professional
services
division

SOILS INVESTIGATION

OAK ISLAND, NOVA SCOTIA

REPORT

WARNOCK HERSEY INTERNATIONAL LIMITED

SOILS INVESTIGATION

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WARNOCK HERSEY INTERNATIONAL LIMITED

Professional Services Division

Dartmouth, N.S.

July 31, 1969.

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ABSTRACT

Warnock Hersey International Limited performed a soils investigation at Oak Island, Nova Scotia. The investigation was undertaken at the request of Mr. J. Carr of Carr and Donald and Associates.

The investigation established the subsurface strata and their index and engineering properties to within the requirements of design and limitations of the materials encountered.

No specific recommendations and methods of analysis are listed in this report in lieu of the fact that no particular type of substructure is or has been proposed. This report therefore discusses conditions, precautions etc. on a purely qualitative basis. As mentioned later in the text of this report, we would be most happy to offer our services in connection with actual design on a quantitative approach to effect the completion of the project in a satisfactory manner.

INTRODUCTION

Warnock Hersey International Limited, acting at the authorization of Mr. J. Carr of Carr and Donald and Associates Ltd. contained in his letter dated May 13, 1969 to our Mr. MacDonald, performed a soils investigation at Oak Island, Nova Scotia.

The purpose of the investigation was to establish engineering characteristics of the subsurface strata in order to design underground structures that will perhaps take the form of tunnels, shafts, caissons etc.

GEOLOGY AND SITE

Oak Island is situated on the Western Shore of Nova Scotia, a few hundred feet from the mainland. It is presently joined to the mainland by a single lane causeway. The area of the site where the investigation is being performed is located on the south shore of the island.

The topography at the exploration site is very rugged. Evidence of glaciation is depicted by the large granite boulders strewn all over the ground surface. The superficial soil is primarily a glacial till comprising mainly of a silty sand matrix. It is interesting to note that boulders in the overburden are granite in composition whereas bedrock is an anhydrite. This is indicative of the once southward movement of glaciers during the glacier age.

PROCEDURE

The investigation program was commenced on May 21, 1969 and four holes were completed as of the 20th of July, 1969. The drillers are presently on their fifth hole. All holes were located by Mr. Dan Blankenship and the locations are shown in a borehole location plan appendixed to this report. The north area shown in the plan entitled "Oak Island Explorations" prepared by Carr and Donald and Associates Ltd. is assumed to bear magnetic north.

The field program was performed using a skid mounted heavy duty BBS-1 (Boyles Bros) hydraulic head drill rig. The overburden at the commencement of a hole was cased at HX size. When the HX casing could no longer be advanced or when drilling became difficult, the casing was then telescoped into NX.

Similarly, at larger and larger depths, the telescoping of the outside casing continued from NX to BX and from BX to AX size. Diamond articles were employed in each case to advance the casing. Whenever it was required to clean the insides of the casing, this was accomplished by either the use of a roller cone or the core barrel.

The field testing programs consisted of performing standard penetration tests in the boreholes at every change in the strata and whenever possible, at intervals of approximately five feet. The samples retrieved from the performance of the standard penetration tests were classified

and stored in the laboratory.

Laboratory tests were performed on different disturbed samples retrieved during the performance of the standard penetration test in order to determine the index properties of the material. The results of the moisture contents are shown on the borehole records. Mechanical analyses and Atterberg Limits are shown on Grain Size Distribution and Plasticity Chart sheets respectively, appendixed to this report. All laboratory tests were performed in accordance with the respective governing ASTM Designations.

All soil samples and rock cores will be retained in our Dartmouth laboratory for a period of six months from the date of issue of this report. The samples will later be discarded unless information to the contrary is received within that period of time.

The work was carried out as recommended by "Method for Diamond Core Drilling for Site Investigations" (ASTM - D2113-62T)

and by the National Building Code of Canada, 1965, Part 4.2, Foundation Design. In accordance with N.B.C. of Canada Code No. 4.2.2.1.1. a, we certify that all exploration, testing, and application of soil mechanic principles were carried out by personnel competent in these fields of work.

Procedures for the soils investigation performed were in accordance with "Code for Split-Barrel Sampling of Soils" (CSA-A119.1 - 1960) and Standard Penetration tests thereof.

A survey was performed to locate and obtain the ground surface elevations of the boreholes. The ground surface at the "large stake" representing hole 24(L) shown on the plan "Oak Island Exploration" was assumed to be at elevation 100.00'. As mentioned earlier, the north arrow shown on the same plan was assumed to bear magnetic north and all locations were obtained with respect to the "large stake".

SOIL PROFILE AND CONDITIONS

The overburden material at the investigation site is glacial in composition and probably mainly of the Pleistocene epoch. The matrix varies considerably at different depths but it is felt that predominantly all of the overburden material deposition is in some way connected with glaciation. The isolated sand and varved silts and clay strata encountered are probably glacial material water sorted by melting waters of the glaciers.

Bedrock is composed of Gypsum and Anhydrite with some seams of shale and the odd seam of a volcanic rock. Anhydrite is nothing but a dehydrate of Gypsum. The cavities encountered in bedrock in certain holes are possibly caused by the chemical or mineral $CaSO_4$ going into solution.

The cavities encountered in the boreholes in the overburden material and in bedrock are probably either air voids or pockets of loose saturated silty sand. In lieu of the depth at which these irregularities

were encountered, it was observed that the drilling equipment penetrated these zones under its own weight. It is extremely difficult to obtain a sample of so loose a material in a saturated state, thus leading to an even greater doubt as to what is actually existant in these areas. However, it is more likely that the voids or cavities in the overburden material are filled with some material as against the cavities in bedrock.

It is the writer's opinion that Borehole No.2 was performed in a previously drilled hole. This accounts for the amazing loose and soft nature of the material encountered and the ease of advancement of the borehole.

In conclusion, the soil stratigraphy at the site is so heterogeneous that no general unifying statements can be made. The subsurface strata is best judged at a particular location by observation of the borehole records closest to the particular location.

GROUNDWATER CONDITIONS

Water level readings were taken daily in the boreholes and at the termination of the boring of each hole. The results of the readings are shown on a "Water Level Observation" plan appendixed to this report.

During the advancement of the boreholes, the water level readings in the silt and clay glacial tills are not truly indicative of the static water table level in the area. This is a result of the high quantity of water employed in the boring process and the semi-impervious nature of the overburden material. To obtain the actual static water table level, drilling would have to be terminated for an interval of time (depending on the material encountered) long enough for the water level in the borehole to stabilize. The actual intervals of time in the readings observed are roughly ten to twelve hours;;the time between termination and starting of drilling on two successive days.

It is noted that once a pervious sand stratum is encountered, the water level in the hole immediately stabilizes approximately in line with the tide level at the island.

The permeability of the different materials from the different strata vary considerably. The permeability of a soil is a prime function of the percentage of fines contained in the material. Approximate estimated coefficients of permeability for the silt and silty sand layers is 10^{-6} to 10^{-7} cms/sec. Fair to high coefficients of permeability in clean sands of the order of 10^{-3} to 10^{-1} cms/sec can be expected.

DISCUSSIONS, RECOMMENDATIONS, AND CONCLUSIONS:

It is apparent that the crux of the problem when attempting to sink a shaft or caisson etc. at the site will be to contend with the water. A few of the possible ways to eliminate the seepage of water will be by internal freezing of the soil in front of the advancing shaft or tunnel, chemical grouting, or the use of pneumatic caissons.

The use of pneumatic caissons are however restricted to depths at which water heads are approximately 115' (50psi) in lieu of the human capability to work.

Before any excavation method or type of substructure is adopted, a thorough research and feasibility study should be conducted to ascertain the probability of success and the various difficulties that might be encountered

Regarding structural design of the shaft or caisson etc., various soil pressure diagrams have been recommended by different people such as Peck, Borman, Terzaghi, Goldbeck, Muhs and others for a variety of different conditions. In most cases, these recommendations are based on actual field measurements carried out on various substructures built in connection with bridges, subways etc.. It is evident that the total horizontal force exerted by a soil medium is a combination of the horizontal soil reaction and the hydrostatic water pressure dependant

upon the level of the free water table. It is the adoption of a soil pressure or reaction diagram that involves a certain amount of judgment.

In sands and clays, it is evident that a triangular soil pressure diagram with a base equal to γHKa (the active pressure) is unrealistic. Peck and Terzaghi instead recommend a rectangular load diagram with an ordinate equal to $0.65\gamma HKa$. Similarly, in clays a trapezoidal pressure distribution diagram is recommended, the ordinates of which vary with the state of stress and consistency of the clay. In view of the preliminary nature of this investigation, specific recommendations cannot be made; however, a few precautions mentioned in the following paragraphs might be taken.

During excavation in the glacial material below the water table, adequate precautions will have to be taken to account for or to prevent blowouts or heaves at the bottom of

the excavation. This is most likely to occur when the excavation approaches a pervious stratum underlying an impervious material. The vertical force imbalance caused by the difference in the upward hydrostatic pressure acting on the base of the impermeable stratum and the downward weight of the same stratum remaining (that which has not been excavated) could be the source of a blow out.

In open excavations with shoring, bracing, etc., an adequate factor of safety should be employed in order to avoid the possibility of a single unit or strut collapsing. The single collapse of an individual component can lead to a progressive failure due to the redistribution of stresses.

The writer would like to mention that he has been connected with the design and research of flexible buried structures under the advice of Dr. G.G. Meyerhof (Dean of Engineering at the Nova Scotia Technical College). Dr. Meyerhof has headed research and practical

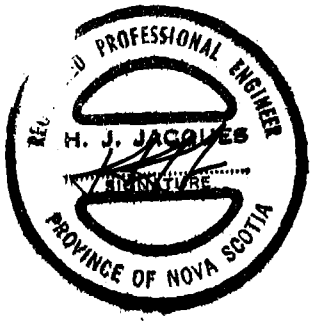
design in the field of flexible substructures (corrugated pipes and tunnels) better known at the present time as soil-structure interaction. The principle of soil structure interaction is based on the force that arching in a soil exhibits when suitably provided with a flexible inner lining (that is the structure itself). A flexible structure in this instance is a must in order that some displacement is effected in order to mobilize the full arching in the soil. Tunnels and shafts as large as sixteen feet in diameter have been successfully constructed based on the soil-steel structure interaction principle with large saving in cost. The writer of this report is the author of a M. Engineering Thesis entitled "Strength of Flexible Semi-Circular Arches under Compacted Clay Backfill", the aim of which was to determine preliminary qualitative modes and predictions of soil-structure failures in cohesive and highly plastic soils.

In conclusion, if the design and construction of a tunnel is to be a reality, we would be

most happy to get involved with whatever personnel and equipment we have at our disposal. The writer feels confident that the services of Dr. Meyerhof can be solicited in this instance in order to evaluate, recommend and enhance the evolution of a suitable and economical design.

Respectfully submitted,

WARNOCK HERSEY INTERNATIONAL LIMITED
Professional Services Division.



Hector J. Jacques, M.Eng., P. Eng.,
Assistant Manager Geotechnical Services.

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110
BOREHOLE NO. 1
CASING NX-BX-AX
DATUM assumed

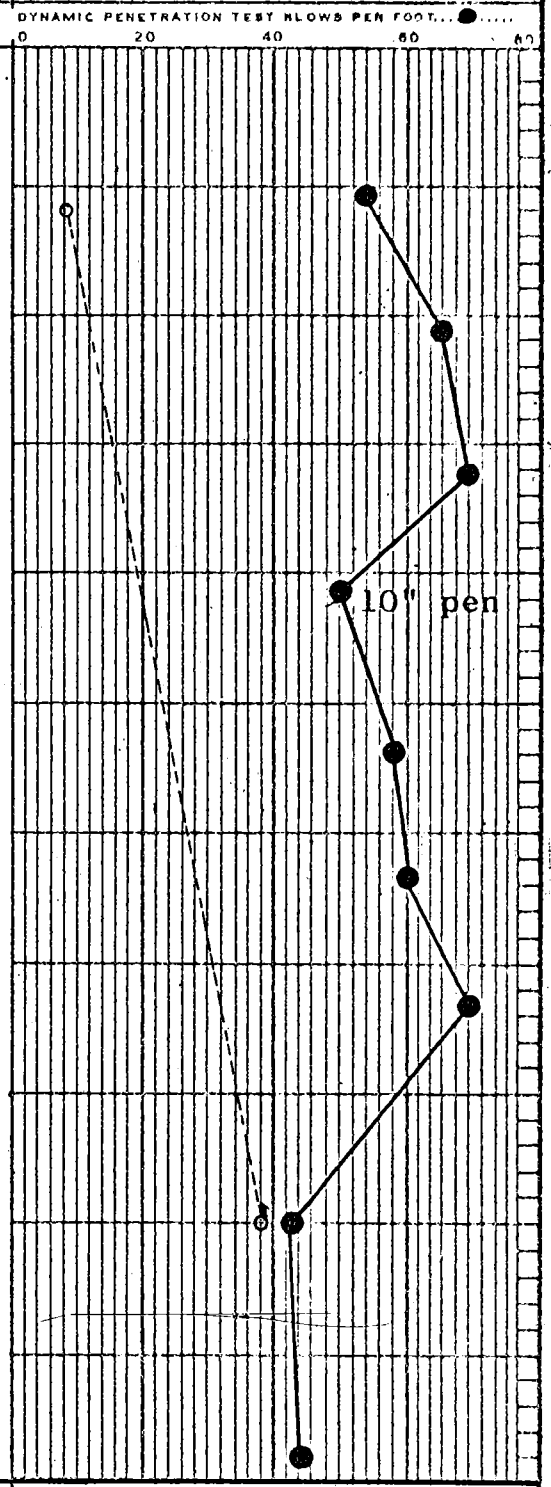
CLIENT Carr & Donald & Associates
LOCATION Oak Island
DATE OF BORING May 22-June 7/69 DATE OF WL READING June 2/69

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
0	116.6									
		Dense brown glacial till. Matrix mainly silt and sand.			D	SS	1	10	54	
	106.5									
10		Hard grey glacial till. Matrix varies from a sandy silt to silty clay.			D	SS	2	6	66	
15					D	SS	3	10	70	
20					D	SS	4	6	50+	
25					D	SS	5	6	58	
30					D	SS	6	6	60	
35					D	SS	7	6	70	
40										
45					D	SS	8	10	43	
50										
	62.5									
55	60.5	Silty sand			D	SS	-	0	44	
		Continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS.
Wp W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT...
0 20 40 60 80



OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 1

LOCATION Oak Island — CASING NX-BX-AX

DATE OF BORING May 22-June 7 — DATE OF WL READING June 2/69 — DATUM assumed

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
55	60.5	Silty sand.								
60	55.5				D	SS	-	0	59	
		Hard brown glacial till. Cobbles and boulders predominant. Turning softer with depth.			D	SS	-	0	30	
65										
					D	SS	9	4	37	
70										
					D	SS	10	7	18	
75										
80					D	SS	-	0	16	
85					D	SS	-	0	10	
					D	SS	11	1	25	
90										
95					D	SS	-	0	21	
100					D	SS	12	3	37	
105										
					D	SS	13	3	35	
110	5.5									
		continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBURG LIMITS. Wp W Wl

DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80

6" pen

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

BOREHOLE NO. 1

CLIENT Carr & Donald & Associates

LOCATION Oak Island

CABIN NX-BX-AX

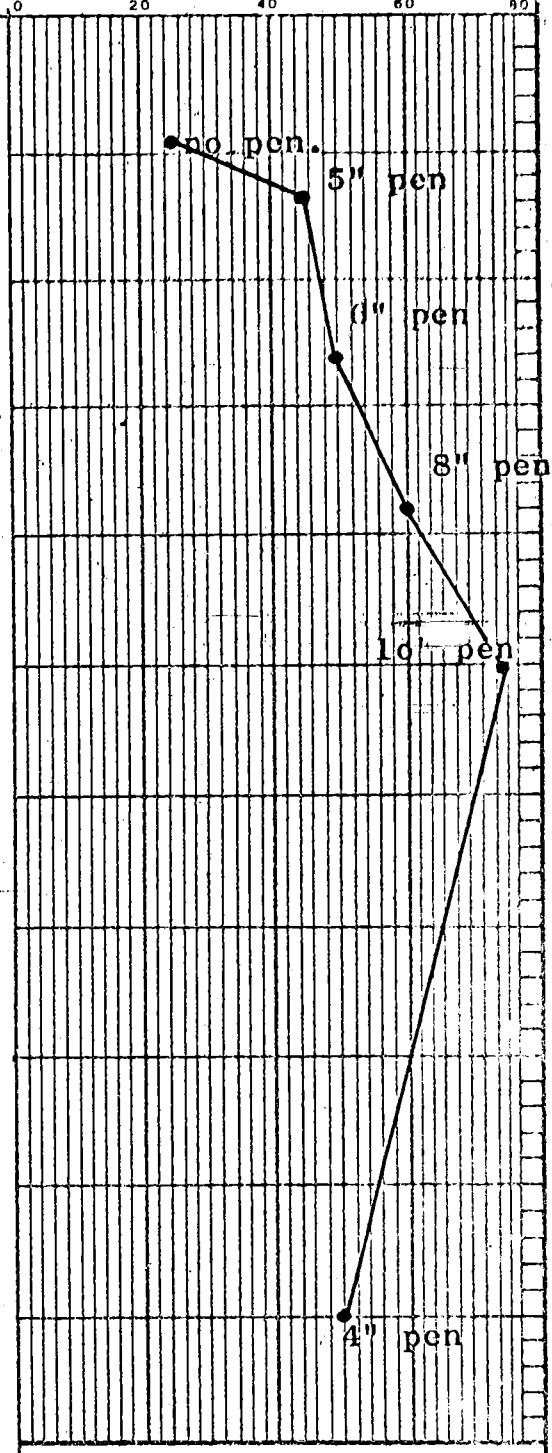
DATE OF BORING May 22 - June 7 DATE OF WL READING June 2 DATUM assumed

