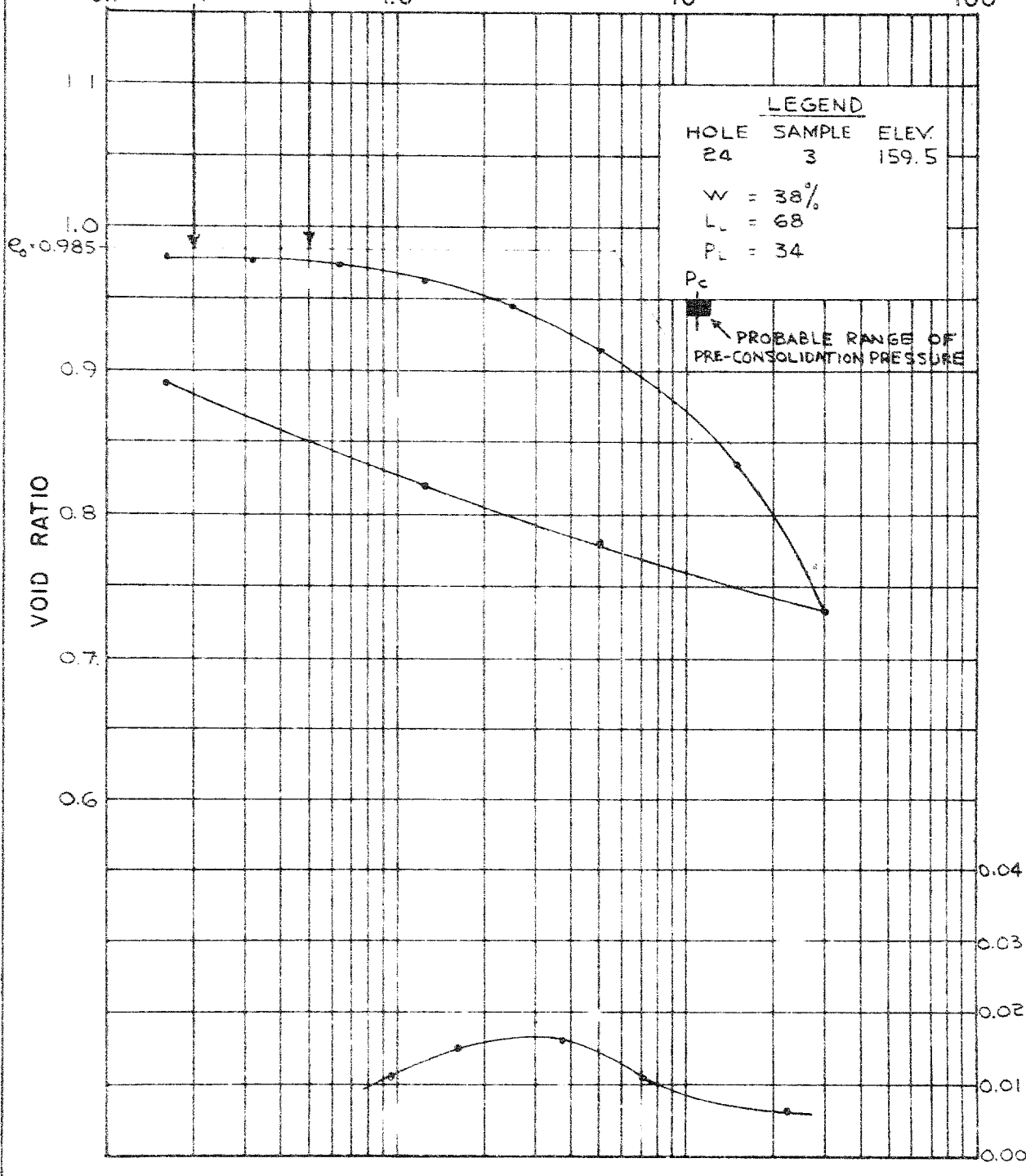
FIGURE 12

P_0 - EXISTING OVERBURDEN PRESSURE

PRESSURE, TONS/SQ.FT.

P_0 (WITH FILL)