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
110	5.5	Brown hard glacial till.								
115	-0.5				D	SS	-	0	25+	
					D	SS	14	4	45+	
120		Mixture. dense glacial till and varved silty clay			D	SS	15	6	50+	
125		Glacial till mixture mainly a yellow silty sand								
130					D	SS	16	8	60+	
135	-19.5				D	SS	17	10	75+	
		Cavity or possibly loose saturated silty sand.								
140										
145	-30.6									
	-31.5	Compact glacial t			D	SS	18	6	7	
150		Cavity or possibly loose saturated silty sand.								
	-37.5									
	-38.5	Compact silt								
155		Loose saturated silty sand.								
160	-44.5									
	-45.5	Gypsum cobbles			D	SS	19	4	50+	
		Bedrock - Anhydri fractured			RC	BXT	1	14/60		
165	-50.5									
		continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. Wp W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80



OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110
BOREHOLE NO. 1
CASING NX-BX-AX
DATUM assumed

CLIENT Carr & Donald & Associates
LOCATION Oak Island
DATE OF BORING May 22 - June 7 DATE OF WL READING June 2

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL)	LAB TEST RESULTS: DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, 80)
165	-49.5	Bedrock - Anhydri fractured. Some crystallisation between 171-181'			RC / BXT		2	60/60				
170							3	60=/60				
175							4	32/60				
180	-65.5											
		Cavity or very loose saturated silty sand.										
185	-71.0											
		Mixture of sand and stiff varved silt. Strength increases with depth.										
190												
195												
					D	SS	20	7/	58			
200												
	-88.5											
205		Bedrock - Anhydri 204'-240' Severely fracture with soft gypsum pocket at 220'. 240-250' fairly sound.			RC / AXT		5	0/36				
							6	36/48				
210							7	35/72				
215												
220							8	31/72				
223	-107.5	continued										

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 1

LOCATION Oak Island — CASING NX-BX-AX

DATE OF BORING May 22 - June 7 — DATE OF WL READING June 2 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N - VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, WL)	LAB TEST RESULTS: DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, 80)
220	107.5											
		Bedrock - Anhydrite					9	51/84				
225												
230												
235					RC	AXT	10	97/120				
240												
245							11	120/120				
250	-134.5											
		End of Hole 250.0'										
255												
260												
265												
270												
275												

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 2

LOCATION Oak Island — CASING HX-NX-BX-AX

DATE OF BORING June 10-19/69 — DATE OF WL READING June 16/69 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, 80)
0	100.0										
		Mixture of silty sand gravel and cobbles. Some organic material.									
5					D	SS	1	12	19		
10					D	SS	2	0	5		
15	85.0										
		Very loose to loose silty sand, saturated and sensitive.			D	SS	-	0	5		
20					D	SS	-	0	0-1		
25											
30											
35											
40					D	SS	-	0	0-1		
45					D	SS	-	0	0-1		
50											
55	45.0				D	SS	2	3	1		
		continued									

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 2

LOCATION Oak Island — CASING HX-NX-BX-AX

DATE OF BORING June 10-19/69 — DATE OF WL READING June 16/69 — DATUM assumed

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS
55	45.0										
60		Very loose to loose silty sand. Saturated and sensitive.									
65											
70											
75					D	SS	-	0	1		
80											
85											
90											
95											
100	0.0	Stiff sandy clay with silt and sand lense's.			D	SS	3	12	10		
105											
	-8.0				D	SS	4	12	14		
110	-10.0	Loose silty sand									

WATER CONTENT & ATTERBERG LIMITS: WP — W — WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT... ● 0 20 40 60 80

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 2

LOCATION Oak Island — CASING HX-NX-BX-AX

DATE OF BORING June 10-19/69 — DATE OF WL READING June 16/69 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS
110	-10.0	Very loose to loose silty sand. Saturated and sensitive. Traces of glacial clay.									WATER CONTENT & ATTERBERG LIMITS. Wp W WL; DYNAMIC PENETRATION TEST BLOWS PER FOOT....K 0 20 40 60 80
115											
120											
125											
130											
135											
140											
145											
150											
155											
160											
165	-65.0	continued									

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 2

LOCATION Oak I$land — CASING HX-NX-BX-AX

DATE OF BORING June 10-19/69 — DATE OF WL READING June 16/69 — DATUM assumed

SOIL PROFILE					SAMPLES					LABORATORY TESTS PERFORMED	LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE		WATER CONTENT & ATTERBERG LIMITS: Wp — W — WL; DYNAMIC PENETRATION TEST BLOWS PER FOOT ● 0 20 40 60 80
165	-65.0										
		Silty sand and gravel. Loose to compact. Some glacial material.			D	SS	-	0	23		
170					D	SS	-	0	22		
175					D	SS	-	0	58		
180											
185											
190											
195					D	SS	5	3	14		
200	-102.0										
		Sand, gravel and anhydrite cobbles									
205											
210	-112.0										
		Bedrock- Anhydrite 212-217 severely fractured.			RC →	AXT →	1	19/60			
215											
220					RC →	AXT →	2	37/60			
	-122.0										
		continued									

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OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 2

LOCATION Oak Island — CASING HX-NX-BX-AX

DATE OF BORING June 10-19/69 — DATE OF WL READING June 16/69 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N-VALUE	LABORATORY TESTS PERFORMED
220	-120.0									
225		Bedrock- Anhydrite 217-241 - fairly sound. Some formation of crystals @ 225' 241-251.5 moderately fractured			RC	BXT	3	60/60		
230							4	60/60		
235							5	48/48		
240							6	60/60		
245							7	53/60		
250	-151.5						8	56/66		
		End of Hole 251.5'								
255										
260										
265										
270										
275										

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. WP W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT....K 0 20 40 60 80

CANADA BLUE PRINT CO. LTD. FORM - 103

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

BOREHOLE NO. 3

CASING HX-NX-BX-AX

DATUM assumed

CLIENT Carr & Donald & Associates

LOCATION Oak Island

DATE OF BORING June 20-July 4 DATE OF WL READING June 26th/69

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
0	111.7									
		Hard glacial clay with granite cobbles and boulders. Cobbles and boulders predominant between 38-42'.								
10					D	SS	-	0	21	
15					D	SS	1	12	46	
20					D	SS	-	0	28+	
25					D	SS	2	15	34	
30					D	SS	-	0	40+	
35					D	SS	3	12	60	
40					D	SS	-	0	40+	
45					D	SS	-	0	40+	
50					D	SS	-	0	58	
55	56.7									
		continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. Wp W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT... ● 0 20 40 60 80

6" pen

6" pen

no pen

no pen

CANADA BLUE PRINT CO. LTD. FORM - 103

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 3

LOCATION Oak Island — CASING HX-NX-BX-AX

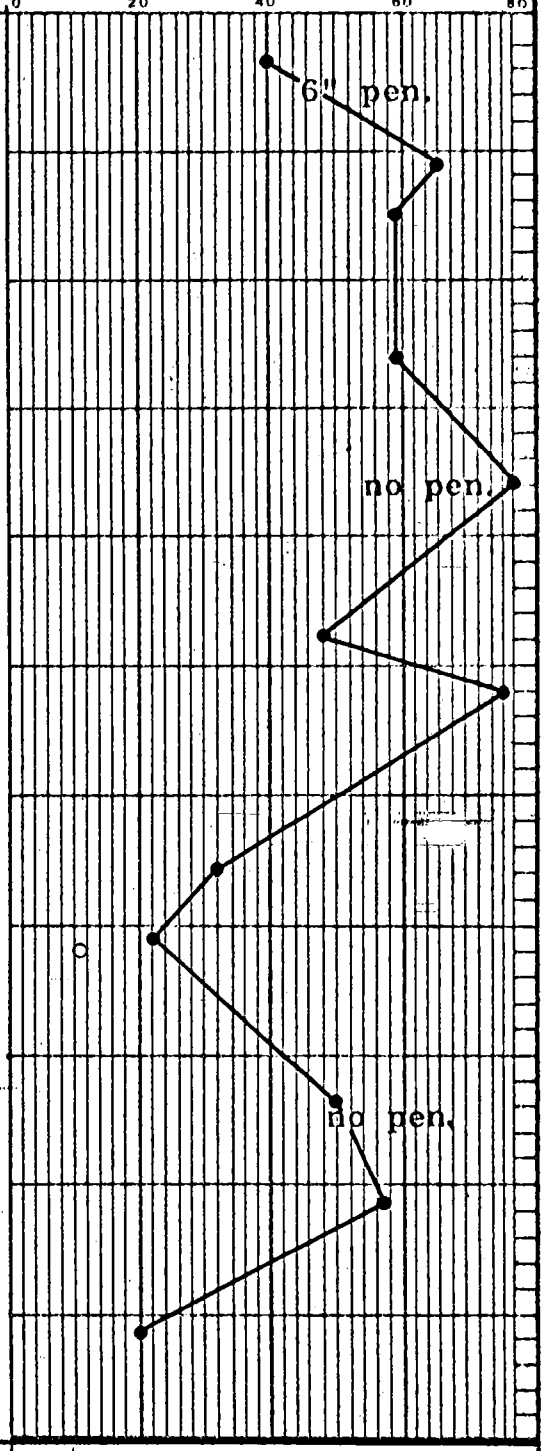
DATE OF BORING June 20-July 4 — DATE OF WL READING June 26th — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
55	56.7									
		Till. Hard glacial clay with granite cobbles and boulders.			D	SS	-	0	40+	
60					D	SS	4	3	66	
					D	SS	5	2	59	
65										
					D	SS	6	3	59	
70										
					D	SS	-	0	80+	
75										
					D	SS	-	0	48	
80					D	ss	7	14	78	
		Some stiff varved silt Between 87-90' and 100-105'								
85					D	SS	8	20	32	
90					D	SS	9	18	22	
95					D	SS	-	0	50+	
100					D	SS	10	15	57	
105					D	SS	1	0	20	
110	110.7									
		continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. WP W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60 80



CANADA BLUE PRINT CO. LTD. FORM - 103

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Asssociates

LOCATION Oak Island

BOREHOLE NO. 3

CASING HX-NX-BX-4X

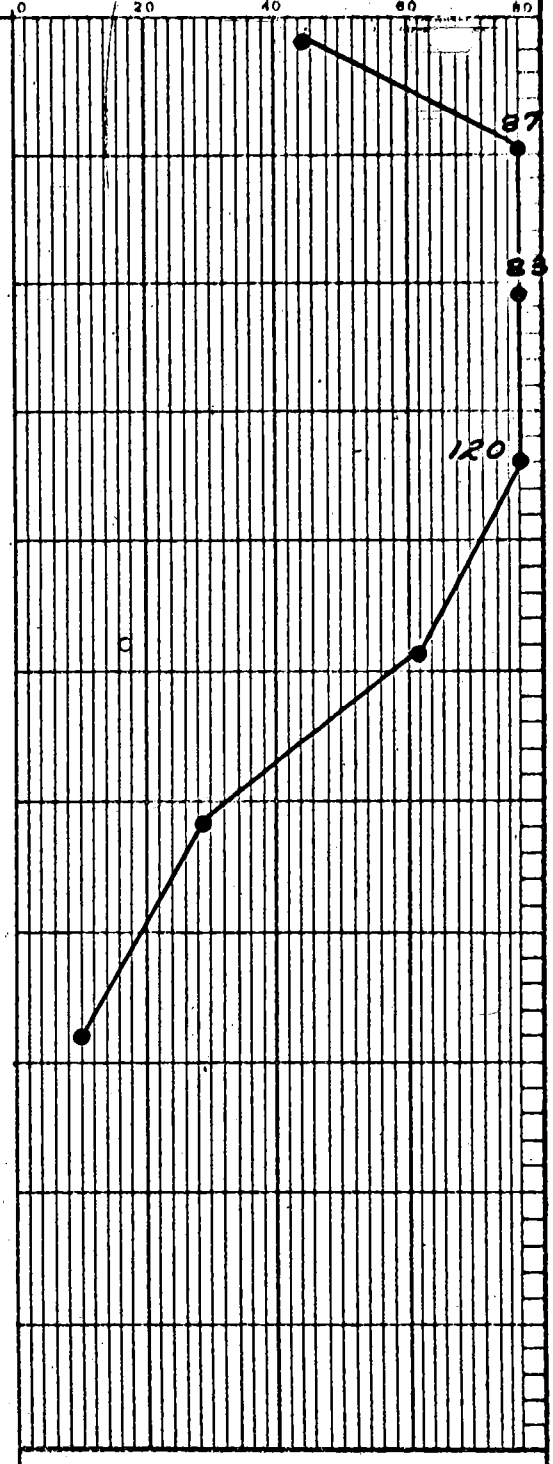
DATE OF BORING June 20 - July 4 DATE OF WL READING June 26, 1969 DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
110	1.7									
		Hard Glacial Clay with granite and anhydrite cobbles and boulders.			D	SS	-	0	45	
115					D	SS	11	12	87	
120					D	SS	-	0	83	
125		Sand Content appreciable between 142-150'			D	SS	12	12	120	
130										
135					D	SS	13	20	62	
140					D	SS	14	8	29	
145										
150	-38.3				D	SS	15	10	10	
		Anhydrite cobbles and glacial clay. Cobbles predomina								
155										
160	-49.3									
		Bedrock: Anhydrit			RC	BXT	1	26/48		
165	-54.3									
		Continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. WP W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80



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OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates

BOREHOLE NO. 3

LOCATION Oak Island

CASING HX-NX-BX-AX

DATE OF BORING June 20-July 4 DATE OF WL READING June 26

DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
165	-54.3	Cavity								
170	-58.3	Silty sand								
175	-66.3	Bedrock - Anhydrite Cavity between 182-185'			RC	BXT	2	40/66		
180							3	16/30		
185	-74.3	Silty sand and gravel. Composition Anhydrite								
190										
195	-85.3	Bedrock- Anhydrite severely fractured			RC	BXT	4	48/60		
200							5	60/60		
205							6	40/48		
210							7	60/60		
215							8	56/60		
220	-109.3	continued								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. WP W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT.... N .....

0 20 40 60 80

CANADA BLUE PRINT CO. LTD. FORM - 103.

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr & Donald & Associates — BOREHOLE NO. 3

LOCATION Oak Island — CASING HX-NX-BX-AX

DATE OF BORING June 20-July 4/69 — OF WL READING June 26 — DATUM assumed

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, 80)
220	220-106.3										
225		Bedrock - Anhydrite and shale, 220'-246'. Anhydrite 246-248 shale			RC	BXT	9	54/60			
230							10	60/60			
235							11	60/60			
240							12	48/60			
245	-136.3						13	48/48			
250		End of Hole 248'					14	36/36			
255											
260											
265											
270											
275											

CANADA BLUE PRINT CO. LTD. FORM - 103

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr and Donald and Associates — BOREHOLE NO. 6

LOCATION Oak Island — CASING HX-NX-BX

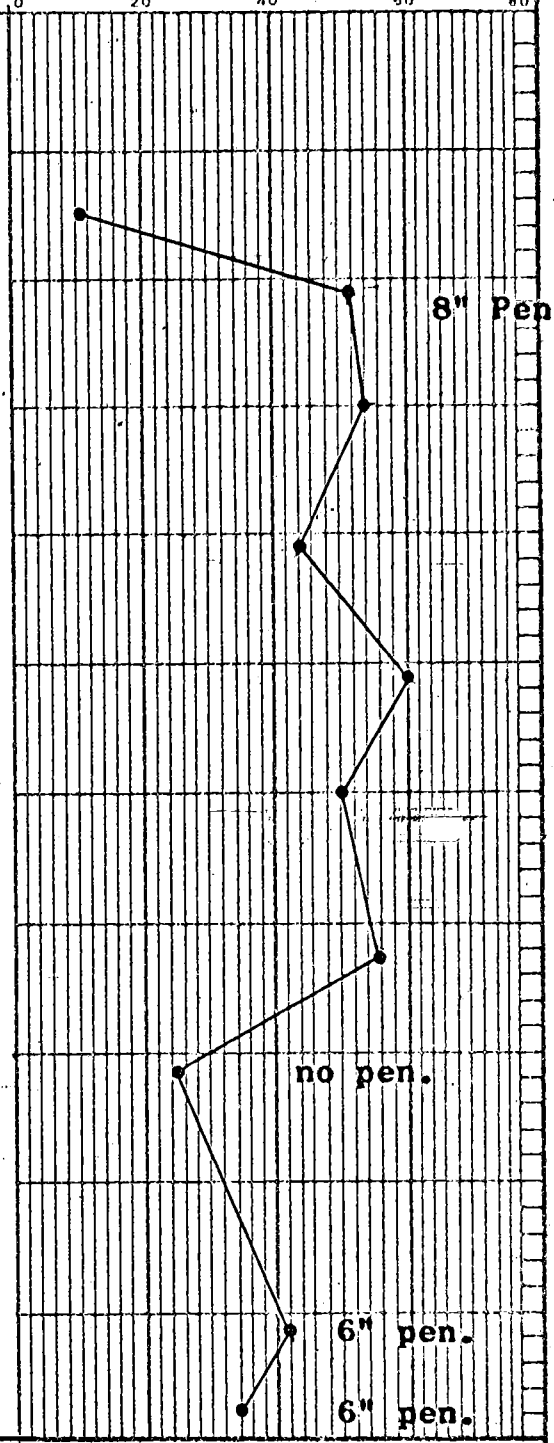
DATE OF BORING July 6-20, 1969 — DATE OF WL READING July 8, 1969 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
0	110.7									
		Dense Brown glacial till, Matrix mainly silt and sand			D	SS	-	0	11	
10					D	SS	1	8	52+	
				▽	D	SS	2	12	54	
20					D	SS	3	12	44	
	86.7									
25		Hard grey glacial till. Matrix mainly a silty and sandy clay			D	SS	4	8	60	
30					D	SS	5	7	50	
35					D	SS	6	10	56	
40					D	SS	-	0	25+	
45										
50					D	SS	-	0	42+	
					D	SS	7	4	34+	
55	55.7									

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. Wp W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT... ●..... 0 20 40 60 80



continued --

OFFICE BOREHOLE RECORD

APPENDIX

CLIENT Carr and Donald and Associates — PROJECT NO. 530-110

LOCATION Oak Island — BOREHOLE NO. 6

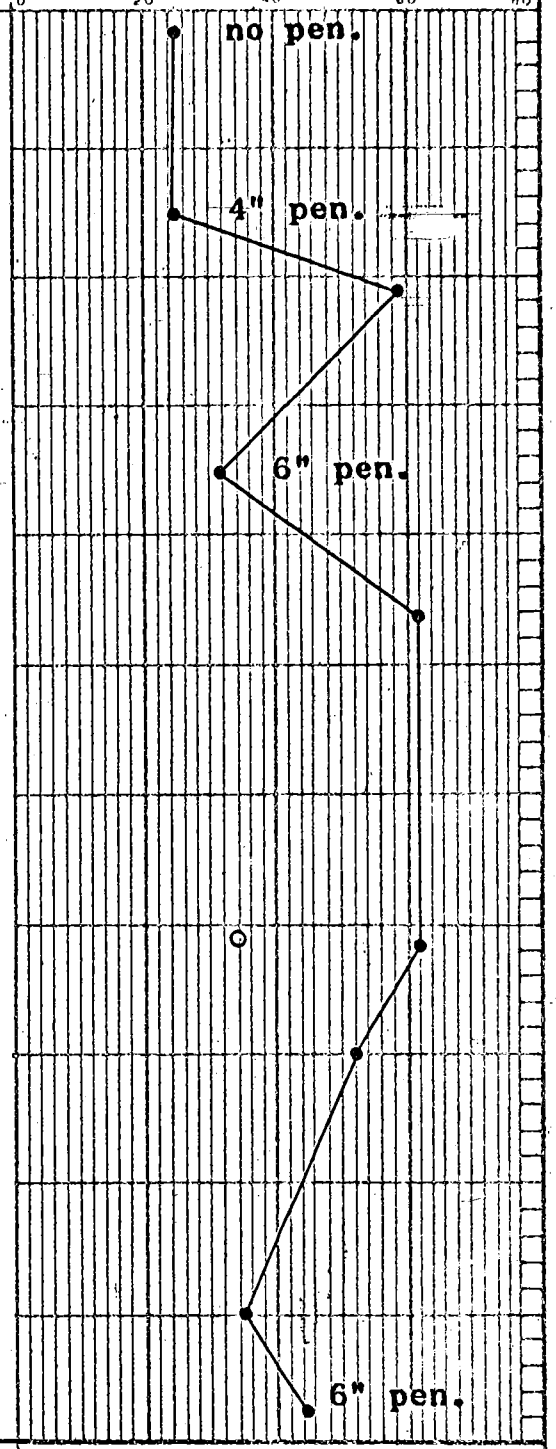
DATE OF BORING July 6-20, 1969 — DATE OF WL READING July 8, 1969 — CASING HX-NX-BX — DATUM assumed

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
55	55.7									
		Hard grey glacial till, Matrix mainly a silty and sandy clay			D	SS	-	0	25+	
60					D	SS	8	2	25+	
65					D	SS	9	12	59	
70					D	SS	-	0	32+	
75					D	SS	-	0	62	
80										
85										
90	80.7				D	SS	10	18	62	
		Grey-brown highly plastic varved clay. Alluvial-Glacial intermittant layers			D	SS	11	18	50	
100										
105					D	SS	12	14	35	
	2.7									
110	0.7	Glacial till			D	SS	-	0	45+	

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS: Wp — W — WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT: ● 0 20 40 60 80



continued --

OFFICE BOREHOLE RECORD

APPENDIX
PROJECT NO. 330-110
BOREHOLE NO. 6
CASING HX-NX-BX
DATUM assumed

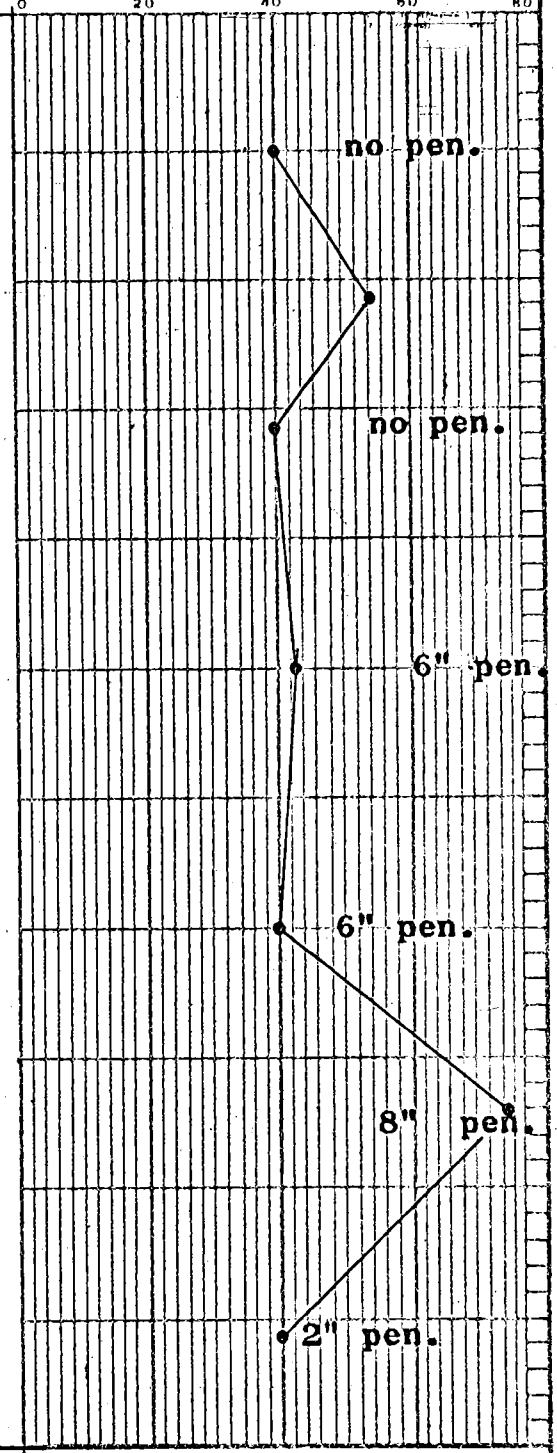
CLIENT Carr and Donald and Associates
LOCATION Oak Island
DATE OF BORING July 6-20, 1969 DATE OF WL READING July 8, 1969

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
110	0.7	Glacial till. Hard brown. Matrix extremely coarse grained. Silty sand & cobbles predominant between depths 120' to 173'. Some varved clay at 152'.								
115					D	SS	-	0	40+	
120					D	SS	13	6	55	
125					D	SS	-	0	40+	
130										
135					D	SS	-	0	43+	
140										
145					D	SS	-	0	40+	
150										
155					D	SS	14	8	77+	
160										
165	-54.3				D	SS	-	0	40+	

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS. Wp W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80



continued --

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

BOREHOLE NO. 6

CLIENT Carr and Donald and Associates

LOCATION Oak Island

CASING HX-BX-NX

DATE OF BORING July 6, 1969 — DATE OF WL READING July 8, 1969 — DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS
165'	-54.3	Glacial till. hard brown. silty sand, Matrix.			D	SS	15	4	40+		WATER CONTENT & ATTERBERG LIMITS. Wp W Wl
170'	-62.3				D	SS	-	0	35+		DYNAMIC PENETRATION TEST BLOWS PER FOOT... ● ..... 0 20 40 60 80 — 6" pen; no pen.
175'		Bedrock: - Anhydrite 173'-19 Fractured anhydri e with grey and whit seams. 6" gypsum a 197'. 198'- 227' Anhydrite with sea of volcanic rock. Probably andesite, fractured. 227'- 250' Fractured anhydrite, grey and white seams, some distinct crystallization at 239'.			RC / BXT		1	44/44			
180'							2	60/60			
185'							3	60/60			
190'							4	60/76			
195'							5	60/60			
200'							6	60/60			
205'							7	60/60			
210'							8	60/60			
215'							9	60/60			
220'							10	60/60			
223'	-112.3	continued									

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OFFICE BOREHOLE RECORD

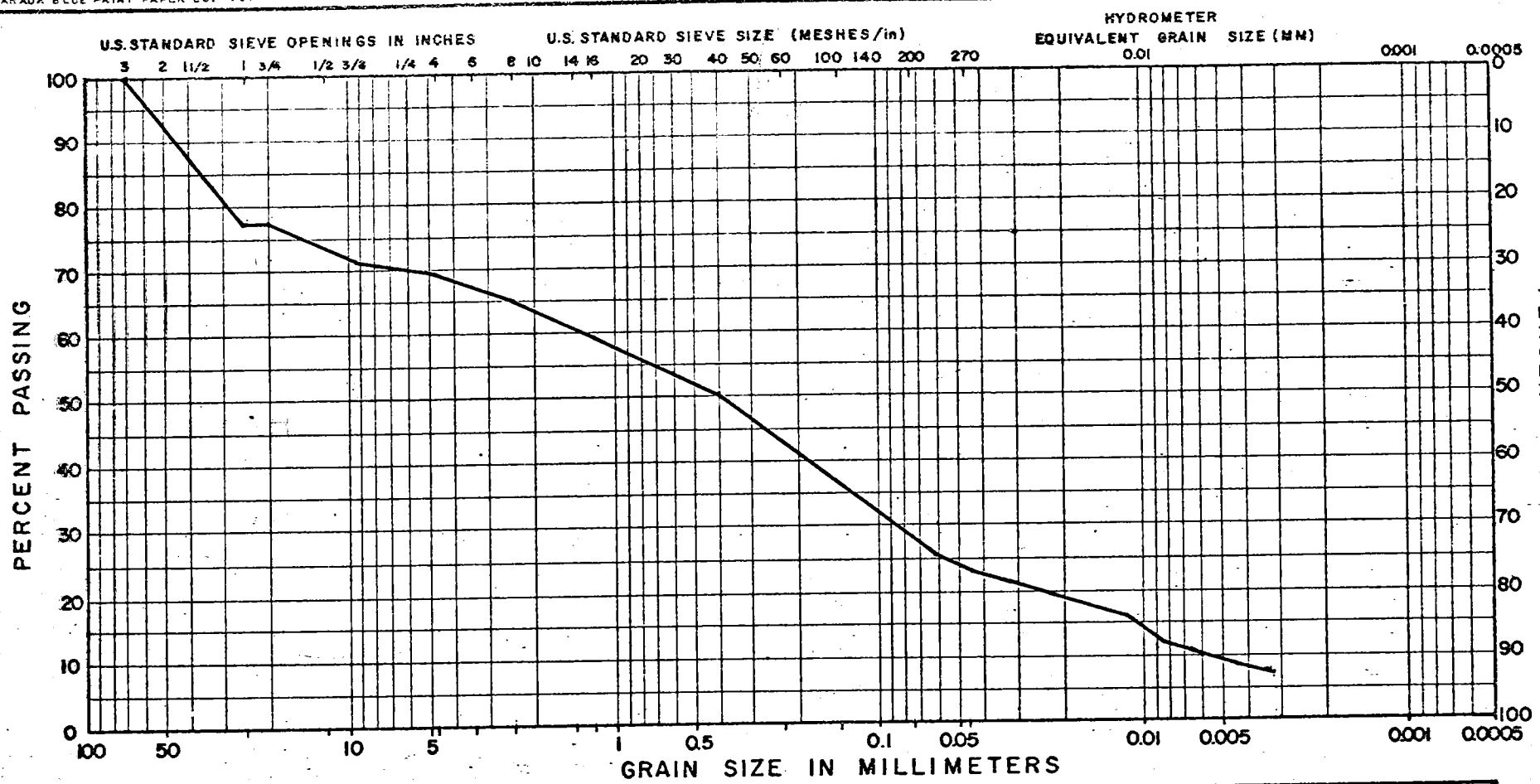
APPENDIX

CLIENT Carr and Donald and Associates
LOCATION Oak Island
DATE OF BORING July 6-20, 1969 DATE OF WL READING July 8, 1969

PROJECT NO. 530-110
BOREHOLE NO. 6
CASING HX-NX-BX
DATUM assumed

SOIL PROFILE					SAMPLES						LABORATORY TESTS PERFORMED	LAB TEST RESULTS
DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE			WATER CONTENT & ATTERBERG LIMITS. WP W WL; DYNAMIC PENETRATION TEST BLOWS PER FOOT....K 0 20 40 60 80
220	-109.3											
		Bedrock - Anhydrite				RC BXT	11	60/60				
225							12	24/24				
230							13	60/60				
235							14	60/60				
240							15	60/60				
245							16	60/60				
250	-139.30											
		End of Hole 250.0'										
255												
260												

GRAIN SIZE DISTRIBUTION



	GRAVEL			SAND			SILT	CLAY
	Coarse	Medium	Fine	Coarse	Medium	Fine		

M.I.T CLASSIFICATION SYSTEM.

	GRAVEL	FINE GRAVEL	SAND				SILT	CLAY
			Coarse	Medium	Fine	Very Fine		

U.S. BUREAU SOIL CLASSIFICATION.

	GRAVEL		SAND			CLAY & SILT
	Coarse	Fine	Coarse	Medium	Fine	

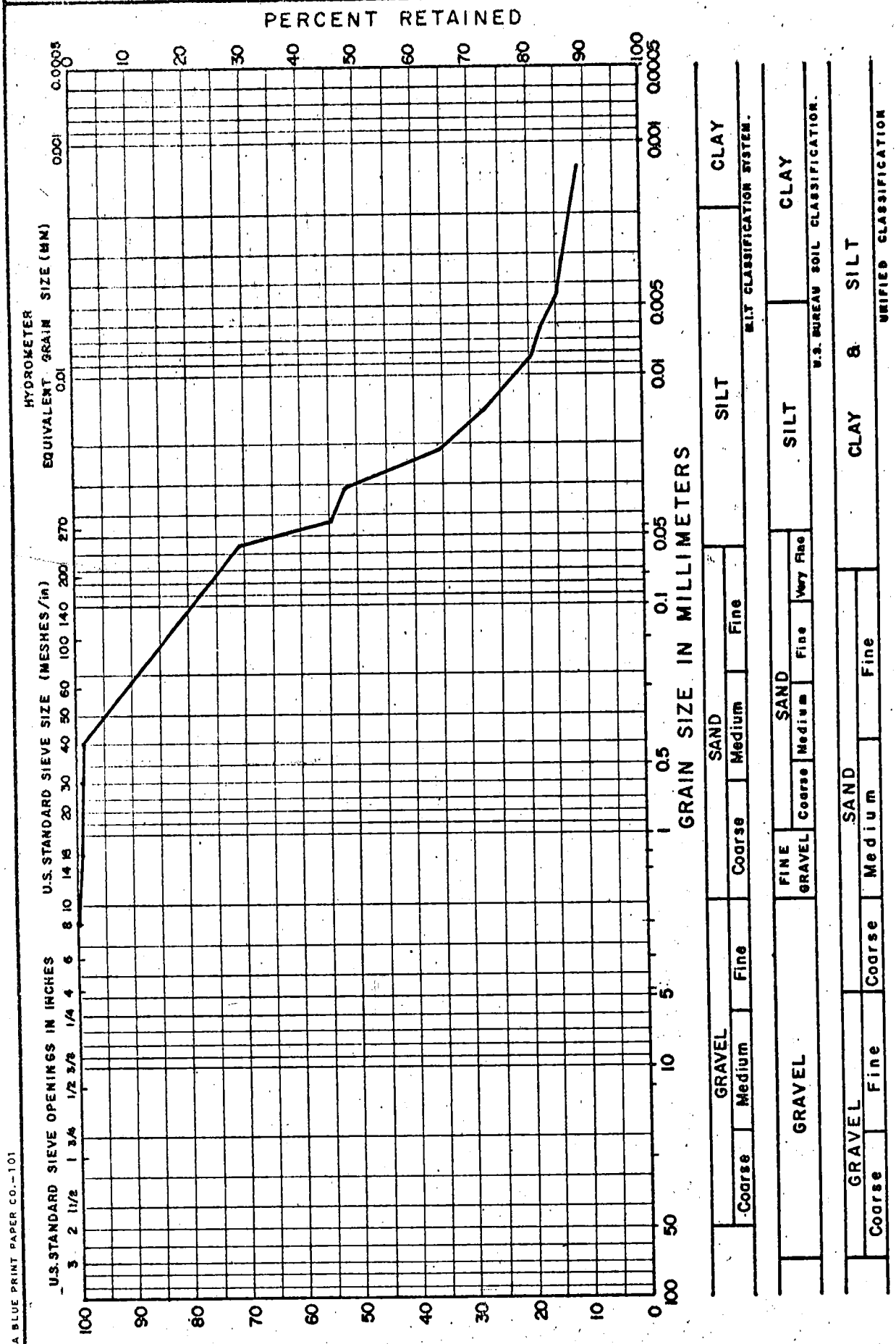
UNIFIED CLASSIFICATION

BOREHOLE No.	SAMPLE No.	DEPTH	DESCRIPTION
BH 1	1 of 2	5'to 6'6"	Gravel - 31% Sand - 41% (SC Unified) Clay and silt - 28%