0.1 P_0 (NO FILL) 1.0 10 100

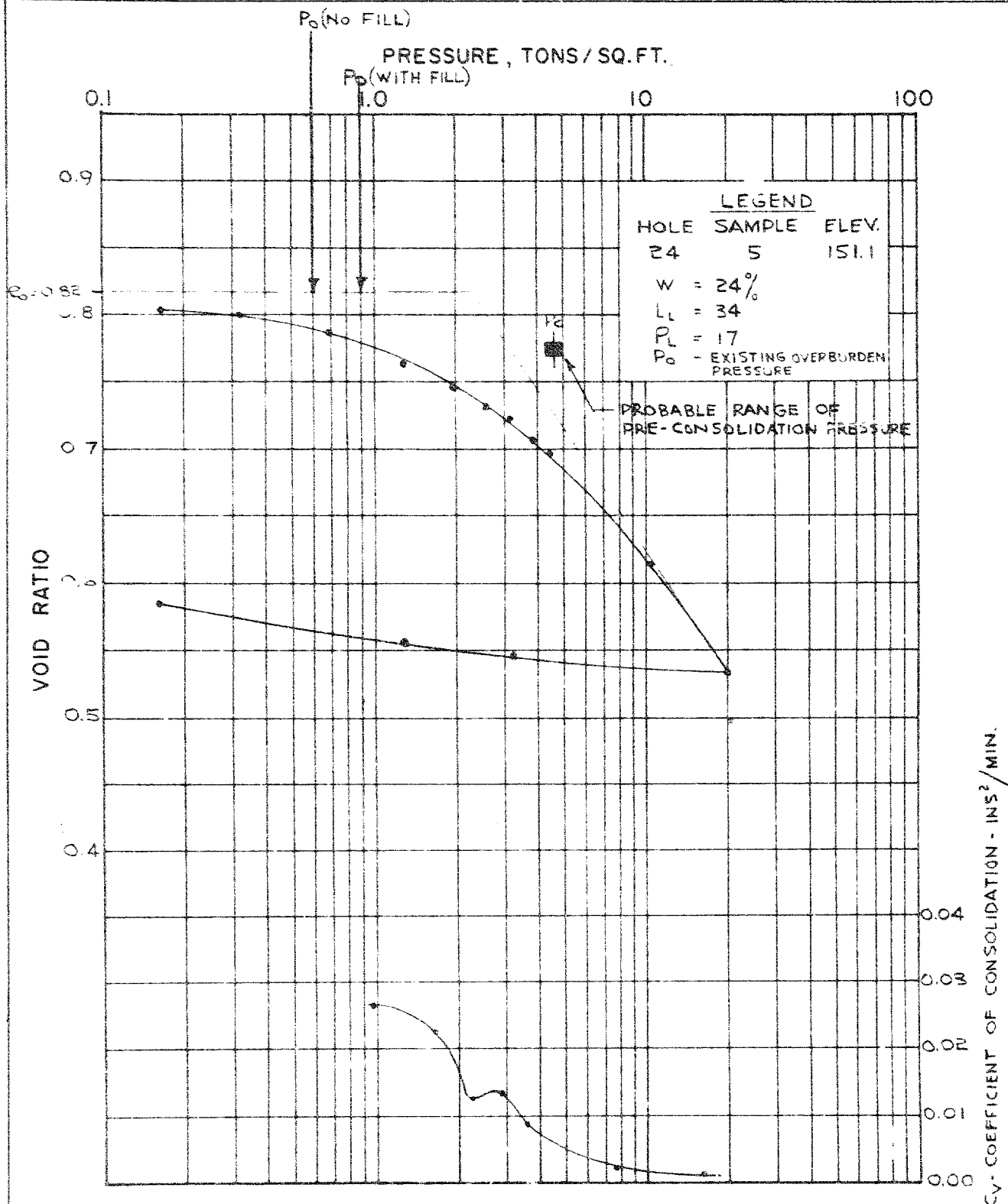


GOLDER & ASSOCIATES

PROJECT No. 9135

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

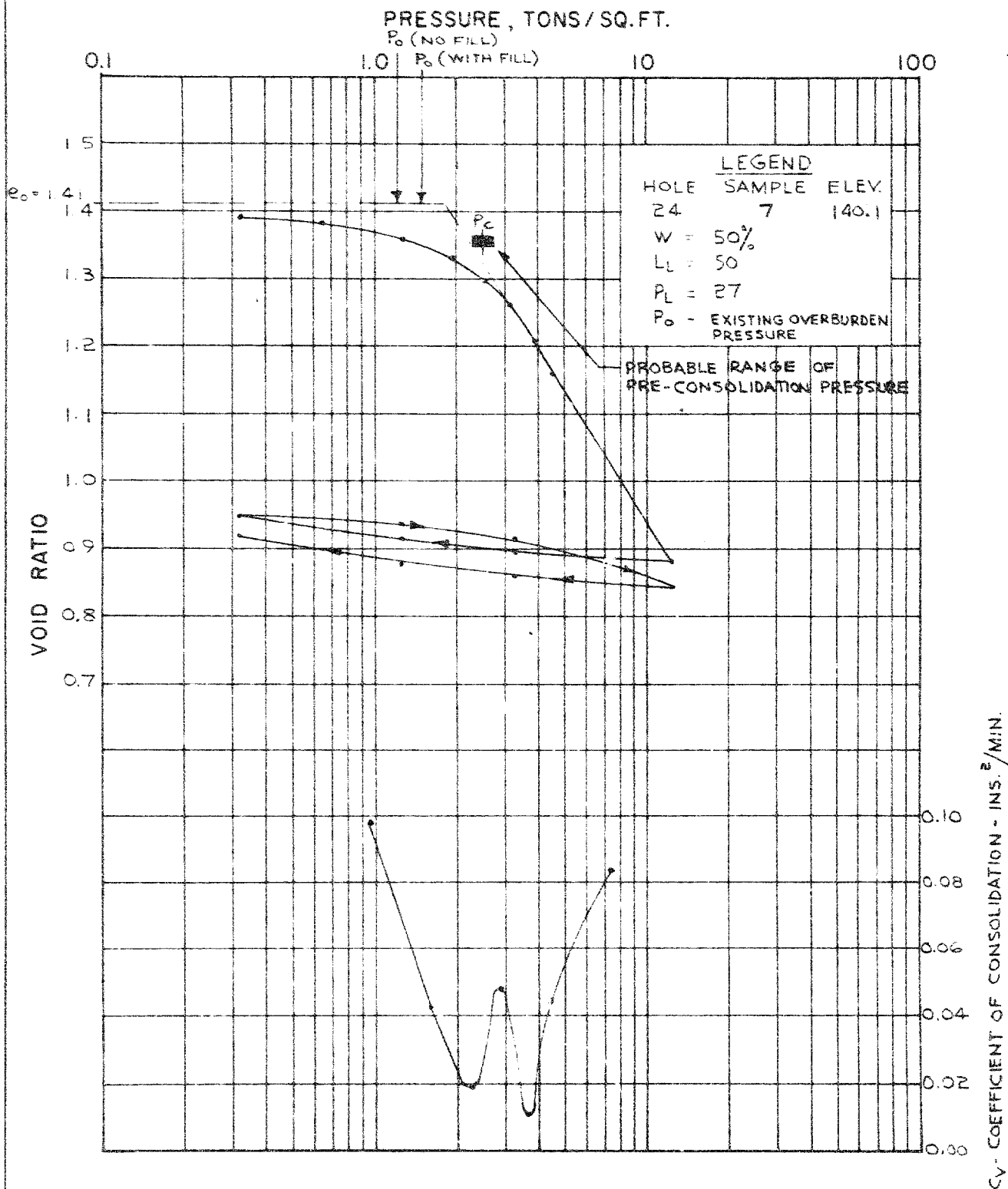
FIGURE 13



GOLDER & ASSOCIATES