APPENDIX 1
FIGURE 1
PROJECT 530-110

GRAIN SIZE DISTRIBUTION

APPENDIX 1
FIGURE 2
PROJECT 530-110



BOREHOLE No. BH-1

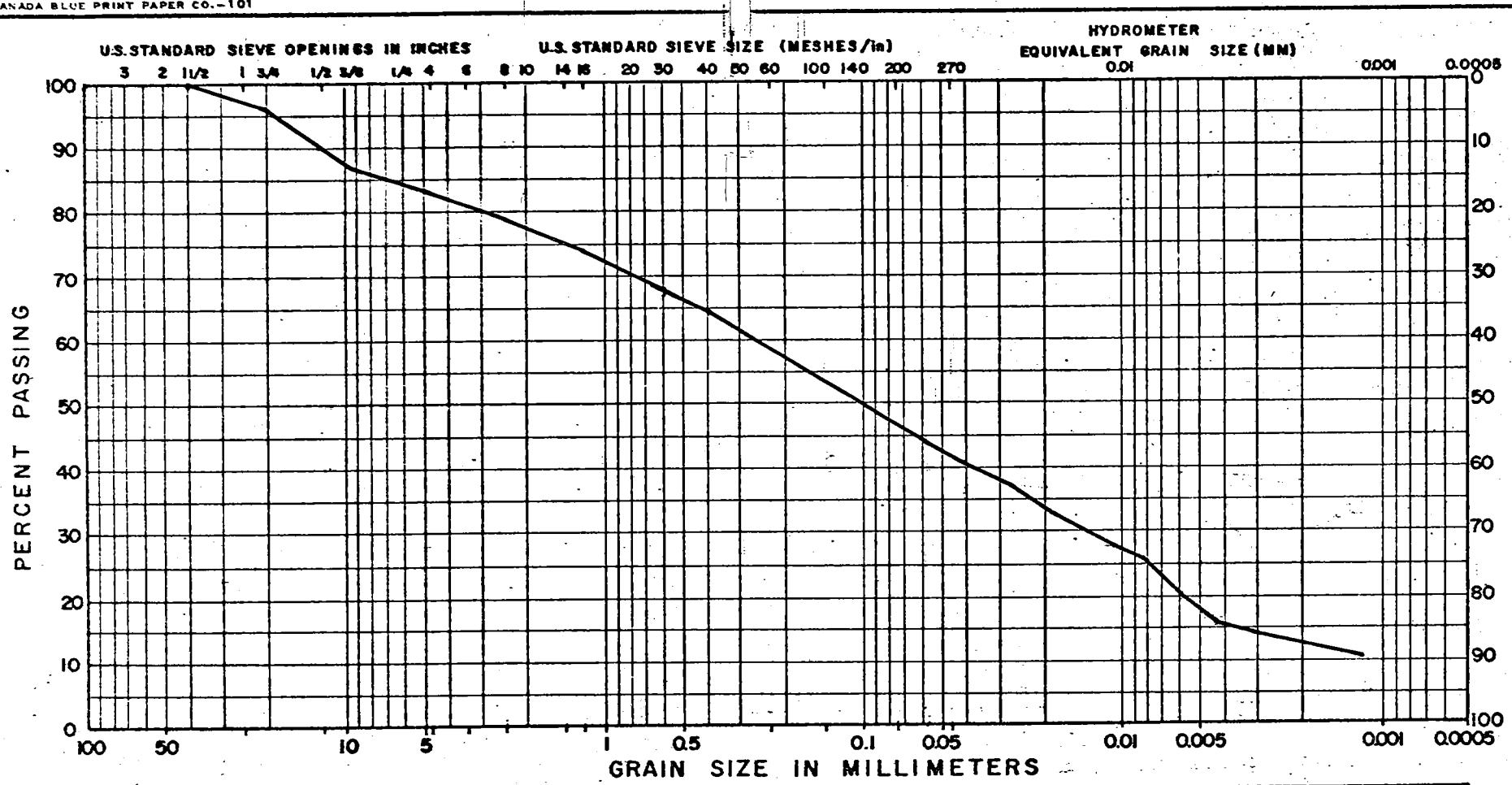
SAMPLE No.

DEPTH 45' to 47'

DESCRIPTION Gravel - 0%
Sand - 25% (ML Unified)
Clay and silt - 75%

CANADA BLUE PRINT PAPER CO.-101

GRAIN SIZE DISTRIBUTION



GRAVEL			SAND			SILT	CLAY
Coarse	Medium	Fine	Coarse	Medium	Fine		

M.I.T CLASSIFICATION SYSTEM.

GRAVEL	FINE GRAVEL	SAND				SILT	CLAY
		Coarse	Medium	Fine	Very Fine		

U.S. BUREAU SOIL CLASSIFICATION.

GRAVEL		SAND			CLAY & SILT
Coarse	Fine	Coarse	Medium	Fine	

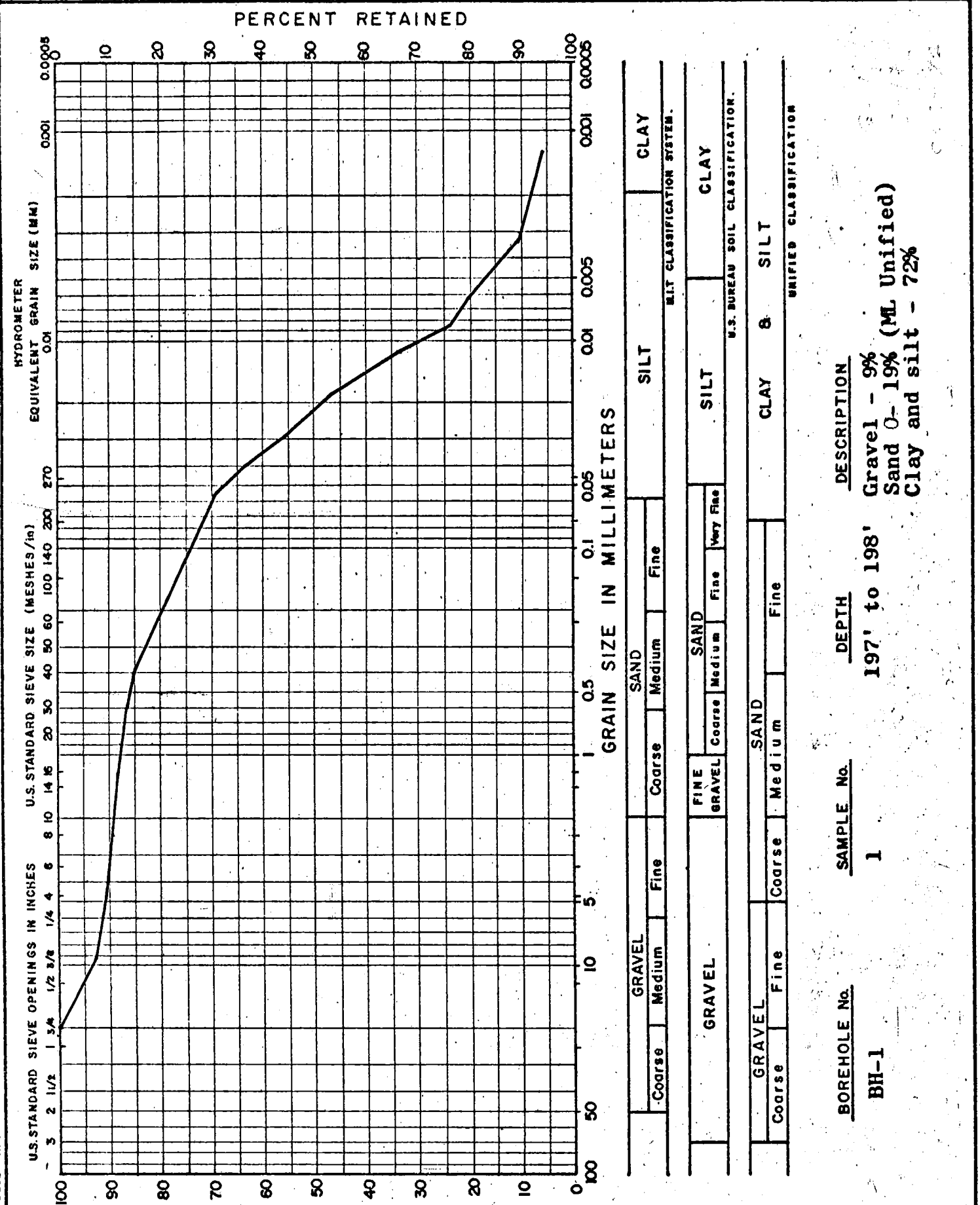
UNIFIED CLASSIFICATION

BOREHOLE No.	SAMPLE No.	DEPTH	DESCRIPTION
BH-1	14	73' to 75'	Gravel - 17% Sand - 36 % (SC Unified) Clay and silt - 47%

APPENDIX 3
FIGURE 1
PROJECT 530-110

GRAIN SIZE DISTRIBUTION

APPENDIX 1
FIGURE 4
PROJECT 530-110



BOREHOLE No. BH-1

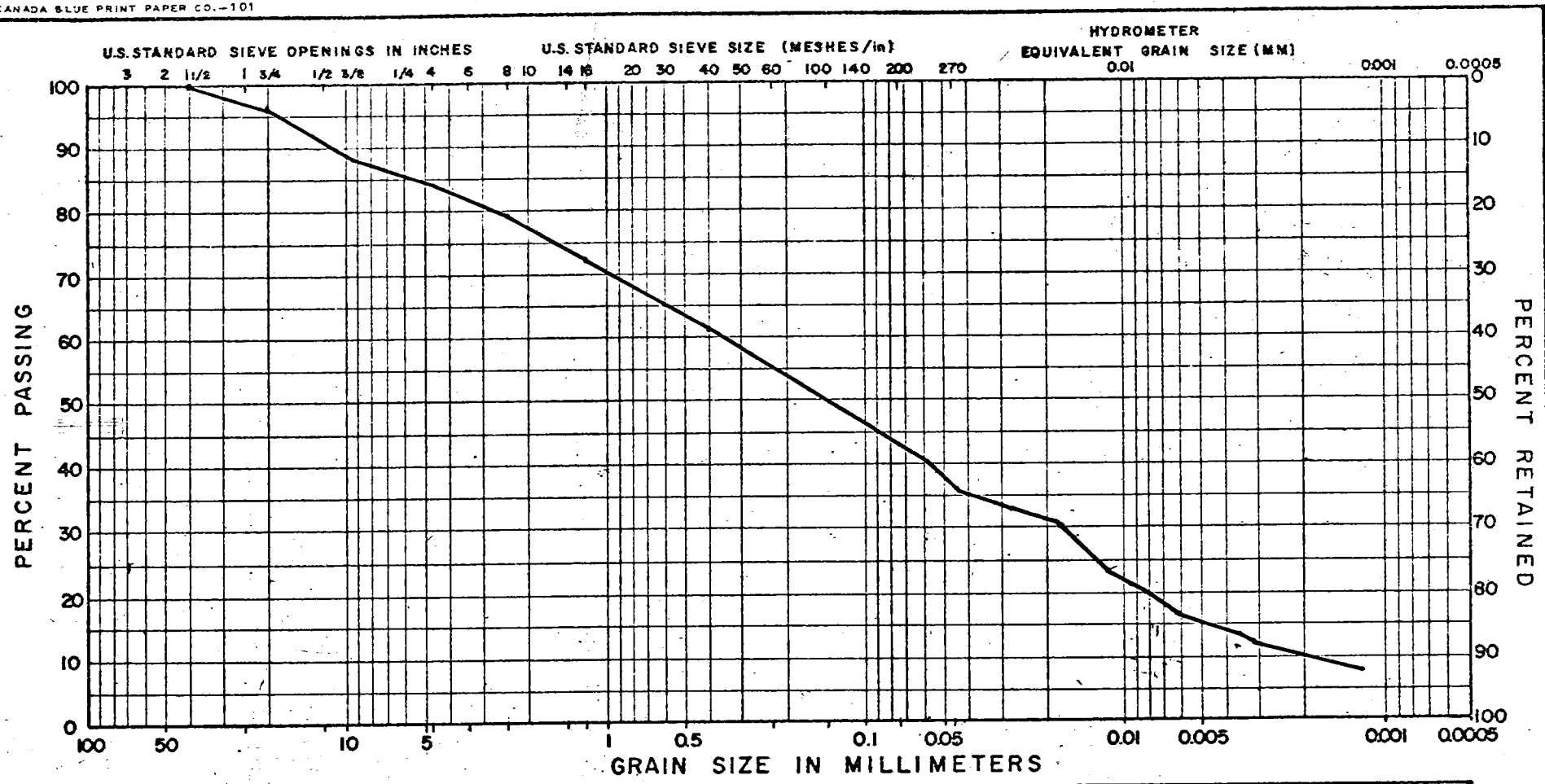
SAMPLE No. 1

DEPTH 197' to 198'

DESCRIPTION
Gravel - 9%
Sand 0- 19% (ML Unified)
Clay and silt - 72%

CANADA BLUE PRINT PAPER CO.-101

GRAIN SIZE DISTRIBUTION



	GRAVEL			SAND			SILT	CLAY
	Coarse	Medium	Fine	Coarse	Medium	Fine		

M.I.T CLASSIFICATION SYSTEM.

	GRAVEL	FINE GRAVEL	SAND				SILT	CLAY
			Coarse	Medium	Fine	Very Fine		

U.S. BUREAU SOIL CLASSIFICATION.

	GRAVEL		SAND			CLAY & SILT
	Coarse	Fine	Coarse	Medium	Fine	

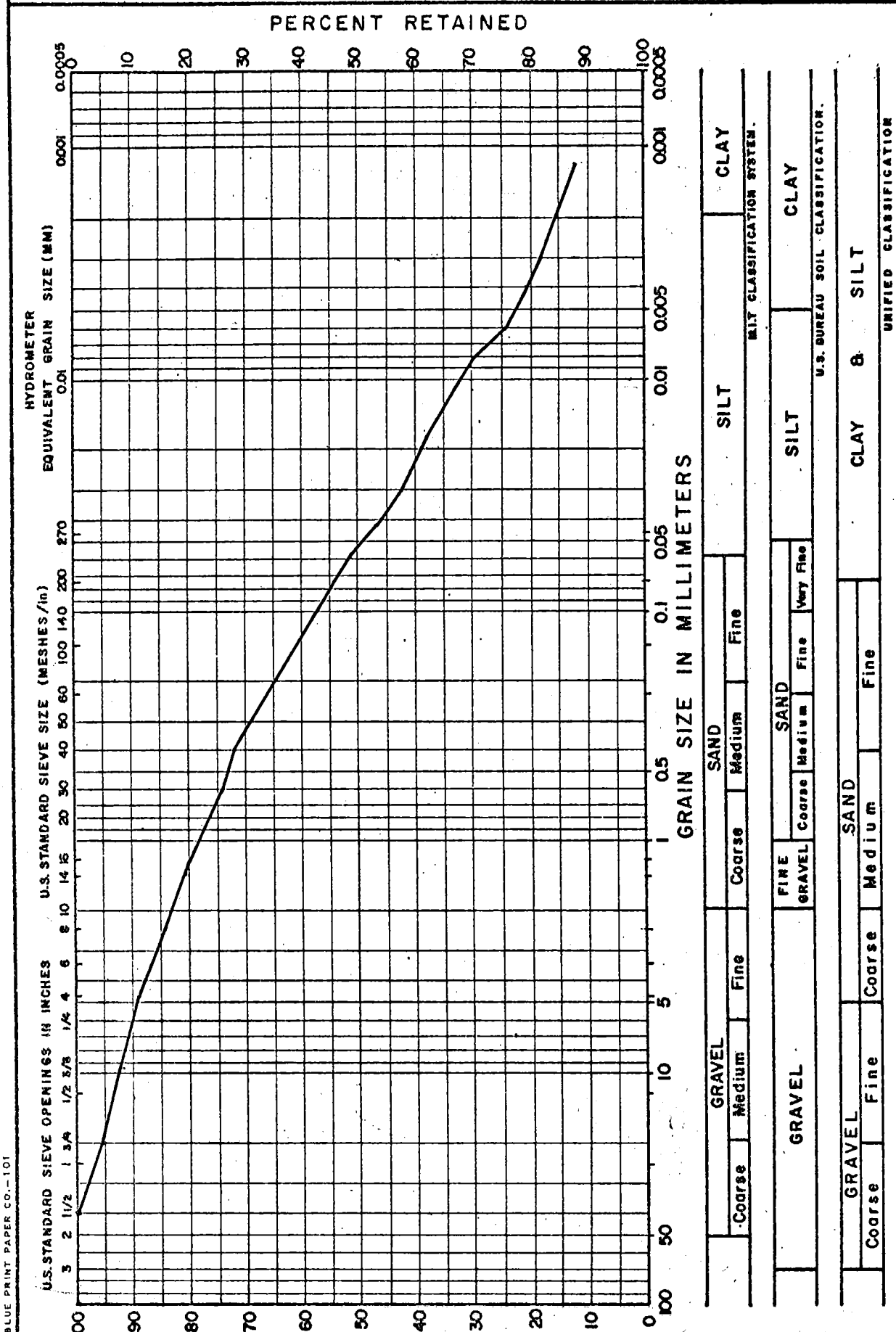
UNIFIED CLASSIFICATION

BOREHOLE No.	SAMPLE No.	DEPTH	DESCRIPTION
BH-2		100' to 102'	Gravel - 16% Sand - 41% (SC Unified) Clay and silt - 43%

APPENDIX 5
FIGURE 1
PROJECT 530-110

GRAIN SIZE DISTRIBUTION

APPENDIX 1
FIGURE 6
PROJECT 530-110



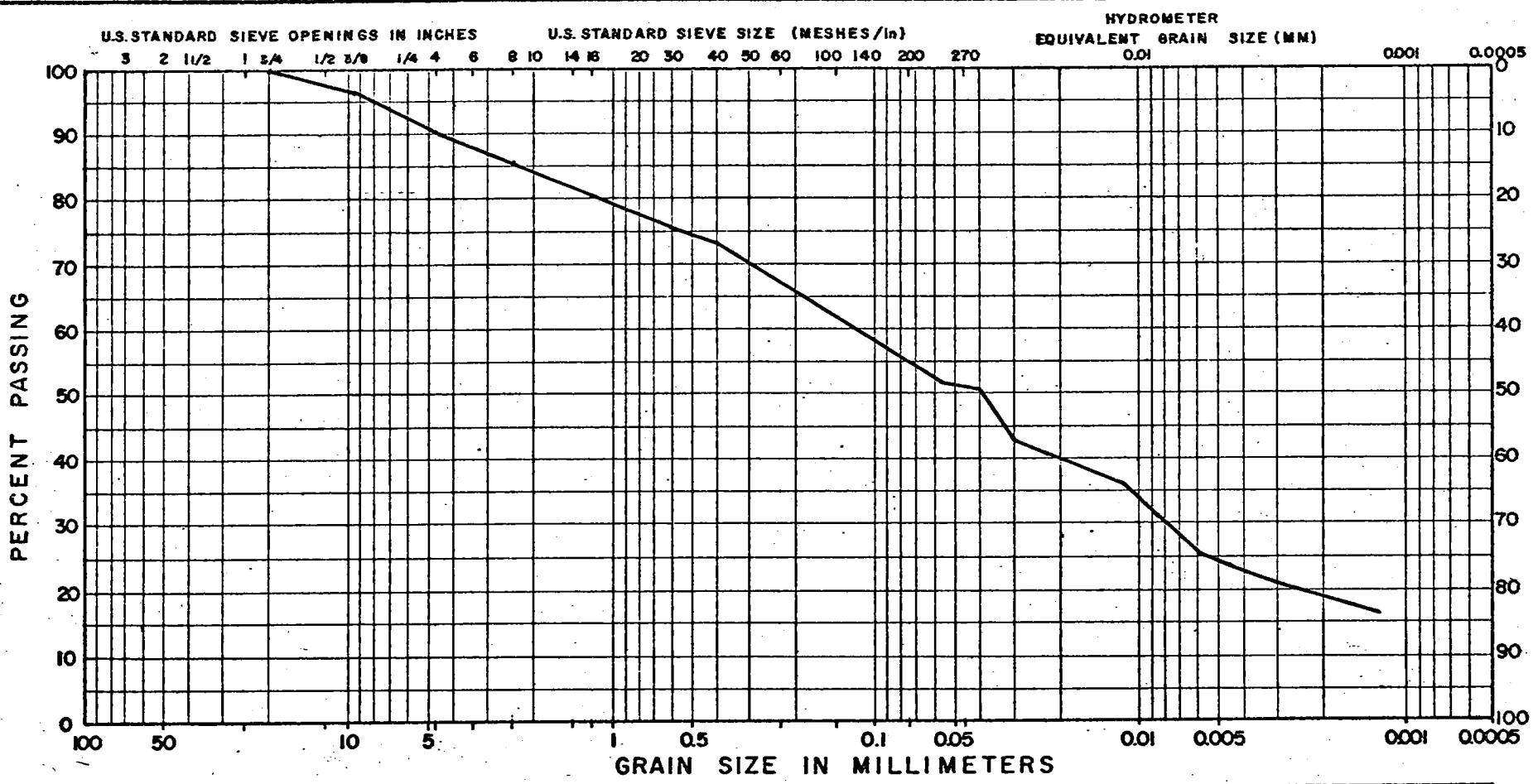
BOREHOLE No. BH-3

SAMPLE No. 3 of 3

DEPTH 25' to 26'6"

DESCRIPTION
Gravel - 11%
Sand - 35% CL (Unified)
Clay and silt - 54%

GRAIN SIZE DISTRIBUTION



GRAVEL			SAND			SILT	CLAY
Coarse	Medium	Fine	Coarse	Medium	Fine		

M.I.T CLASSIFICATION SYSTEM.

GRAVEL	FINE GRAVEL	SAND				SILT	CLAY
		Coarse	Medium	Fine	Very Fine		

U.S. BUREAU SOIL CLASSIFICATION.

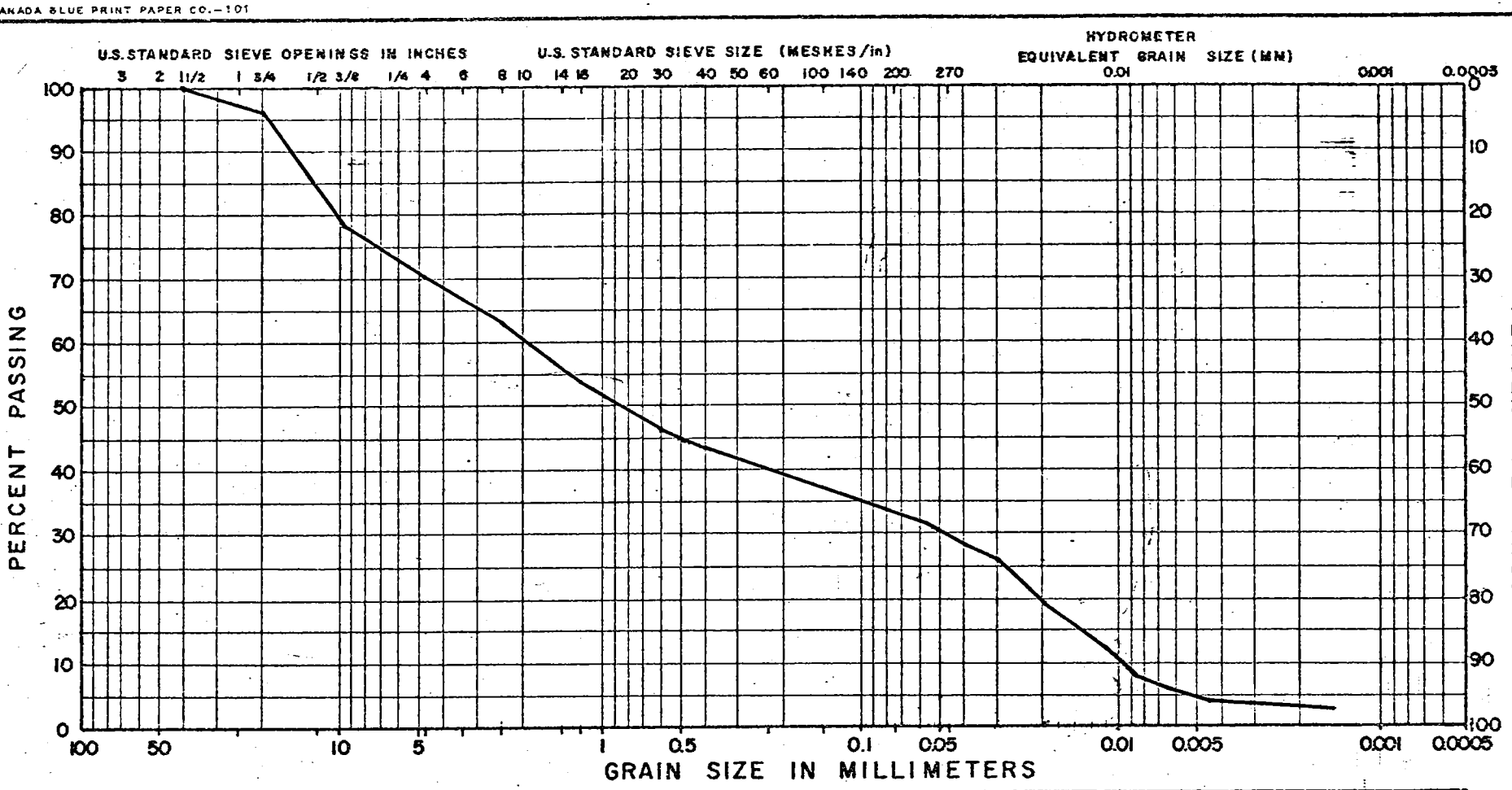
GRAVEL		SAND			CLAY & SILT
Coarse	Fine	Coarse	Medium	Fine	

UNIFIED CLASSIFICATION

BOREHOLE No.	SAMPLE No.	DEPTH	DESCRIPTION
BH-3	2 of 2	90'10" to 91'6"	Gravel - 10% Sand - 35% (CL Unified) Clay and silt - 55%

APPENDIX 1
FIGURE 7
PROJECT 530-110

GRAIN SIZE DISTRIBUTION



	GRAVEL			SAND			SILT	CLAY
	Coarse	Medium	Fine	Coarse	Medium	Fine		

M.I.T CLASSIFICATION SYSTEM.

GRAVEL	FINE GRAVEL	SAND				SILT	CLAY
		Coarse	Medium	Fine	Very Fine		

U.S. BUREAU SOIL CLASSIFICATION.

GRAVEL		SAND			CLAY & SILT
Coarse	Fine	Coarse	Medium	Fine	

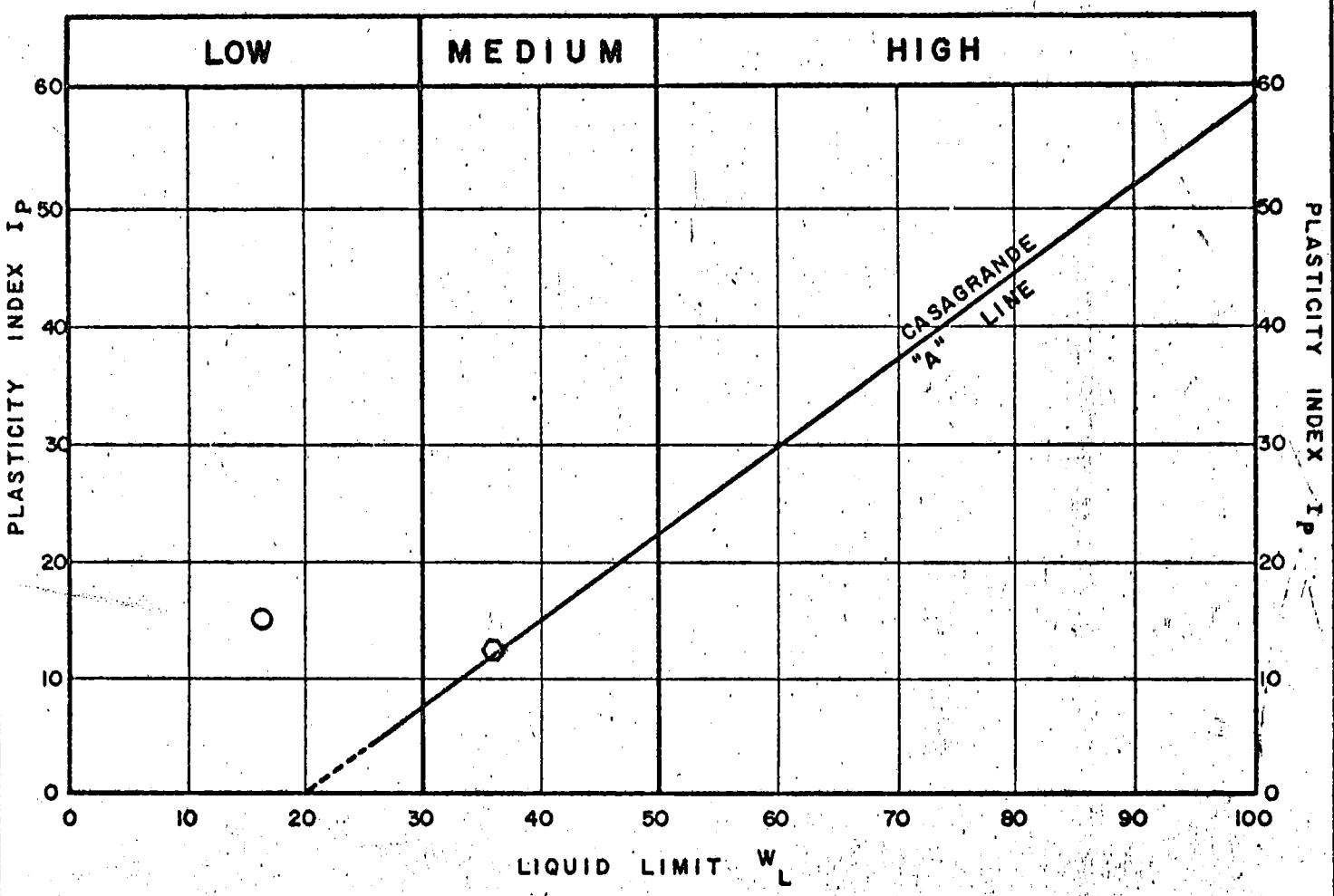
UNIFIED CLASSIFICATION

BOREHOLE No.	SAMPLE No.	DEPTH	DESCRIPTION
BH-3		133' to 135'	Gravel - 30% Sand - 37% (SM Unified) Clay and silt - 33%