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 14

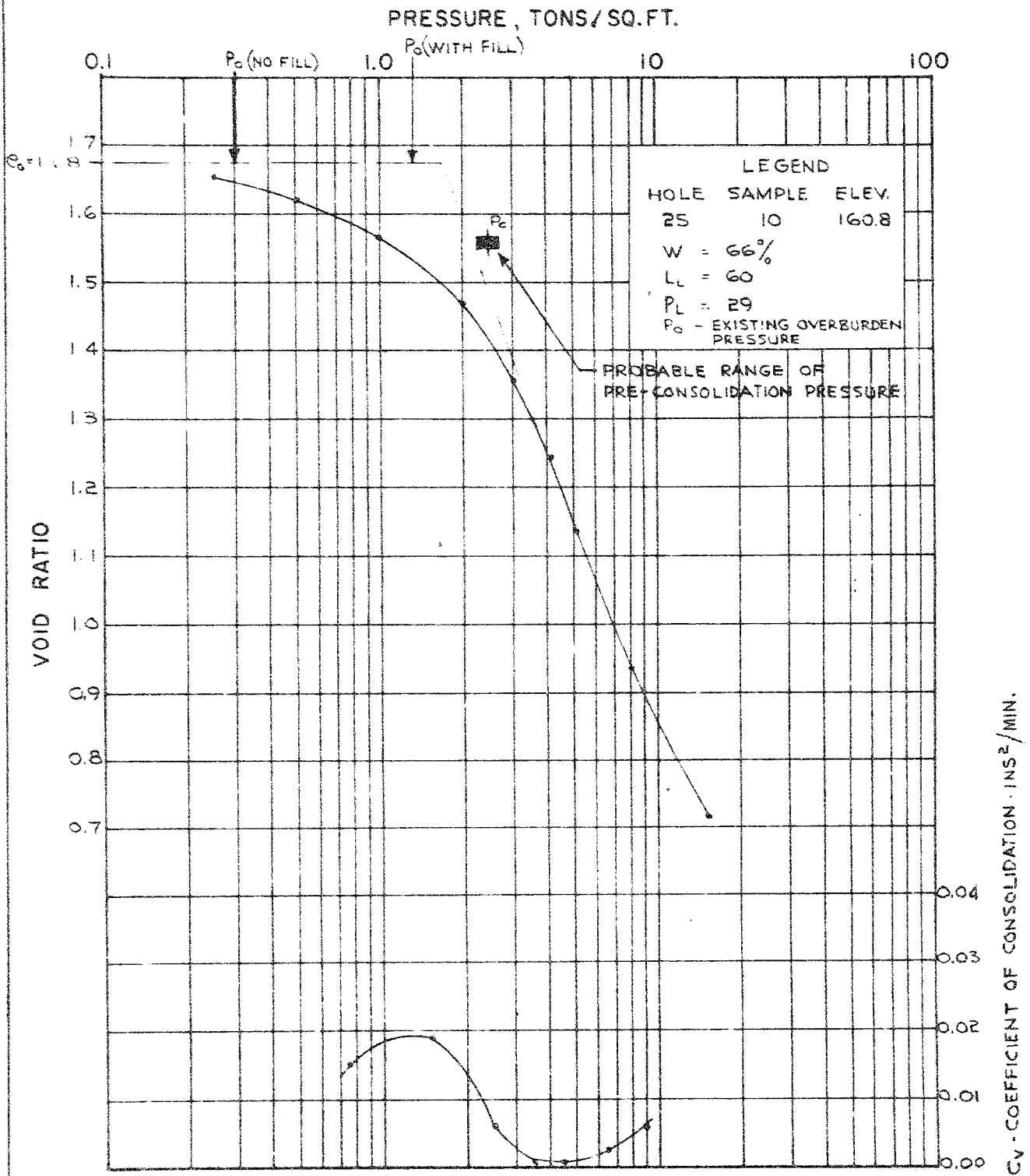


GOLDER & ASSOCIATES

PROJECT No. 6135

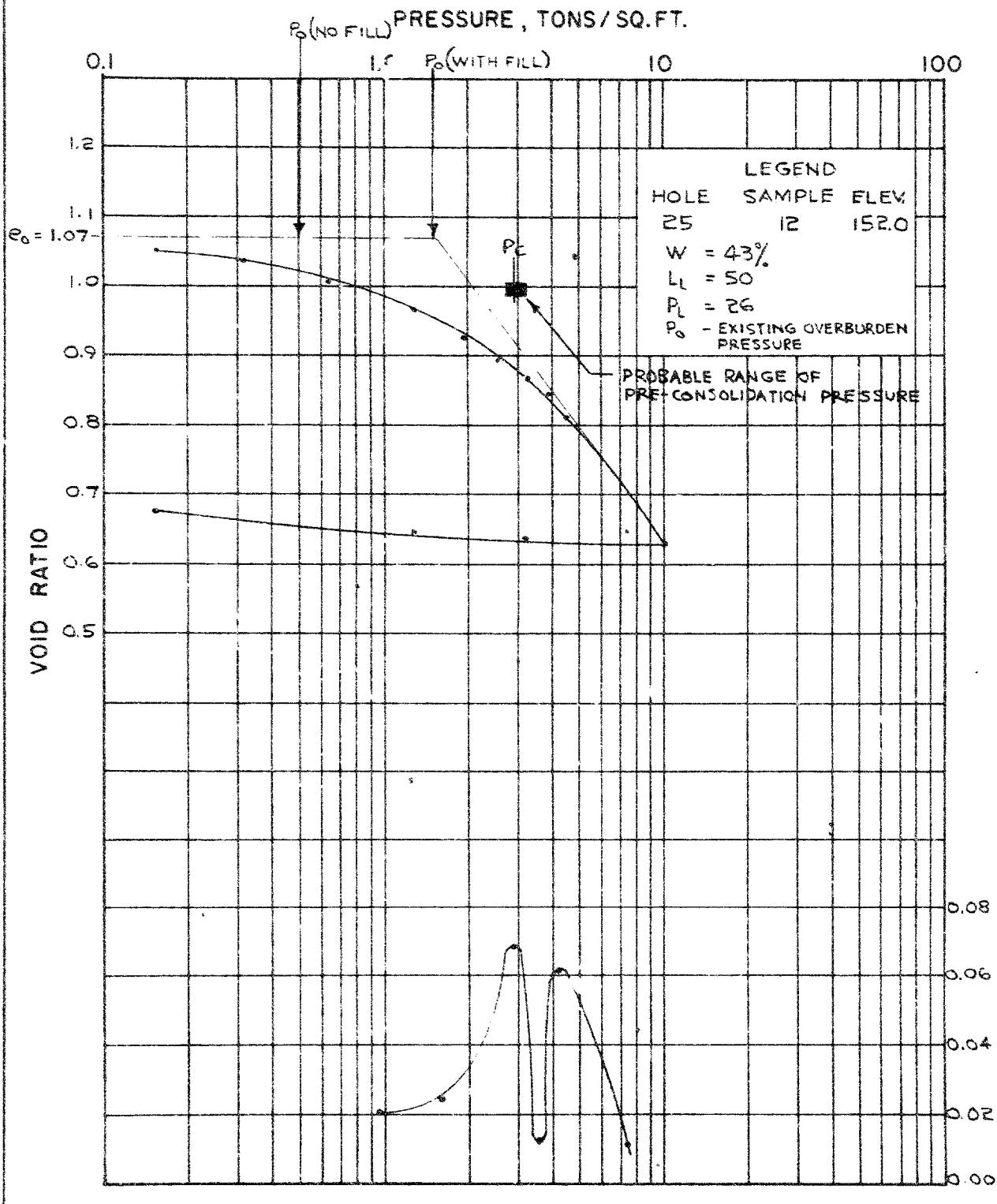
VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 15



VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

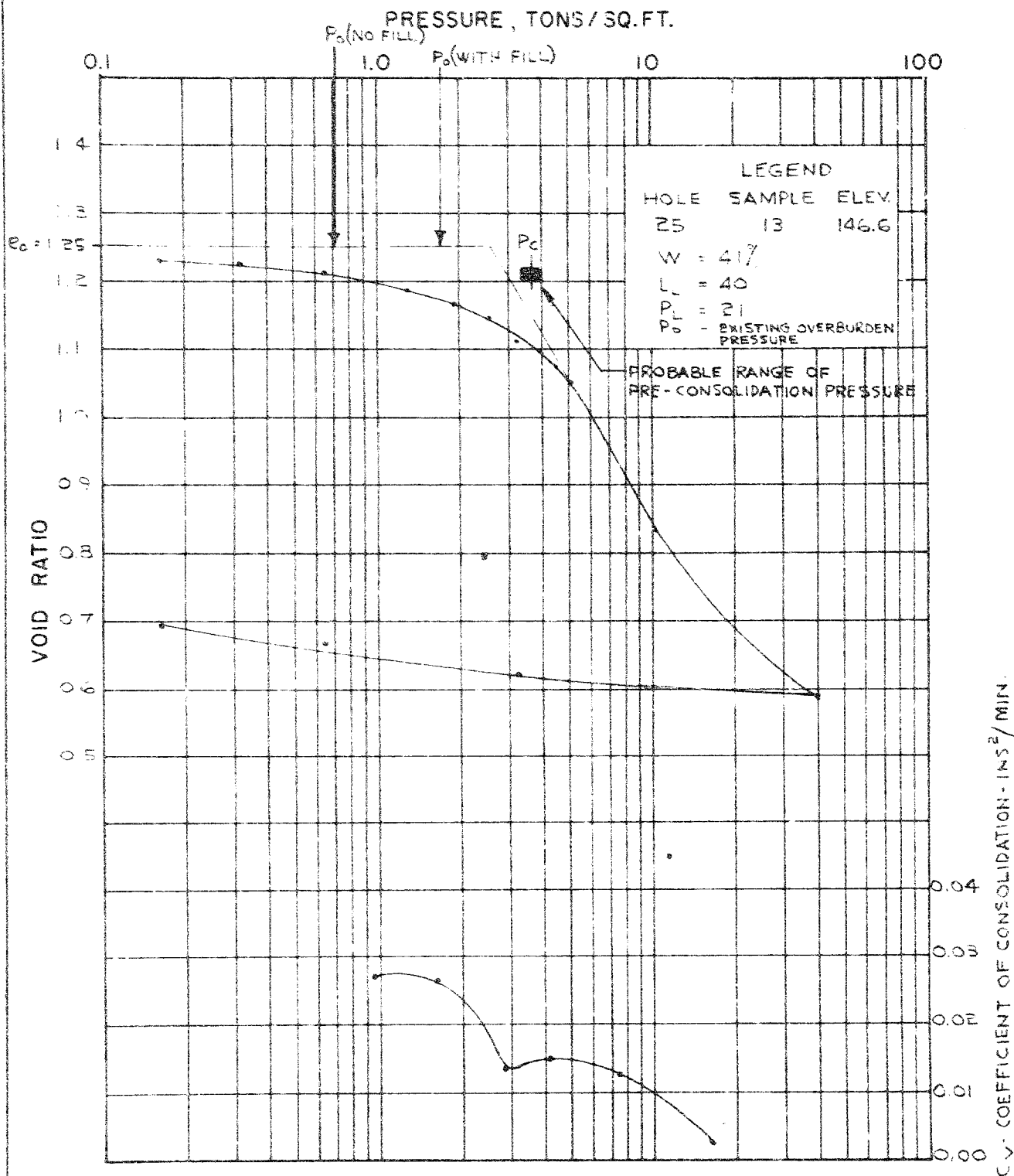
FIGURE 16



PROJECT No. 6135

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 17

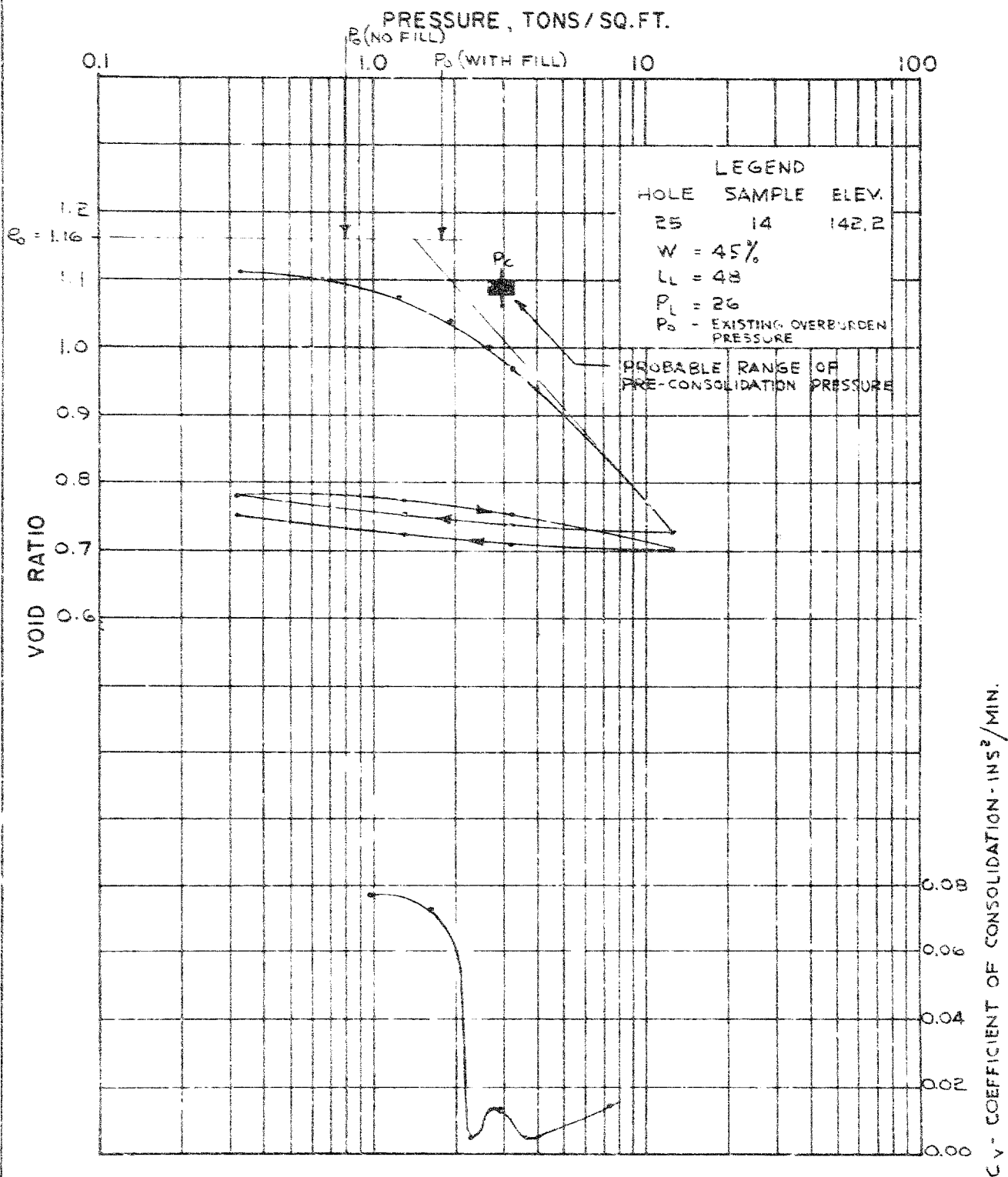


GOLDER & ASSOCIATES

PROJECT No. 6135

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

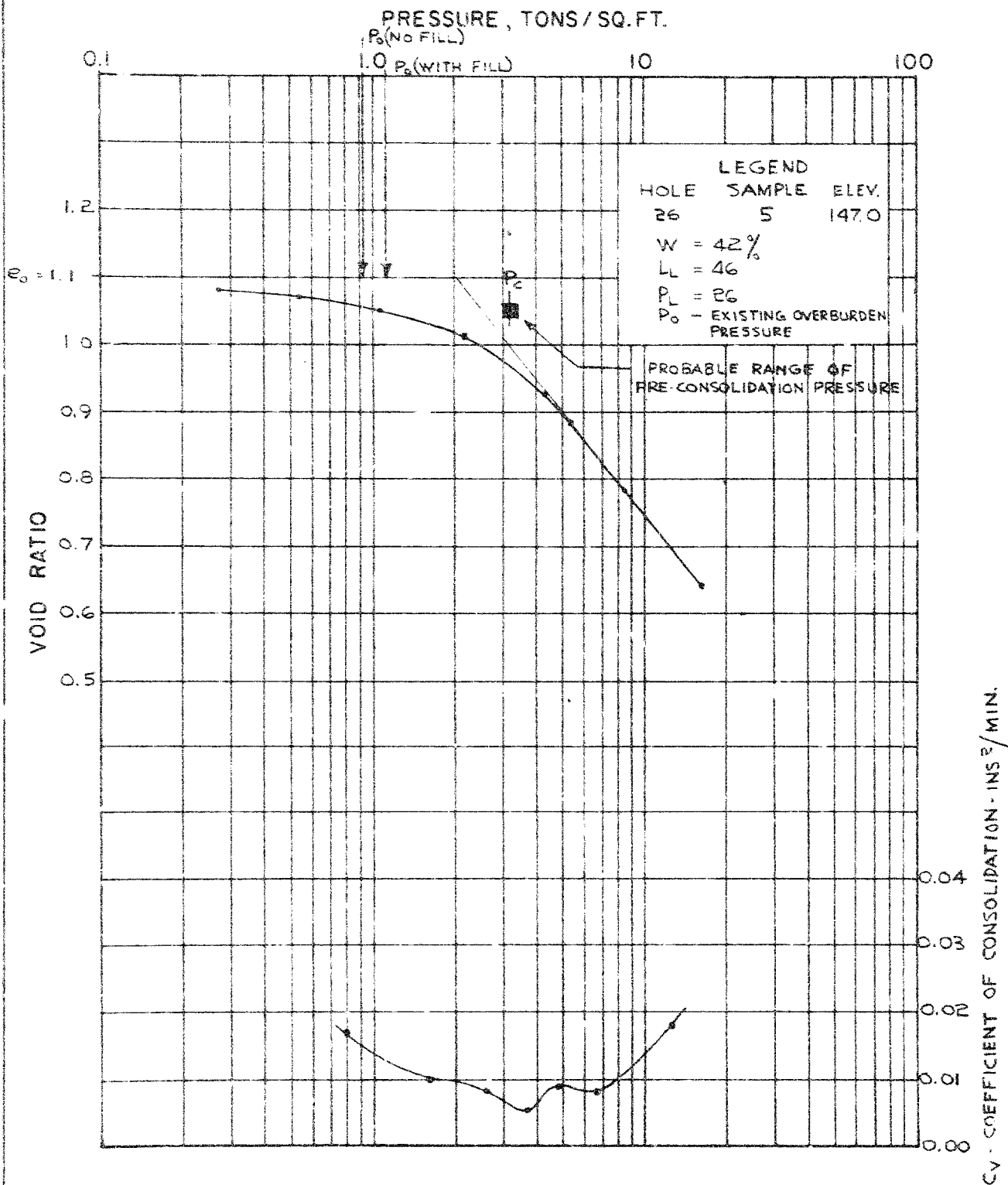
FIGURE 18



GOLDER & ASSOCIATES

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

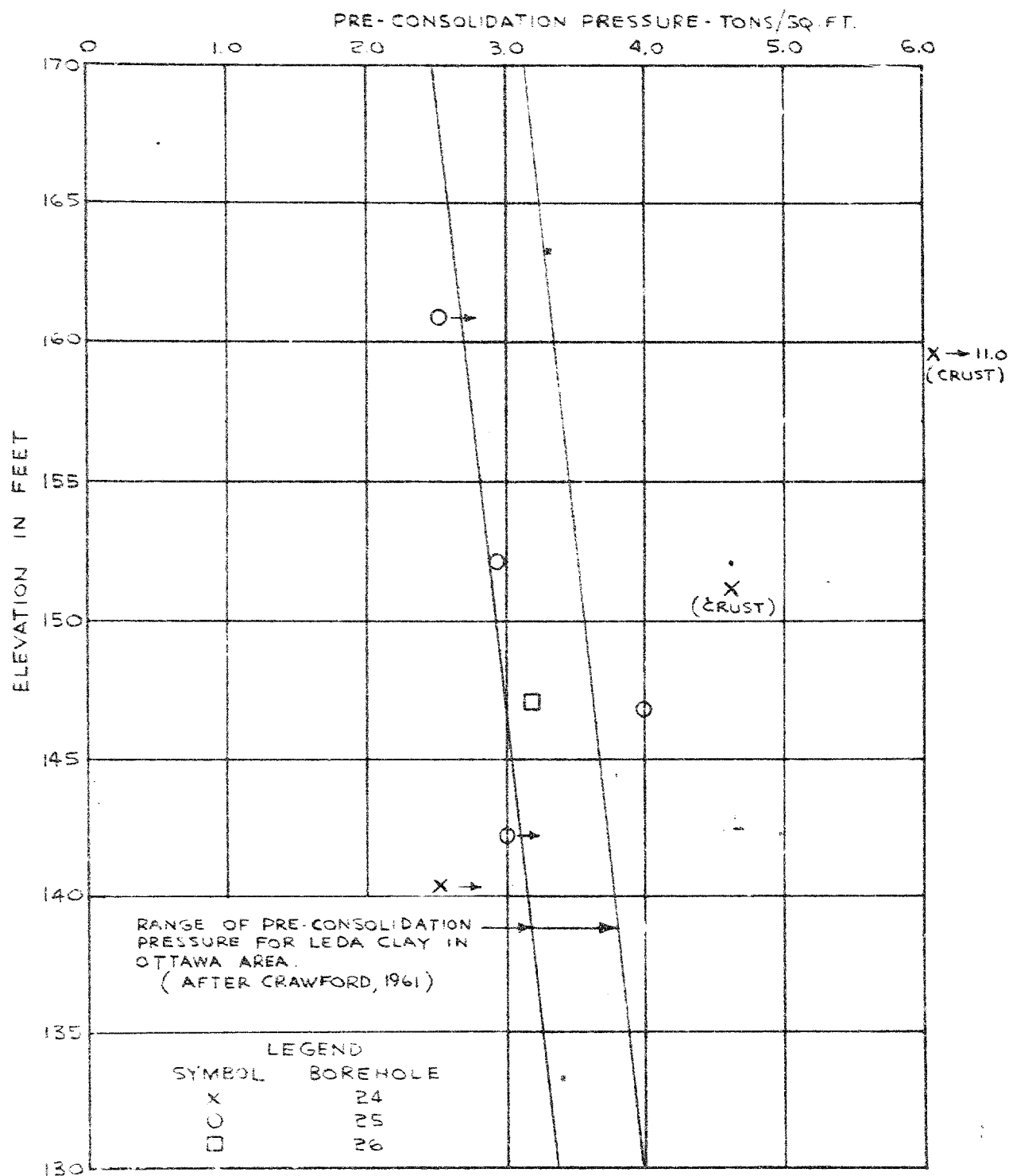
FIGURE 19



GOLDER & ASSOCIATES

PRE-CONSOLIDATION PRESSURE VS ELEVATION SILTY CLAY STRATUM