APPENDIX 1
FIGURE 8
PROJECT 530-110

PLASTICITY CHART

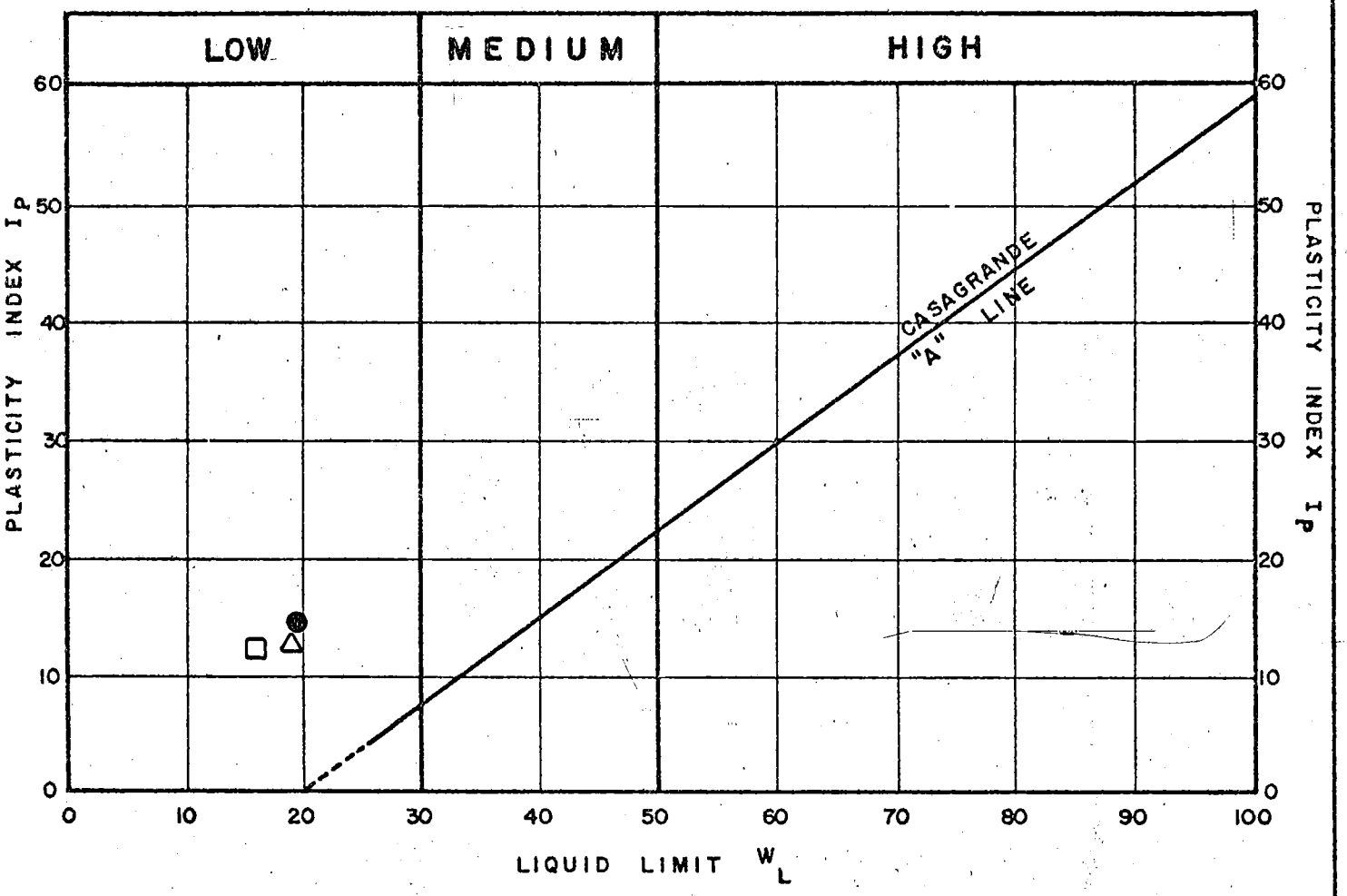
APPENDIX 1
FIGURE 9
PROJECT 530-110



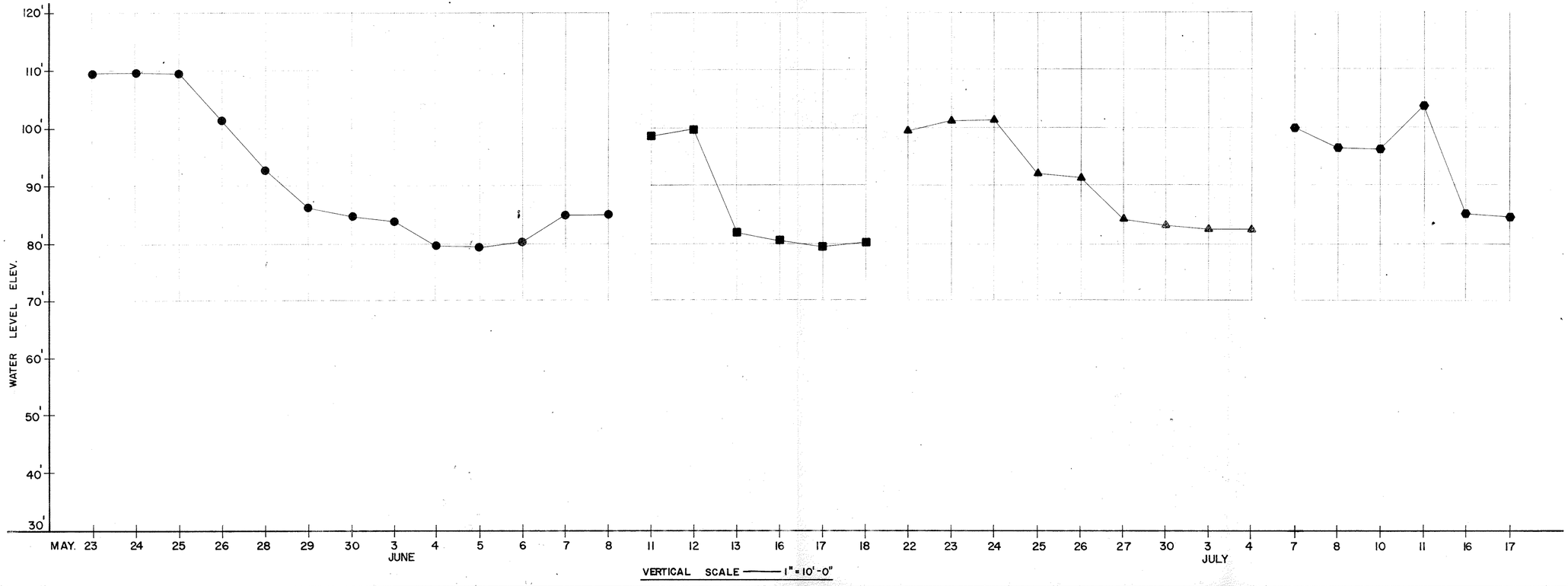
SYMBOL	BOREHOLE	SAMPLE	DEPTH	DESCRIPTION
○	BH#1	1 of 2	5'-6'6"	SC(Unified)
	BH#1		45' to 47'	Non Plastic (ML Unified)
○	BH#1		73' to 75'	SC (Unified)
	BH#1		197' to 198'	Non Plastic (ML Unified)

PLASTICITY CHART

APPENDIX 1
FIGURE 10
PROJECT 530-110



SYMBOL	BOREHOLE	SAMPLE	DEPTH	DESCRIPTION
□	BH#2		100' to 102'	SC (Unified)
△	BH#3		25' to 26' 6"	CL (Unified)
●	BH#3		90'10" to 91' 6"	CL (Unified)
	BH#3		133' to 135'	Non Plastic (SM Unified)



LEGEND

- ● BH-1
- ■ BH-2
- ▲ BH-3
- ⬢ BH-6

REFERENCES

DRWG. NO.	DESCRIPTION	DATE

OAK ISLAND EXPLORATION

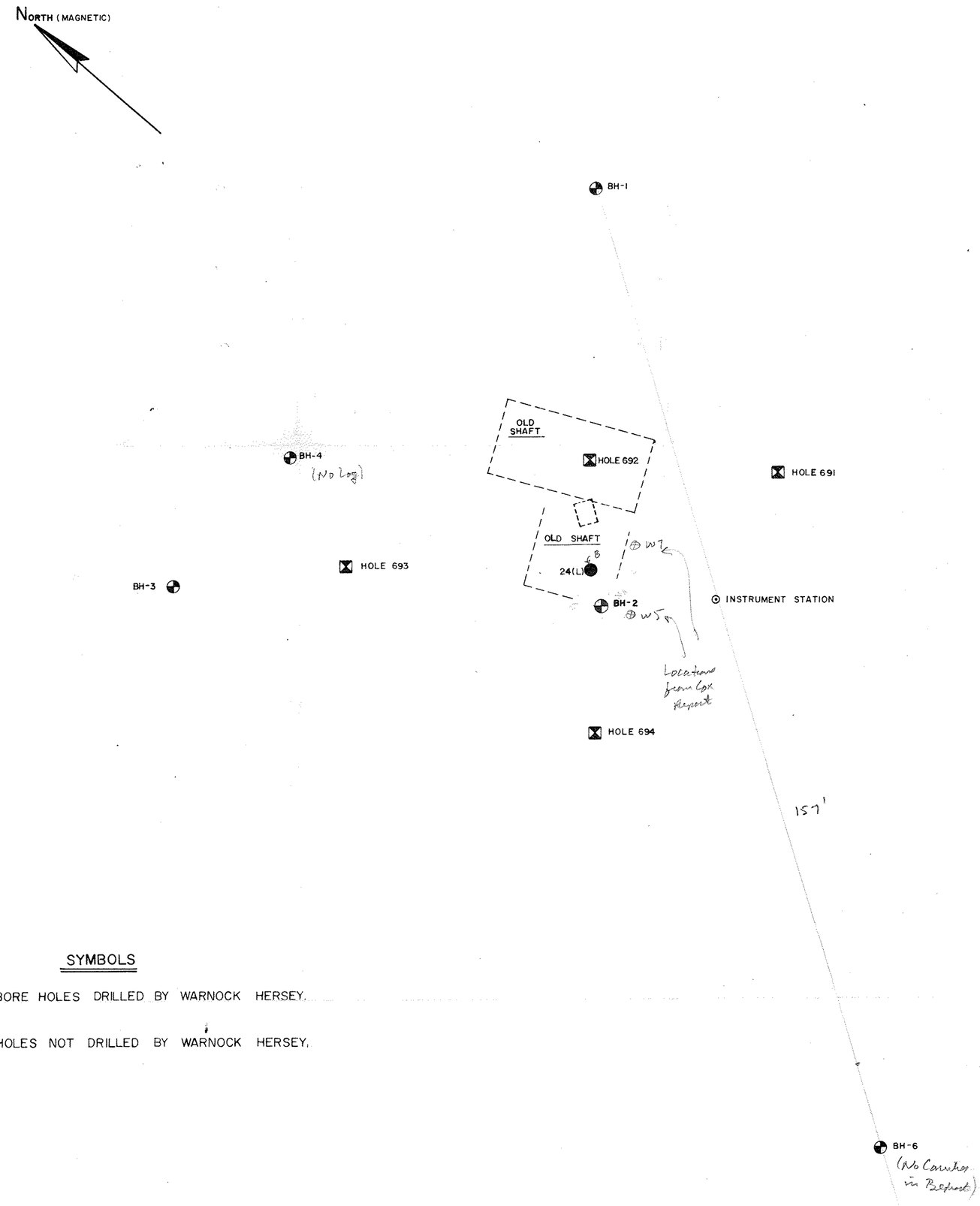
WATER LEVEL OBSERVATIONS

WARNOCK HERSEY INTERNATIONAL LIMITED
Professional Services Division

DATE	SCALE	DRAWN BY
JULY 30/69	1" = 10'	Jane O'Brien

APPROVED BY

DRAWING NO. 530-110



SYMBOLS

- BORE HOLES DRILLED BY WARNOCK HERSEY.
- HOLES NOT DRILLED BY WARNOCK HERSEY.

REFERENCES		
DRWG. NO.	DESCRIPTION	DATE
Q-1.	OAK ISLAND EXPLORATION	APR 24/69
	CARR & DONALD &	
	ASSOCIATES LTD.	

OAK ISLAND EXPLORATION

BORE HOLE LOCATION PLAN

WARNOCK HERSEY INTERNATIONAL LTD.

Professional Services Division

DATE	SCALE	DRAWN BY:
JULY 22/69	1" = 12'-0"	Jane O'Brien

APPROVED BY:

DRAWING NO: 530-110

Document 1 of 5 Submitted after Initial Report

Warnock Heresy International Limited, Dartmouth, Nova Scotia.
Letter to Carr and Donald dated August 27, 1969.
(This letter transmitted the logs for Boreholes 5 and 7.)

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

4 MacDonald Ave., Dartmouth, N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S. Tel 463-6130 - Telex 01[illegible]42623

August 27, 1969.
Our file 530-110

Carr and Donald and Associates,
Suite 305, 55 Yonge St.,
Toronto, Ontario.

Oak Island

Attention: J. Carr

Gentlemen:

Re: Oak Island Exploration

Please find three copies of each of the borehole numbers five and seven performed at Oak Island, N.S. At the instruction of Mr. Dan Blankenship, no testing above a depth of 175 feet was performed. We are therefore unaware of the soil conditions between 0 and 175 feet. The quantity of information contained in these two borehole logs is not appreciable and does not differ in any substantial way from our findings connected with the performance of the soils investigation proper. All conditions of our original report dated July 31, 1969 stand therefore unchanged and we see no specific reason for editing an addendum.

If we may be of any service to you or should you have any queries, please do not hesitate to contact the undersigned at your convenience.

Yours very truly,

WARNOCK HERSEY INTERNATIONAL LTD.,
Professional Services Division.

Hector J. Jacques, M.Eng.P.Eng.,
Assist. Manager, Geotechnical Services.

HJJ/eb
encls

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr and Donald and Associates

LOCATION Oak Island

BOREHOLE NO. 5

CASING NX-BX

DATE OF BORING July 23-Aug 1/69 TOP OF WL READING --

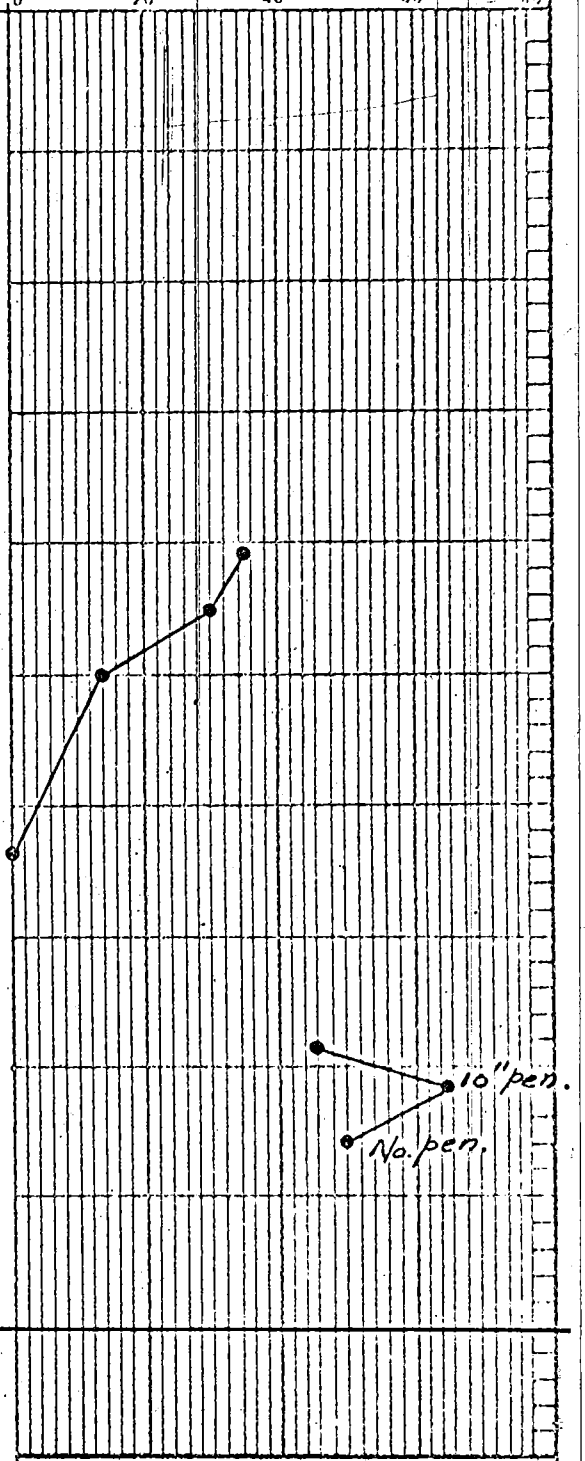
DATUM assumed

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED
0		0-172' -unaware of the overburden material. No tests performed.								
170										
175		Bedrock - Anhydrite. Soft and fractured.			RC	BXT	1	24/96		
180		Silty Clay. Some isolated silt and sand lenses. Stiff. Turns softer with depth. 188'-196'- very soft.			D	SS	1	24	35	
					D	SS	2	24	30	
185					D	SS	3	24	14	
190					D	SS	4	24	0	
195		Anhydrite gravel								
200		Grey sandy silt. Hard. Some anhydrite gravel.			D	SS	5	24	46	
					D	SS	6	10	65+	
					D	SS	-	Nil	50+	
205		Anhydrite gravel			RC	BXT	2	12/24		
		Bedrock - Anhydrite. Fractured					3	48/48		
210		End of Hole 210.0'								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS: WP — W — WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT... 0 20 40 60 80



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OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 530-110

CLIENT Carr and Donald and Associates

LOCATION Oak Island

BOREHOLE NO. 7

CASING NX-BX

DATE OF BORING Aug. 5-13/69 DATE OF WL READING

DATUM Assumed

DEPTH	ELEVATION	DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS Wp W WL
0												DYNAMIC PENETRATION TEST BLOWS PER FOOT ... 0 20 40 60 80
170			0-165' - overburden. No tests performed. 165'-175'. Bedrock Anhydrite									
175			Bedrock - Anhydrite. Very soft.			RC	BXT	1	0/60			
180			Silty Clay. Some isolated silt and sand lenses. Soft to very soft.			UD	ST	1	24			
190						UD	ST	2	24			
195						UD	ST	3	12			
200			Grey sandy silt. Hard. Some anhydrite gravel & cobbles.			D	SS	1	18	34		
205			Anhydrite gravel and cobbles									
210			Bedrock - Anhydrite. Fractured			RC	BXT	2	0/48			
215								3	60/60			
220			End of Hole 218.0'									

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Document 2 of 5 Submitted after Initial Report

Warnock Hersey International Limited, Dartmouth, Nova Scotia.
Letter to Carr and Donald dated October 22, 1969.
(This is a follow up description of varved strata encountered in the boreholes.)

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

MacDonald Ave. Dartmouth N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S., Tel. 463-6130 - Telex 014-2623

October 22, 1969,
Our file 530-110.

Carr and Donald and Associates,
Suite 305,
55 Yonge St.,
Toronto, Ontario.

Attention: Mr. J. Carr

Gentlemen:

Re: Soils Investigation, Oak Island, N.S.

At the request of Mr. Blankenship, the undersigned has examined all samples of a varved character. Varved strata were encountered in different boreholes and at several locations. These locations are as follows:

Borehole Number	Depths (feet)
1	116 to 135, 197 to 198
2	100 to 108
3	87 to 90, 100 to 105
5	180 to 196
6	90 to 108, small trace at 152
7	180 to 196

One of the stratums in these varved deposits consists primarily of a grey highly plastic clay. There appears to be two approximate bands at which these deposits are encountered, one between depths of ninety and one hundred twenty-five feet and the other at depths of approximately one hundred eighty feet.

Mr. Blankenship has suggested that these deposits are the result of a practical method employed to seal incoming water. This may possibly be the case and the undersigned in that text is not qualified to remark, However, varved deposits are not uncommon in these areas and are primarily caused by water sorting of original glacial deposits.

It is obvious at the present moment that bedrock contains several cavities and that the grey material in colour is similiar

continued ---

D. WEBSTER

WARNOCK HERSEY INTERNATIONAL LIMITED
PROFESSIONAL SERVICES DIVISION

to some of the superficial grey clay till deposits. However, the material could have reached the cavities either by man made operations or by series of floodings from the surrounding ocean.

Yours very truly,

WARNOCK HERSEY INTERNATIONAL LTD
Professional Services Division

Hector J. Jacques, M.Eng.,P.Eng.,
Assist. Manager, Geotechnical Services.

HJJ/eb

Document 3 of 5 Submitted after Initial Report

Warnock Hersey International Limited, Dartmouth, Nova Scotia.
Letter to Carr and Donald dated November 5, 1969.
(This letter transmitted the descriptive results of Boreholes 8, 9 and 10 and provided an updated borehole plan.)

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

MacDonald Ave. Dartmouth N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S., Tel. 463-6130 - Telex 014-42623

November 5, 1969.
Our file 530-110.

Carr and Donald and Associates,
Suite 305,
55 Yonge St.,
Toronto, Ontario.

Attention: Mr. J. Carr

Gentlemen:

Re: Oak Island, Nova Scotia

Please find enclosed four copies of our report on boreholes eight, nine and ten performed on Oak Island, Nova Scotia. These reports have been prepared by our Mr. Joe Stein.

If any queries arise with respect to the contents or interpretation of this report, please do not hesitate to contact our Mr. J. Stein at your convenience.

Yours very truly,

WARNOCK HERSEY INTERNATIONAL LTD
Professional Services Division

C.D. MacDonald, M.Eng.,P.Eng.,
Manager, Geotechnical Services.

CDMacD/eb
encl. 4
c.c. Mr. D. Blankenship
as authorized by Mr. W. Donald.

DCW

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

MacDonald Ave. Dartmouth N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S., Tel. 463-6130 - Telex 014-42823

Client: Carr, Donald & Associates

Project: Oak Island Investigation

Borehole No: 8

Elevation: 99.0' top of hole

Date of Boring: October 17-21, 1969

0'- 165.5' Drilling performed by W. Bowmaster, prior to October 18, 1969. 6¼" installed by W. Bowmaster 0-165.5'. Warnock Hersey International Limited requested by Mr. D. Blankenship to sample by coring 165.5' to 200.0' with 6" corebarrel to determine the type of subsurface strata.

165.5' - 200.5' 165.5' - 168.0' attempting to core with 6" corebarrel, possibly boulders, cobbles, or anhydrite-gypsum formation. Unable to advance. Core recovery - nil. Abandoned 6" corebarrel. Attempted to core with 3 5/8" NXL corebarrel; indications of boulders, cobbles or anhydrite-gypsum formation 165.5' - 168.5'. Continued to advance 168.5' - 200.5' with little pressure; assumed to be in loose silt or sand formation. We were advised by Mr. D. Blankenship to retract corebarrel. Sample recovery 165.5' - 200.5' equal to thirty inches silty sand and three inches Quartzite cobble. Sample number I. Water return lost at 168.0'.

200.5' End of Hole 200.5'. Mr. D. Blankenship advised to abandon hole.

Comments: Location of borehole as per enclosed Borehole Location Plan. Elevation to top of borehole as per Warnock Hersey International Ltd. datum established on Island.

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

MacDonald Ave. Dartmouth N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S., Tel. 463-8130 - Telex 014-42623

Client: Carr, Donald & Associates

Project: Oak Island Investigation

Borehole No.: 9

Elevation: 99.7'

Date of Boring: October 27, 28, 1969

Entire investigation 0-219.5' performed by W. Bowmaster. Drilling procedure and sampler type employed as directed by Mr. D. Blankenship. Warnock Hersey International Limited personnel requested by Mr. D. Blankenship to be on site to witness drilling operations 164.0'-219.5'.

0'-164.0'

Drilling performed by W. Bowmaster prior to October 27, 1969. 6¼" diameter casing installed to 164.0'.

164.0'-191.0'

6" corebarrel with roller cone cutting and 3" inner barrel advanced 164.0' to 178.0' under weight of drill rods and core barrel. Rotating very slowly and air pressure maintained at 140 p.s.i. Continued to advance 178.0'-182.5'. Progress much slower. Corebarrel retracted. Three inch gypsum and four inch silty sand recovered, highly plastic clay on outside of barrel.

Borehole cased 164.0' to 181.0'; attempted to clean hole to 181.0'. Hole dried up after ten minutes with air pressure. Continued to clean when surge of water appeared. W. Bowmaster suggested air pressure and Tri-Cone possibly penetrated gypsum layer at 181.0' and into silty sand zone. Removed roller-cone and proceeded to advance casing to 183.5'.

continued ---

Six inches core barrel employed to sample formation at 184.0'. Core barrel advanced with little air pressure and rotation 184.0' - 191.0'.

191.0' - 200.0'

Progress slower 191.0' - 192.0' - continued to advance 192.0'-197.5'. Progress very slow; approximately one foot per fifteen minutes. Wash water from forced air pressure consisted of silty sand, fine gravel and wood chips while drilling. 192.0'-195.0'. Sample number I - Wash water from forced air pressure consisted of highly plastic clay chips and trace of wood chips 195.0'-197.5'. Sample number II - approximately twenty per cent of wash water retained. Continued to advance core barrel 197.5'-198.0'. Progress very slow, approximately thirty minutes. Progress near nil at 198.0'. Retracted corebarrel. Recovery = 2" Gypsum, silty clay:.
- 2" medium red silty brick-like material.
- Sample number III

Roller-cone employed for coring when core barrel retracted badly damaged and rollers seized and burnt. End of day.

October 28, 1969 -

6¼" casing advanced to 196.5'. Attempted to clean hole with Tri-cone to 194.0'. Borehole dried up. Retracted Tri-cone; highly plastic clay on Tri-cone bit which plugged up air release holes. Advanced 6¼" casing to 201.5'. Tri-cone bit employed to clean out hole to 200.0'. Wash water consisted of sand, gravel and wood chips. Sample number IV

200.0'-206.0'

Continued to advance Tri-cone 200.0' - 206.0'. Very easy drilling (Cavity?) Wash water consisted of silty clay and trace of wood chips. Odor of wash water appeared very stagnant.

continued -

206.0' - 219.5'

Continued to advance Tri-cone 206.0'-219.5'. Rate approximately one foot per two minutes. Wash water indicated formation soft gypsum.

219.5'

End of Hole

Comments:

Location of borehole as per enclosed Borehole Location Plan.

Elevation top of borehole as per Warnock Hersey International Limited datum established on Island.

Wash water containing wood chips -- It should be noted that wood chips occurred in wash water while attempting to core 192.0'-200.0'. At this depth 6¼" casing had only been down to 183.5'. Wood chips may have been in a strata 183.5'-200.0'. Rate of drilling considerably slower from 192.0'-198.0' than from 184.0'-191.0'. This may have been caused by Tri-cone bit failing to cut after being damaged near 192.0' or by actual wood type formation for 6.0'. In our opinion the Tri-cone bit failure and eventual breakdown may have been caused by numerous reasons namely:

1) Lack of high pressure air circulation through bit to maintain free operation.
2) Air pressure employed rather than high water pressure as a cooling agent.
3) Defective bit.
4) Tri-cone bit with inner core barrel not designed for wood or similiar substance coring.

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

MacDonald Ave. Dartmouth N.S. P.O. Box 310, Armdale Post Office, Halifax, N.S., Tel. 463-6130 - Telex 014-42823

Client: Carr, Donald & Associates

Project: Oak Island Investigation

Borehole No: 10

Elevation: 119.5'

Date of Boring: November 1-2, 1969

0'-230.0'

Borehole drilling performed by W. Bowmaster October 29, 1969. 6¼" casing installed 0-167.0' by W. Bowmaster. Warnock Hersey requested by Mr. D. Blankenship to sample by coring 230.0'-242.5' with 3 5/8" diameter NXL corebarrel to determine the type of subsurface strata.

0'-192.0'

3 5/8" corebarrel installed by Warnock Hersey in previously drilled hole.

192.0'-199.0'

Casing advanced with slight difficulty. Rotating not required. Advanced with continuous driving under its own weight. Assumed to be in silt and sand material.

199.0'-214.0'

Casing advanced with more difficulty. Rotating not required. Advanced as 192.0'-199.0', however rate of progress considerably slower. Assumed to be in some compact silt and sand material.

Samples:
No.1 - 198.0'-204.0' - wash water sample. - fine to medium sand, trace of cloth.

continued --

No.II - 204.0'-209.0' - wash water sample - fine to medium sand, trace of cloth.

No.III - 209.0'-214.0' - wash water sample, fine to medium sand, trace of cloth.

214.0'-218.0'

Casing advanced very slow. Necessary to employ Tri-cone bit and rotary action. Assumed to be in boulder, cobble and gravel material.

218.0'-237.5'

Casing advanced with little difficulty by rotating and slight pressure.

Assumed to be in silt sand mixture to 237.0' when definite indications of rock occurred. Drilled to 237.5' with casing, cleaned hole to 237.5' with Tri-cone and employed NXL corebarrel 237.5'-242.5'

237.5'-242.5'

Bedrock - Anhydrite, white to grey. Sound, rate of drilling approximately fifteen minutes per foot. NXL Rock Core 50% recovery. Unable to recover 100% core due to inability of core catcher to break off core at 242.5'.

¼" diameter X 3/4" length (approx) cylindric metal object ejected with anhydrite core when corebarrel emptied. Situated at top of core or at 197.5' depth. No indication if part of corebarrel or Warnock Hersey drilling equipment, however, it may be. Mr. D. Blankenship in possession of this metal object.

242.5'

End of Hole.

Comments:

Warnock Hersey personnel were not requested to be on site for visual witness to drilling

continued -

operations of borehole number 10 by W. Bowmaster. However, during the locating of borehole number 8 and 9, previously drilled boreholes, J. Stein was requested by Mr. D. Blankenship to inspect wash water being forced out of borehole number 10.

Numerous small metal pieces were being forced out of the hole while drilling 200.0'-230.0' approximately. (Mr. D. Blankenship data) Red cloth fragments were also noticed in the wash water, however later it was divulged that a red cloth had been wrapped around a Tri-cone bit during drilling operations to prevent blocking. The metal pieces were retained by Mr. D. Blankenship.

Location of borehole as per enclosed Borehole Location Plan.

Elevation top of borehole as per Warnock Hersey International Limited datum established on Island.

BH. 10

NORTH (MAGNETIC)

BH-1

OLD SHAFT

HOLE 692

HOLE 691

OLD SHAFT

BH-8

24 (L)

HOLE 693

BH-3

BH-5

BH-7

BH-2

BH-9

INSTRUMENT STATION

HOLE 694

BH-6

SYMBOLS

BOREHOLES DRILLED BY WARNOCK HERSEY

HOLES NOT DRILLED BY WARNOCK HERSEY

REFERENCES		
DRWG. NO.	DESCRIPTION	DATE
0-1	OAK ISLAND EXPLORATION	APR 24, 69
"	CARR & DONALD &	
"	ASSOCIATES LTD.	

OAK ISLAND EXPLORATION

BOREHOLE LOCATION PLAN

WARNOCK HERSEY INTERNATIONAL LTD.
Professional Services Division

DATE	SCALE	DRAWN BY
JULY 22, 1969	1" = 12'-0"	E.W.

APPROVED BY:

DRAWING NO: 530 – 110

Document 4 of 5 Submitted after Initial Report

Memorandum by Dan Blankenship dated November 29, 1969. (This memorandum gives descriptive results of Boreholes 8, 9 and 10.)

November 29, 1969

Resume of Drilling at Oak Island while I was present, Oct. & Nov.

Hole #8

This was put down from the same surface location of hole #24 done by "Becker". The brief history of this orig. hole done by "Becker" in May 27th thru 30th, 1967. A 6" cyclone bit was driven to 165' thru overburden to bedrock of gypsum, at which point a 2 7/8" roller-core bit was used with air getting a good sampling all the way down. After drilling 27' thru gypsum we hit wood, about 5" to 6" and then a foot of clay and then 5" to 6" of wood again and into a cavity at about 194' and bedrock again at 207'.

The idea this time was to core with a 6" coring bit from bedrock thru wood. With that in mind Bowmaster went down into #24 and hit gypsum at 167', at which point we cased the hole with 6" casing and Warnock Hersey moved in. They hit clay at about 178' thru 204'.

Hole #9

Bowmaster had to move 4 times in order to get this hole down. He kept hitting old casing (probably Becker's) and ruined 2 rock bits on steel.

The location of this hole was 4'6" from #33 and 7'4" from #24 to the west. Hit gypsum bedrock at 165' and I went to phone Warneck Hersey to send representative to observe drilling. This was 11:45 A.M Joe Stein said he would come immeadiately. He showed up at 2:30 P.M. In the meantime Bowmaster went back into the hole in order to clean it out in preperation for Warneck Hersey, and broke thru a obviously thin layer of gypsum. Both Bowmaster and Joe Stein was of the opinion that the mat. was not coreable and so it was decided to continue until we hit something more solid. We hit wood at 192' and so changed to a 3" by 22' core barrel with a 6" rock-bit on. We cored from ;92 thru 197' at a very slow rate of penetration.

Then we pulled out, the only thing on the bit was red clay (similar to a brick) with some pieces of gypsum. The bit was completely worn out and about 1" was worn off the rollers. The opinion of Bowmaster was that we had hit on the side of wood cribbing of some nature and that had sealed the bit so the cutting edge coulcn' get the air to cool it off. However, due to the continued return coming up, of which a large amount was saved by Warnock Hersey he was sure we had gone through over 4' of solid wood.

The next day we drove the casing to 196' and continued drilling while Murray from Warnock Hersey was presant. We were getting sand, gravel and small pieces of wood. We hit a cavity from 200' to 206' in which the water changed color and had a stagnant smell. From 206' thru 219 we were in soft gypsum and so closed the hole up. The hole will serve as a pumping shaft in the future, and will be quite valuable.

Hole #10

181' east of #24 by the door of the old Restall house.

We started with a 9" rock-bit and went very fast through overburden and glacial till. We hit a small cavity from 140' = 143' and another from 165' = 169' and hit bedrock at 185' of gypsum. We drove 10' into bedrock with the 9" bit and stopped at 195' at which point we put on the 6" rock-bit in order to leave a shelf in case we hit a cavity for our casing to seat into. We drilled down to 195' at which point his hydrolic motor for his rotary head broke. He pulled 25' off the bottom and it stayed for 5 days until he had a new motor. When we continued, we hit a cavity at 230' to 233'. I was standing there and my orders were to stop the rotary immeadiately when he hit a cavity. This he did, and lowered the drill until it stopped at 233' with me turning. He then pulled the bit out and put on his 6" core barrel 22' long which is suppose to take a 3" core. At this time there wasn't any casing in the hole, so in order to get the core barrel down to the bottom without getting clogged with the debris in the hole, Bowmaster tied a red rag on the end of the bit with wire, and lowered it to 233', at which time he turned his air on which operates at high pressure and started turning his drill. He cored for about 1' to 234' and because he wasn't getting his return back decided to pull out and see what was in the drill. Only a few pieces of gypsum was there, and so we pulled out of hole and went down to do Hole #9.

After #9 was finished I talked Bowmaster into casing the hole in lieu of the second hole which he owed me. It took 7 hrs. to pull out the casing.

He put down 124' of casing before it stopped and hung up. He put the 6" rock drill inside and drilled to 150'/ The casing then went to 148' before it hung up again, at which time he again put the drill back down into the casing and drilled. At this time Joe Stein came onto the site and was present. Bowmaster was using air and the return was very good. I was collecting the return that was coming out and I noticed bits of rags and small pieces of metal. This metal and rags came up from about 166' to 175'. It is very important to note at this time a lot of water was coming up and upon tasting it I discovered it was salt. We collected a quart bottle of it and Joe Stein took it back to the laboratory with him.

We continued drilling down to 198' and then drove the casing to 178'. While driving this the last piece of casing broke off 14' below ground level. The next day I took the samples to Halifzx and we had a conference call that evening. Friday, the next day I used a back-hoe and dug down and cut the casing. Not having a welder, I put a 16' long piece of 8" casing over the 6" and back filled in preparation for Warnock-Hersey. Friday evening they came and unloaded gear and set up.