FIGURE 20



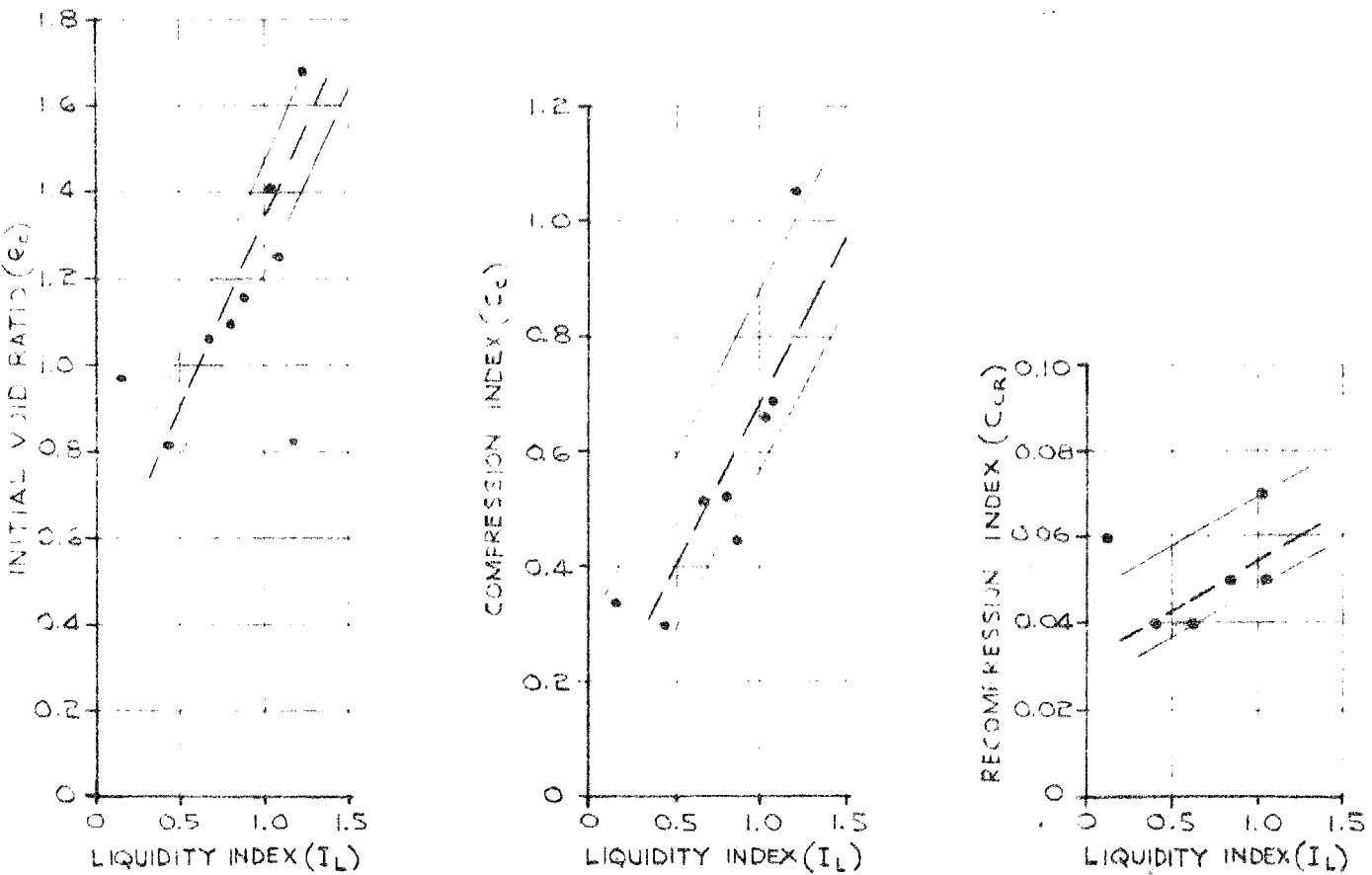
NOTE

PRE-CONSOLIDATION PRESSURE INFERRED FROM RESULTS OF CONSOLIDATION TESTS

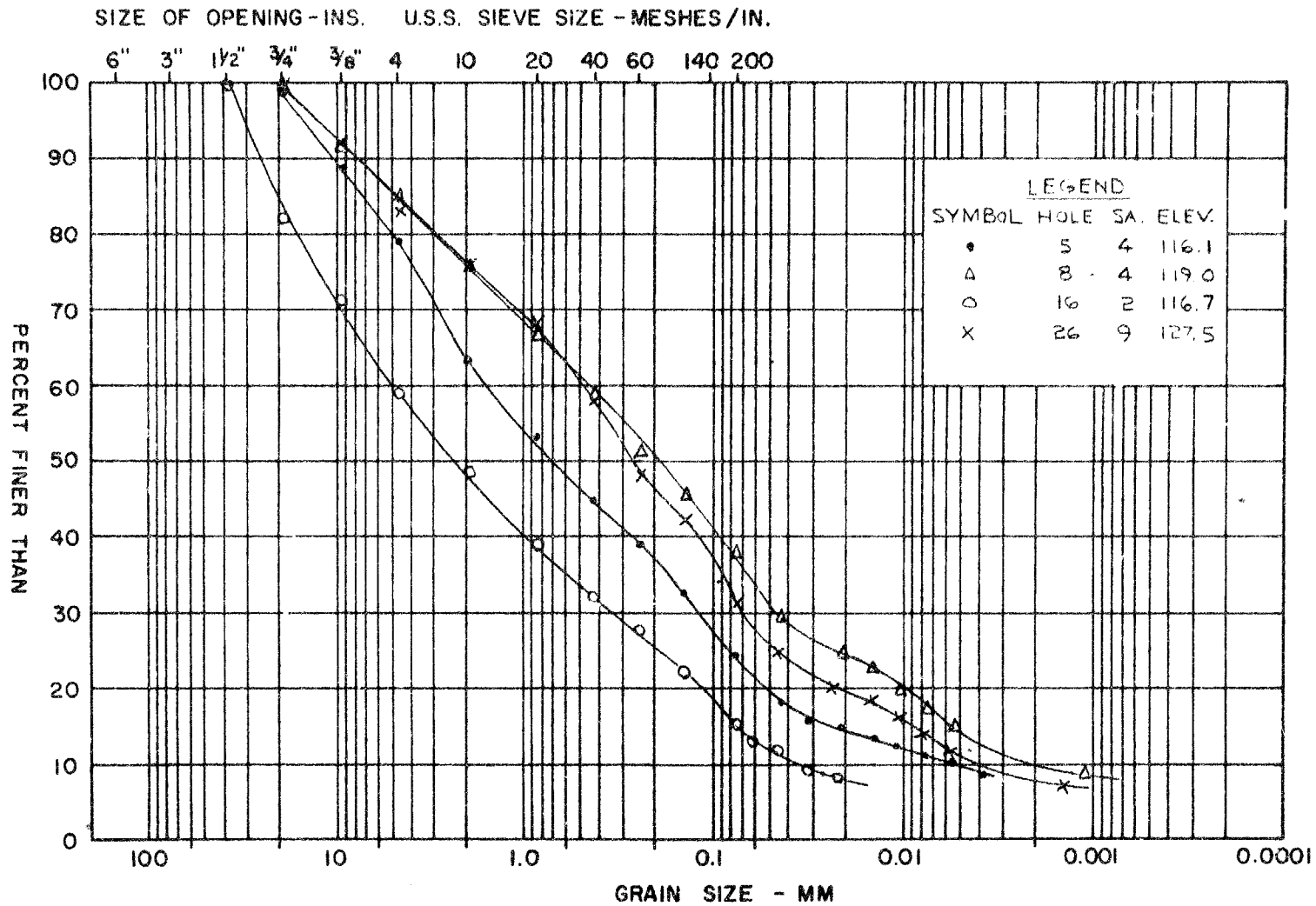
GOLDER & ASSOCIATES

CONSOLIDATION PROPERTIES SILTY CLAY

FIGURE 21



M.I.T. GRAIN SIZE SCALE

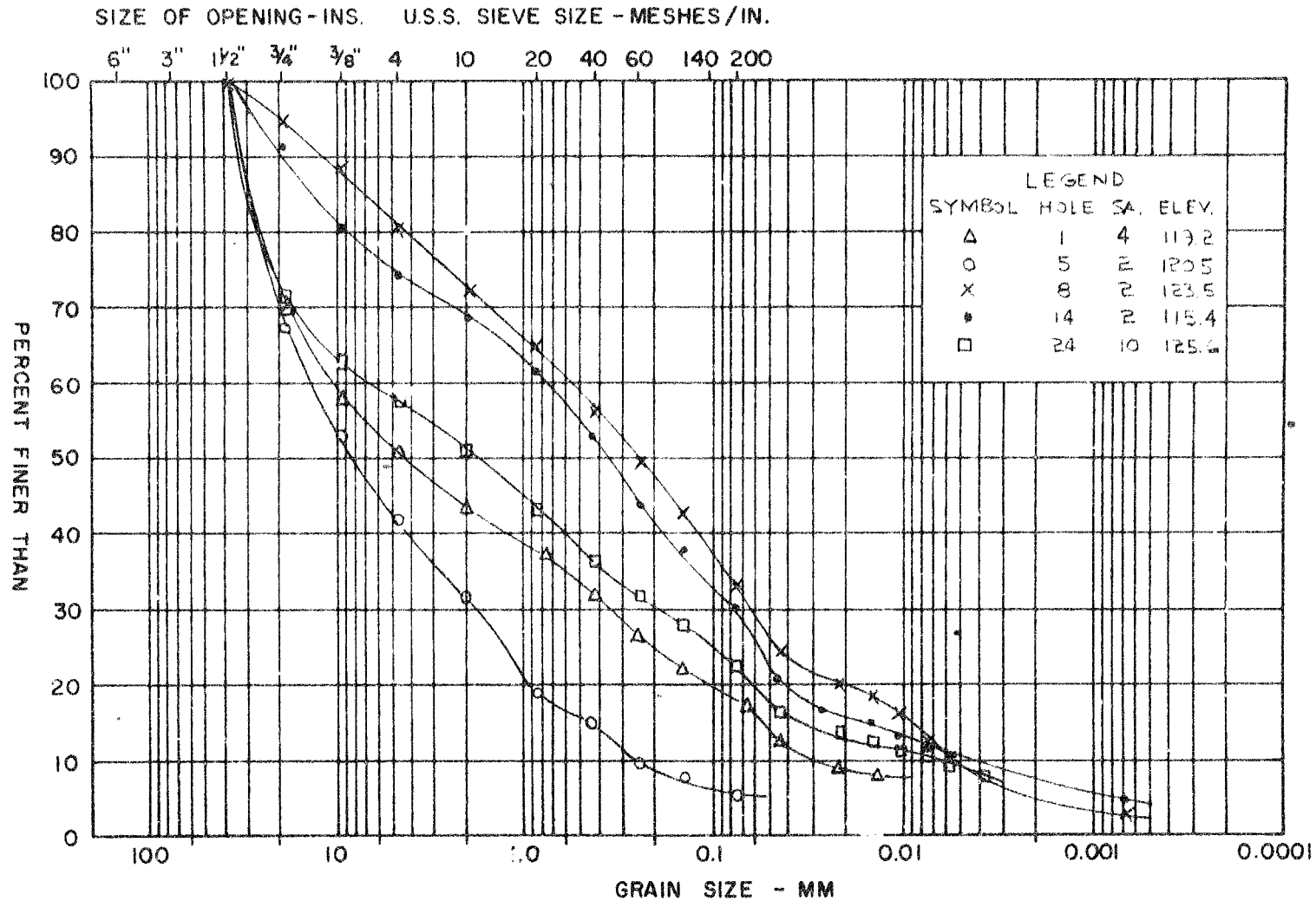


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
TILL

FIGURE 22

M.I.T. GRAIN SIZE SCALE

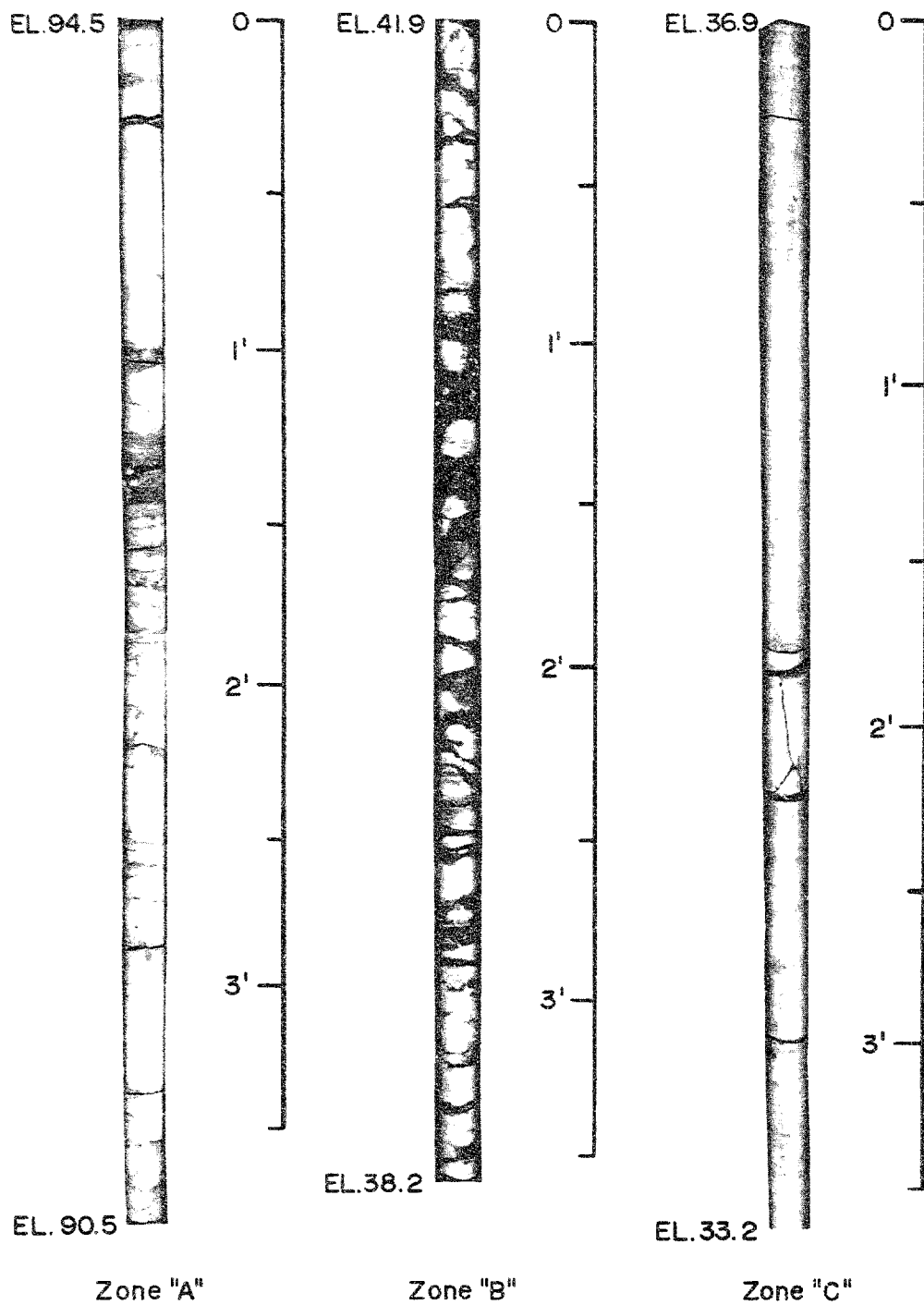


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
TILL

FIGURE 23

COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

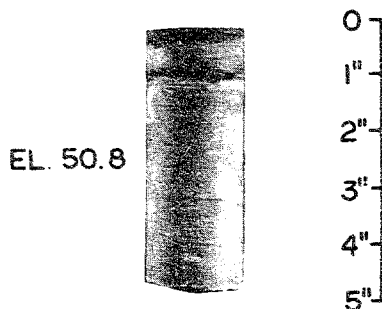


Typical bedrock core from BH13



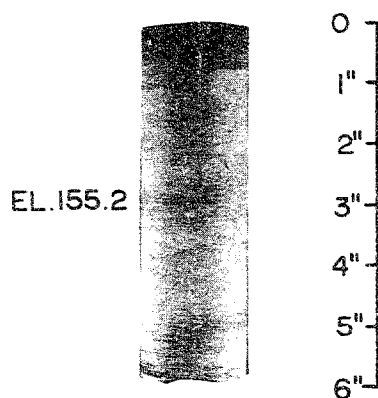
(a)
Borehole 27

Zone "A" Bedrock
Dark grey - brown finely
crystalline impure limestone



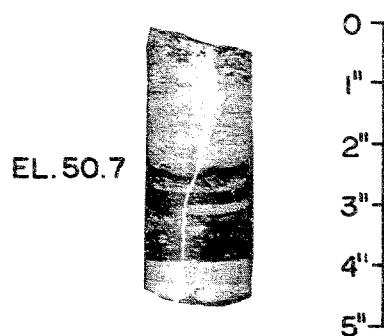
(b)
Borehole 28

Zone "A" Bedrock
Impure limestone with thin
shale partings, shale laminae



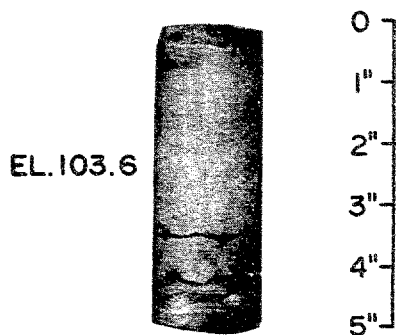
(c)
Borehole 28

Zone "A" Bedrock
Medium grained dark grey
impure limestone with shale
partings. Thin shale member
at top.



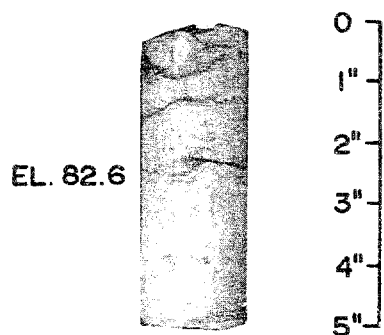
(a)
Borehole 13

Zone "A" Bedrock
Thin beds of black shale in
medium grained impure limestone.
Note healed vertical fracture



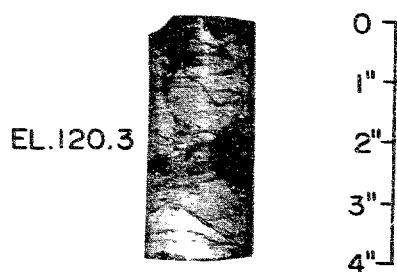
(b)
Borehole 13

Zone "A" Bedrock
Impure limestone with thin
laminae of black shale



(c)
Borehole 3

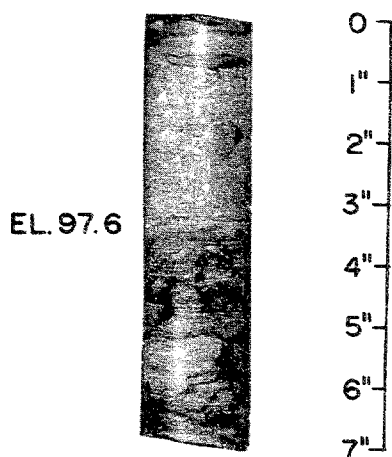
Zone "A" Bedrock
Impure limestone with shale
partings



(a)

Borehole 24

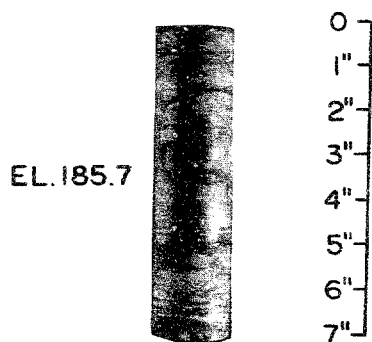
Zone "A" Bedrock
Intra-formational conglomerate
zone in impure limestone



(b)

Borehole 15

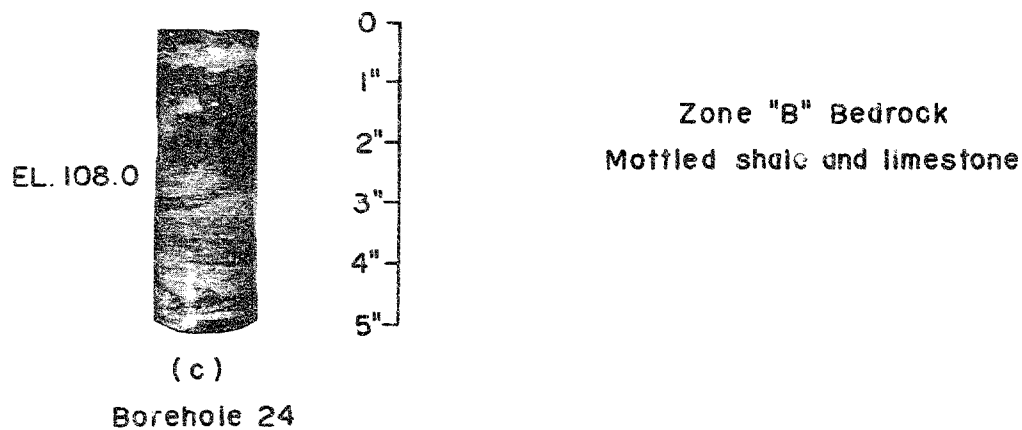
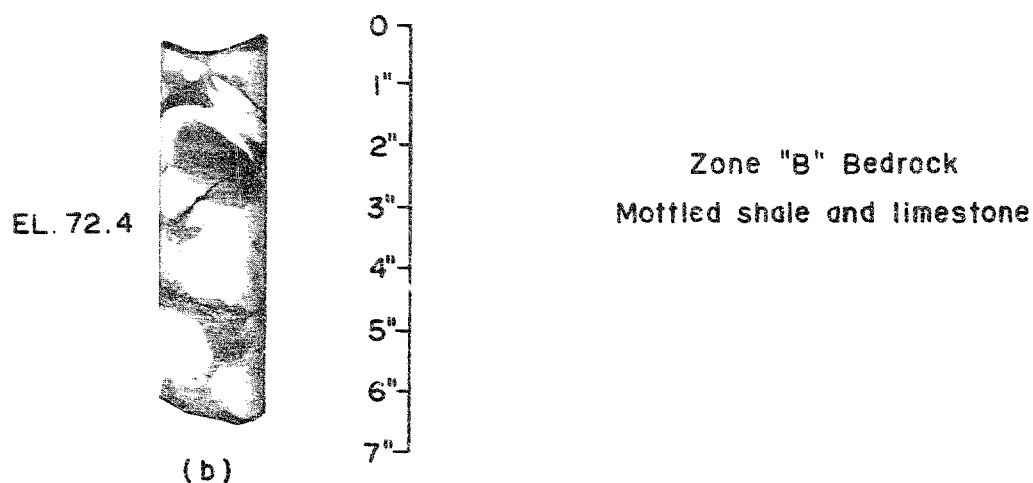
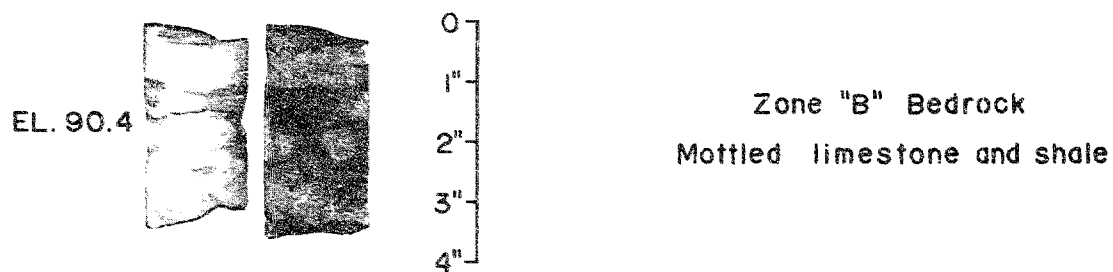
Zone "A" Bedrock
Impure limestone with shale
partings and minor intra-formational
conglomerate

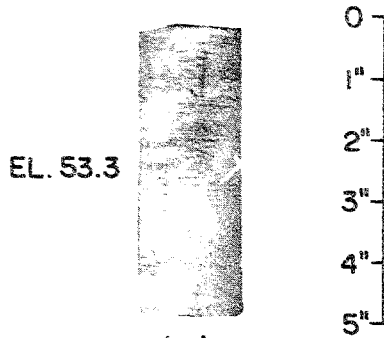


(c)

Borehole 28

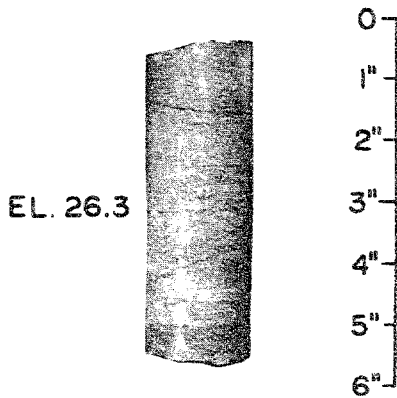
Zone "A" Bedrock
Impure limestone with intra-
formational conglomerate zone





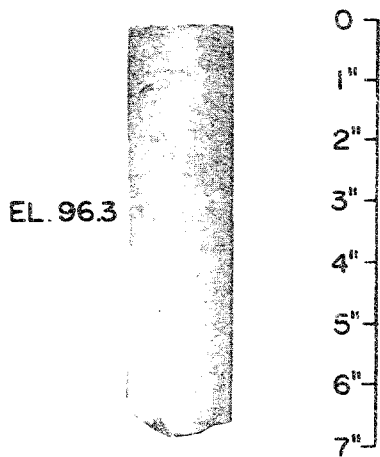
(a)
Borehole 10

Zone "C" Bedrock
Well stratified coarse-grained
crystalline limestone with shale
partings



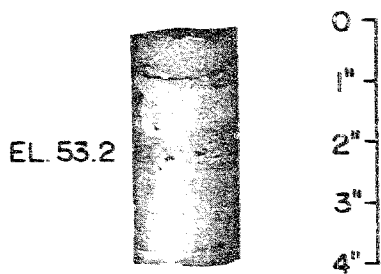
(b)
Borehole 10

Zone "C" Bedrock
Well stratified limestone with
shale partings



(c)
Borehole 24

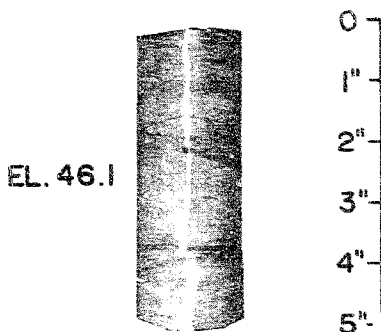
Zone "C" Bedrock
Typical coarse-grained limestone



(a)

Borehole 3

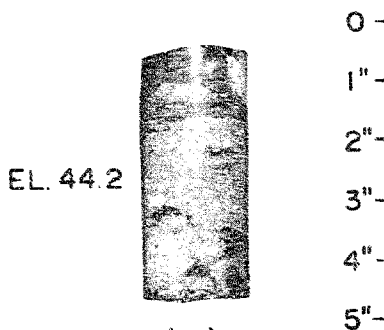
Zone "C" Bedrock
Impure limestone with shale partings



(b)

Borehole 11

Zone "C" Bedrock
Healed fracture in impure limestone with shale partings












(c)

Borehole 15










Zone "C" Bedrock
Impure limestone with shale partings

UNCONFINED COMPRESSION TEST RESULTS ROCK CORE SAMPLES

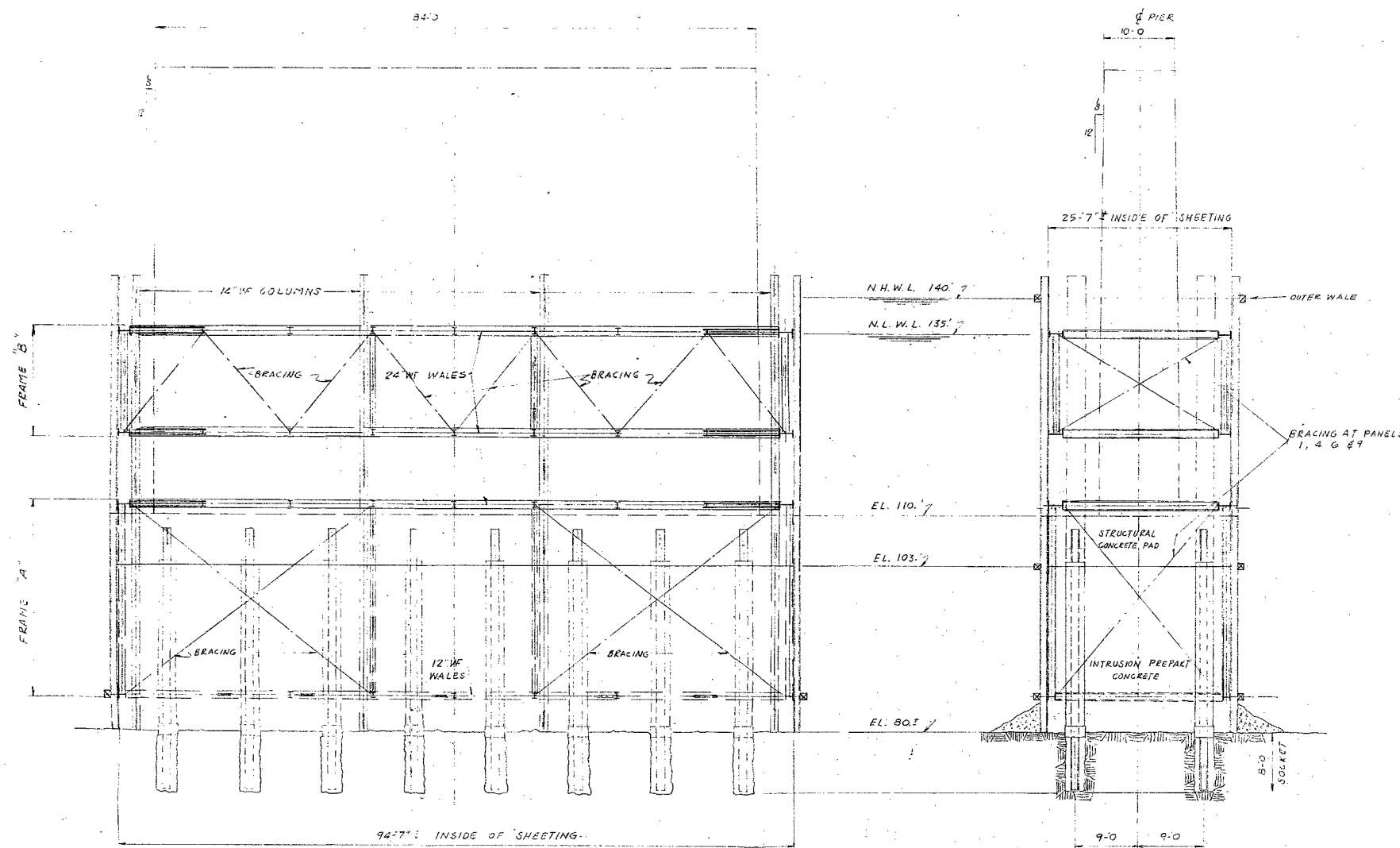
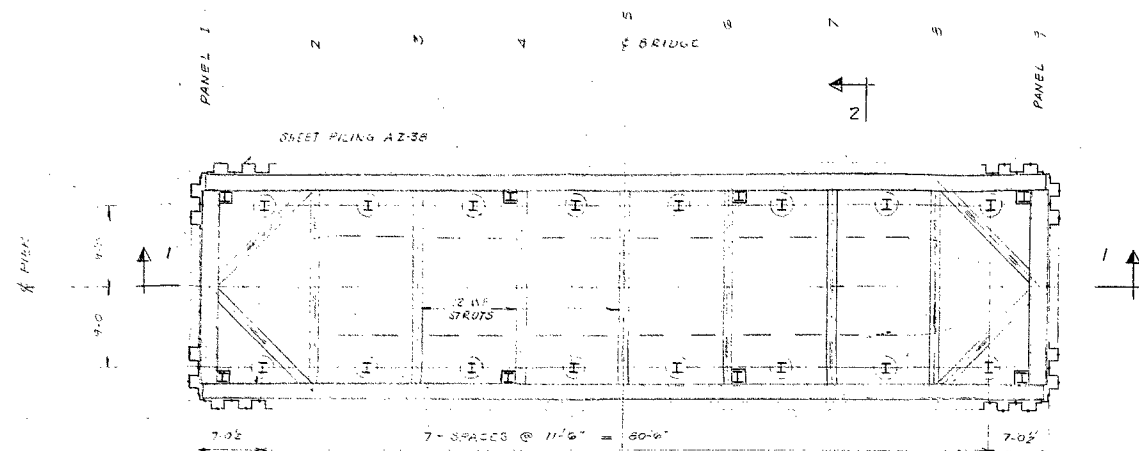
FIGURE 31

ZONE	BH	SA. ELEV.	ULTIMATE COMPRESSIVE STRESS, P.S.I.	SAMPLE DESCRIPTION	TYPE OF FAILURE
"A"	3	83.0	14,900	Well stratified limestone with shale partings	
	8	109.2	22,600	Limestone with shale partings	
	13	100.7	16,450	Limestone with shale partings	
	13	62.1	22,400	Well stratified limestone	
	15	97.3	15,050	Limestone with shale partings	
	24	120.2	15,850	Limestone with conglomerate	
	28	188.0	13,560	Fine grained limestone with shale partings	
	28	120.1	11,000	Fine grained limestone with shale partings	
	28	62.1	15,200	Fine grained limestone with shale partings	

UNCONFINED COMPRESSION TEST RESULTS FIGURE 32
ROCK CORE SAMPLES

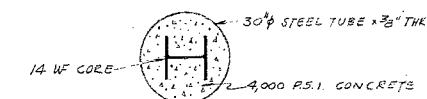
ZONE	BH.	SA. ELEV.	ULTIMATE COMPRESSIVE STRESS, P.S.I.	SAMPLE DESCRIPTION	TYPE OF FAILURE
"B"	8	91.0	—	Mottled limestone and shale	Broke during sawing
	15	72.0	7,620	Mottled limestone and shale	
	24	109.4	9,470	Mottled limestone and shale	
"C"	3	49.1	18,850	Well stratified limestone with conglomerate	
	8	75.0	16,650	Well stratified limestone with shale partings	
	10	52.4	13,800	Well stratified limestone with shale partings	
	10	26.2	18,150	Well stratified limestone with shale partings	
	13	37.3	16,000	Well stratified limestone	
	15	45.4	13,860	Coarse grained limestone and conglomerate	
	24	92.6	12,400	Coarse grained limestone and conglomerate	

#62-F-229C
PROPOSED
MACDONALD-
CARTIER BRIDGE
OTTAWA-HULL



CONSTRUCTION SEQUENCE

1. SUSPEND FRAME 'A' AND DROP H PILES THROUGH SLEEVES TO FIND DOWN LEVEL, AND ATTACH FRAME 'A' THERETO.
2. PLACE FRAME 'B' OVER H PILES AND SECURE.
3. PLACE SHEET PILING AND SECURE TO FRAME.
4. APPLY SEALING MEDIUM AROUND PERIMETER OF COFFERDAM.
5. CLEAN OFF BOTTOM INSIDE COFFERDAM.
6. DRIVE CAISSONS TUBES, DRILL SOCKETS INTO ROCK, AND PLACE SOCKET GROUT.
7. PLACE AGGREGATE AND GROUTING PIPES IN COFFERDAM.
8. GROUT AGGREGATE.
9. DEWATER COFFERDAM.
10. CUT OFF CAISSON TUBES AND STEEL W CORES.
11. POUR STRUCTURAL CONCRETE PAD.
12. FORM AND POUR PIER.
13. CUT OFF SHEET PILING AT TOP OF STRUCTURAL PAD.



PIER DETAIL

SCALE 1/8" = 1'-0"

No.		REVISIONS	BY
MACDONALD - CARTIER BRIDGE			
CONSULTING ENGINEERS			
— A JOINT VENTURE —			
BEAUCHEMIN BEATON LAPORTE MONTREAL 26 CANADA	LAUGHEIN WYLLIE UPHAL 53 KIPING AVE. SOUTH TORONTO 18 ONTARIO	A. B. SANDERSON FOR: A. B. SANDERSON & COMPANY LTD. 224 DROUGHTON STREET VICTORIA B.C.	
COFFERDAM CONSTRUCTION DETAILS			
DESIGNED: F.F.L.	CHECKED:	DATE: JUNE 4, 62	REF. No.
DRAWN: P.R.J.	APPROVED:	DWG. No. 5K-C-40	
TRACED:	SCALE: AS NOTED		