Sat. they came and started droping 3 1/2" casing inside Bowmaster's 6" casing and it went easy to about 212' at which time they started drilling it down. They then put a roller cone bit on and drilled inside of their casing. The drilling was hard at first and then eased up breaking thru of its own weight at about 218'. The 3 1/2" casing was then turned for about 1 1/2" into bedrock, which interesting enough was 237'6". This measurement was exact. I went bsck to Bowmaster and he is positive his depth was no lower than 234' - 235'. I believe the measurements are correct. Bill's machine has a scale every 1' marked with every 5'

in large numbers. I measured the core barrel with Joe Stein and it is 22' and his rods are 25'. The difference of 3' is very important.

After the 3 1/2" casing was seated, Warnock-Hersey started coring with a 2 1/2" core barrel 5' long. They just started coring when it was quite evident that the 3 1/2" casing was loose and bouncing around. We were using water and no water came back.

We cored for 5' but only recovered 2"6" which was the top of the hole which we were interested in. It was pure gypsum.

Decided to pull out of hole and pulled 24' of 3 1/2" casing and casing jammed and machine broke. They took the part to Halifax Sun. evening and didn't return until Tues. morning. Mon. it rained, anyway. Tues. morning Warnock=Hersey put down a split spoon and had no recovery. I had made a bailer at the machine shop, Mon. and we tried that. The first time he came up with about 2' of sand, in which was a small piece of metal, the same as that found with Bill Bowmaster. After repeated tries we brought up about 6 pieces of this small metal and a little piece of the red rag that Bowmaster had used. We worked 7 hrs. Tues. and 2 hrs. Wed. morning and started pulling casing at 10 A.M.

A very important point to remember is that when we started with the syfon tube the sand was at 212'. The bottom of the hole was 237'6" less the 24' of casing pulled out which meant that the bottom of the casing was 213'6" down.

The recovery while Warnock Hersey was working was sand, gravel and a piece of granite rock every so often. The fact that the metal was still near the bottom of the hole lead me to believe that it was coming from that depth. However, later events proved me wrong. It was decided to continue with a churn drill as this would bail out the hole fastest.

Note:

At this time I had to redig the casing down to 15' below the surface with a back-hoe again so I could weld the 6" pipe back on. this was done and then back-filled.

We set up over the hole with Harold Verge's churn drill and drove the casing down 10' to begin with. That meant from 176' to 186' He then started to bail out the hole. The sand was so tight that he had to use his drill bit in order to loosen it up, after which he would alternate with his bailer. The hole was at 210' when the churn drill started.

He started bringing up pieces of metal almost immeadiately and continued until he reached about 232'. The hole was finally cleaned out to 236'6", and the material was sand, gravel and a small piece of granite rock every so often. We noticed that the bottom of the hole would fill up about 2' overnight and so drove the casing another 2' to 188'.

It was thought at this time that the metal was coming from the bottom of the hole and so we decided to blast. We blasted and

bailed out a total of 4 times at the bottom of the hole. It was during this time that we started getting clay in pieces and also pieces of gypsum.rock. However, no metal at all came out. I did get a large amount of cement like material that later proved to be natural. We then terminated the drilling with Harold Verge and he pulled out.

After consulting with Bill Bowmaster it was agreed the metal came from higher up. The drilling at 215' had been hard and soft with a little drop of 2'. I set up a tri=pod with Gerald Dorey about 30' high and rented a gasoline driven hoist that would pick up about 1200lbs. Harold Verge loaned me his bailer and his cable, I purchased a case of dynamite in Halifax.

We then started systemmatically to blast and bail at the bottom of the hole and worked our way up. The blasting was done with two sticks of 2" X 8" of 75% dynamite using a cap for each stick and was done every 2' and bailed out each time to 232'. The total height reached was 215' at which point we put a total of 5 sticks 2" x 8". After blasting we could hear the rocks falling in, about 4times and dropped our measuring rock down and found that a total of 12' had piled at the bottom of the hole. This was after dark Sat. night and so nobody would get hurt we quit work and started to bail out Monday morning, at which time only 6' was piled at the bottom of the hole, so the blasting done at the bottom had to be extensive. We bailed the hole out again to 232' and not one piece of metal was found. It was then painfully plain that the metal came from higher up behind the casing and that driving the casing had effectively sealed it off as well as sealed the sand and rocks.

The hole was then sealed and the equipment taken back to Halifax. It should also be noted that we made an electice magnet and dropped it to the bottom of the hole before activating and pulled it slowly up the hole without any affect. This was of course done before any blasting.

Conclusions:

The 9" rock bit was put down to 195'. The casing was then driven to 176' leaving 19' below, that wasn't sealed and consequently that's where the sand, gravel, small pieces of granite rock and pieces of metal came from.

During the churn drilling the casing was evenually driven to 189, sealing off anything from above.

The only material that came from the hole after the blasting was clay and pieces of gypsum.

Solution:

1. Fill the hole with sand or fine gravel to 215'.

2. Pulling the casing back 5' at a time, and lower the electric magnet down to the bottom of the hole and then turn it on and pull it slowly up to the casing. This magnet is capable of picking up at least 20 lbs. and will really grab and not let loose until you break the electric contact.

3. Bail out with the churn drill to the desired depth

looking carefully for pieces of metal.

4. When the metal makes contact you can then blast with at least 3 sticks of dynamite at the exact depth needed. Whatever is covered with this metal will then fall into the hole below and be easily recovered with the bottom type bailer we have, in the event that metal bars are encountered a tool can be welded on the bottom of the bailer that will pick up bars.

This phase of the operation will take a total of 2 or 3 days and not run over $500.00.

Daniel C. Blankenship

Document 5 of 5 Submitted after Initial Report

Letter from John C.Osler to The Oak island Exploration dated June 3, 1970.
(This document is a report on diamond consumption by Warnock Hersey.)

JOHN C. OSLER, P.ENG.
145 ROWAN AVENUE
BEACONSFIELD, QUEBEC

June 3, 1970.

The Oak Island Exporation,
c/o Jonergin Co. Inc.,
6200 Grande Allee,
St. Hubert, Quebec.

Attention: Mr. D. Tobias

RE: REPORT ON DIAMOND CONSUMPTION,
WARNOCK-HERSEY INVESTIGATION OF 1969,
OAK ISLAND, NOVA SCOTIA.

Dear Sirs:

At the request of Mr. D. Tobias, we have examined various reports, invoices and other documents relating to an investigative drilling programme carried out by Warnock-Hersey International Limited, Professional Services Division during 1969 at the subject site. The purpose of this study was to prepare an objective appraisal of the consumption of diamond set bits, reaming shells and casing shoes which accounted for a total billing of $7,035.19 ($6,395.63 of items consumed, plus 10 per cent).

A list of the factual data on which this report is based is included in Appendix I, which is attached. From the various borehole logs available, it has been possible to gain an overall view of the drilling performed, and the terms of reference under which the initial investigation was conducted. Since borehole logs are prepared to summarize the technical results obtained in a specific hole, they do not lend themselves to a detailed analysis of drilling methods, daily progress, difficulties experienced by obstructions encountered during drilling, etc. Such specific information would only be available on detailed daily logs kept by the driller or supervising technician, from which

the consolidated log for the completed borehole is prepared. Thus with the information available, the observations in this report must of necessity be general in nature, being based on the writer's experience in the field of site exploration which dates back to 1953.

To gain an appreciation of the amount of drilling conducted by Warnock-Hersey, a table of the footage drilled in each hole was prepared and is presented as Appendix II. The tabulation is first presented such that the total footages agree with those reported in the Warnock-Hersey letter of March 10, 1970. However, as outlined by the notes in Appendix II, 25 feet of drilling reported in Borehole 10 was not actually executed, and 85 feet of drilling in Borehole 11 resulted from redrilling the hole to an already established depth of 145 feet, and so can hardly be classified as productive footage. We therefore conclude that the drilling accomplished by Warnock-Hersey amounted to 1,658 feet. It is also noted in Appendix II that up to 250 feet of drilling in Boreholes 2 and 10 were in backfill or caved material, which should certainly not account for any appreciable diamond loss during drilling.

We conclude that the calculation of $3.98 per foot for diamond consumption (Warnock-Hersey letter of March 10, 1970), which they do not feel to be extravagant, would be more realistically quoted as $4.99 per foot ($7,035.19 divided by 1,408 feet of "productive" drilling in undisturbed strata). We will reserve comment on this latter figure until later in this report.

An analysis of diamond consumption for casing shoes and coring bits is given in Appendix III. This analysis must be considered approximate, because actual day-to-day details are necessary to reconstruct what actually transpired, as already mentioned. The calculations show that, while the footage achieved

with the coring bits is generally low, the major costs in diamond set articles resulted from the consumption of diamond set casing shoes, with 21.7 bits of various sizes being reported as consumed. This item should be borne in mind when comparative costs of drilling methods are considered later in this report.

In preparing Appendix III, several apparent errors were noted in the Diamond Report (Warnock-Hersey letter dated January 7, 1970). HX casing shoe 29316 appears twice at 100 per cent consumption, while extention errors were noted for BX core bit H 13994 and NX core bit 97802. By our calculations, these errors amount to $444.47 (or $488.91 at cost plus 10 per cent). An examination of the various Warnock-Hersey invoices for the job reveals another apparent discrepancy in the total amount billed for diamond consumption. Invoice 69489 states "Diamond consumption first borehole = $577.56". Invoice 69508 amounting to $3,429.50 states "Diamond consumption - includes all diamond articles issued to job May 19 to July 15, 1969 (less May Invoice diamond charges). Invoice 69530 lists diamond consumption as $1,754.41. Invoice 69538 charges $103.04 as "Total diamond consumption during project May to August includes two-cone and tri-cone bits = $5,286.95; diamond consumption previously invoiced = $5,183.91". It would appear, however, that the original amount of $577.56 was not deducted from the second invoice because the total of $7,035.19 currently under discussion can only be obtained by adding the above four figures to the last item for diamonds amounting to $1,170.68 which appeared on Invoice 69587 (see Appendix IV). In summary, the correct charge for diamond consumption would appear to be $6,457.63 (the sum of $5,286.95 on Invoice 69538 and $1,170.68 on Invoice 69587) and <u>not</u> the figure of $7,035.19, as arrived at on the Diamond Report. The discrepancies noted on the diamond report would thus help explain an apparent overcharge of $577.56.

Based on the information and analyses presented above, we now wish to comment on the overall drilling costs, of which the charges for diamond consumption form an important component. In reply to their proposal of May 9, 1969, Warnock-Hersey were informed by Mr. J. Carr that "the purpose of this soils investigation is to obtain the data for the possible future construction of various underground structures" and that they were to submit "a regular soils report giving standard N values and soil and rock logs so that civil engineering design can take place". The original proposal covered four holes (numbers 1, 2, 3 and 6) and logs were obtained and reported on July 31, 1969. To meet these terms of reference, it is considered that the drilling methods and equipment were appropriate, although a Boyles BBS-1 rig is generally not considered to be "heavy-duty" and might well have been too small for the job. Warnock-Hersey, on their part, obviously knew the site conditions prior to submitting their proposal and undertook to advance the holes "in the most economical manner" by using diamond articles if such use would produce a saving to the client. It would also appear rather obvious that Warnock-Hersey did not consider that diamonds would prove to be a major item of cost when they estimated a total cost of $8,000 for the project, including the drilling of 4 - 220 foot holes and the preparation of their report.

The total footage drilled in the first four boreholes amounted to about 1,000 feet. In Appendix IV, it is estimated that the overall drilling costs by Warnock-Hersey work out to $14.43 per foot, using the lower figure for diamond consumption referred to above. Engineering charges for the initial four-hole phase of the work amount to about $1.60 per foot. Considering that the soil conditions in Borehole 2 were much less difficult than average, and overall charge of about $15.00 per foot for an "engineered" borehole with intermittent sampling is arrived at.

This is about what the writer would have used for estimating purposes on a project of this nature, despite the fact that Warnock-Hersey saw fit to quote a comparible figure of less than $10.00 per foot. It is also observed that a second proposal received for this project worked out quite closely to an estimate of $15.00 per foot.

The terms of reference for the remaining boreholes (Nos. 5, 7, 8, 10, 11 plus No. 9 which was drilled entirely by others but witnessed in part by Warnock-Hersey) are not clear to the writer. No specific instructions or statements of intention appear in writing and technical details appear to have been worked out in the field. With regard to the participation of Warnock-Hersey in this latter work it cannot be established whether they acted only as drillers and technicians, or whether they acted (at least jointly) as engineers. This distinction is important when the relative costs of drilling "blank" or unsampled holes are considered (see Appendix IV). The larger capacity rig operated by W. L. Bowmaster Well Drilling Ltd. was capable of advancing a hole at $9.25 per foot, including some sampling at depth. This is some $5.00 per foot lower than the average cost incurred by Warnock-Hersey, who also undertood to drill "blank" holes at the locations of Boreholes 5, 7 and 11, where detailed sampling at depth was all that was requested. The difference is seen to be closely related to the cost of diamonds per foot. From Appendix II, it is concluded that about 500 feet of such "blank" drilling was carried out in these three holes.

The conditions encountered in Borehole 11 were extremely difficult and, as noted by Warnock-Hersey, their <u>driller</u> recommended that the hole be relocated when it had reached a depth of 80 feet. It is reported that Mr. D. Blankenship decided to continue with the hole because of time considerations. The ultimate unit cost of drilling this hole probably was $20.00 per foot, or even more.

Certainly, an amount of the order of $1,000 of diamond set articles was consumed in this hole. What is not known is whether Warnock-Hersey, as engineers, ever questioned the drilling equipment used for the latter stages of the work and whether, under the extended terms of reference, they were rightfully expected to do so.

It is thus concluded that the ultimate costs of the investigation involving Boreholes 5, 7, 8, 9, 10 and 11 could have been reduced by perhaps $2,500, if the "blank" holes in the upper parts of Boreholes 5, 7 and 11 had been drilled by the Bowmaster rig, which produced at a rate of about $5.00 per foot less than the diamond drillrig. Whether such a potential saving should have been pointed out to you depends on the degree of technical responsibility assumed or exerted by Warnock-Hersey during this stage of the work.

SUMMARY

1. It is concluded that consumption of diamond set articles did occur as reported, with the use-rate of coring bits being higher than what would normally be expected, if used for coring only.

2. An apparent overcharge for diamond consumption of $577.56 was noted in the Warnock-Hersey invoices and it is considered that this item should be credited to the client. Certain discrepencies noted in the Diamond Report account for the majority of this apparent overcharge.

3. An overall reduction in drilling charges of about $2,500 could have been achieved in Boreholes 5, 7 and 11 and it should be established to what extent Warnock-Hersey might have shared or assumed technical responsibility for this fact.

We trust that this report will tend to clarify the events which occurred during the execution of this investigation and will serve as a useful basis for your deliberations with Warnock-Hersey on the matter of their final charges. If we can be of further assistance to you, we would be pleased if you would contact us.

Yours very truly,

JCO:jg

John C. Osler, Eng.

APPENDIX I

LIST OF REFERENCES

1. Borehole Logs and Reports

   a) Report by Warnock-Hersey dated July 31, 1969 containing logs of boreholes 1, 2, 3 and 6.

   b) Letter from Warnock-Hersey dated August 27, 1969 with appended logs of boreholes 5 and 7.

   c) Letter from Warnock-Hersey dated November 5, 1969 with appended descriptions of boreholes 8, 9 and 10.

   d) Letter from Warnock-Hersey dated December 10, 1969 with appended description of borehole 11.

2. Terms of Reference

   a) Proposal letter from Warnock-Hersey to Carr & Donald & Associates Ltd., dated May 9, 1969.

   b) Letter from Mr. J. Carr to Warnock-Hersey dated May 13, 1969 accepting quotation of May 9, 1969.

   c) Letter from Warnock-Hersey to Mr. J. Carr dated July 7 1969 regarding authority to proceed with two additional boreholes.

   d) Letter from Mr. J. Carr to Warnock-Hersey dated Nov. 3, 1969 containing authority to drill 5th and 6th boreholes plus additional drilling to commence on October 17, 1969.

   e) Letter from Mr. J. Carr to Warnock-Hersey dated Nov. 3, 1969 containing authority to drill hole No. 11.

   f) Letter from Mr. J. Carr to Warnock-Hersey dated Nov. 25, 1969 advising that the drilling programme is considered to be complete.

APPENDIX I (cont'd.)

3. Invoices

a) Invoices from Warnock-Hersey as follows:

Number	Date	Operating Period
69489	June 13/69	May/69
69508	July 21/69	June/69
69530	Aug. 15/69	July/69
69538	Sept. 8/69	up to Aug. 18/69
69571	Nov. 11/69	Oct. 17-31/69
69587	Dec. 12/69	Nov. 1-17/69

b) Invoices from W. L. Bowmaster Well Drilling Ltd. dated Oct. 20, 1969 and Oct. 30, 1969.

4. Correspondence Regarding Invoices

a) Letter from Mr. J. Carr to Warnock-Hersey dated Oct. 20, 1969 requesting an explanation and breakdown of drilling costs.

b) Letter from Warnock-Hersey to Mr. J. Carr dated January 7, 1970 with appended diamond consumption report.

c) Letter from Mr. J. Carr to Warnock-Hersey dated Jan. 29, 1970 requesting dates of consumption to augment diamond bit consumption report.

d) Letter from Mr. J. Davis, Golder Associates to Mr. D. Tobias dated February 9, 1970 containing typical bit prices and general observations on bit consumption under normal and abnormal circumstances.

e) Letter from Mr. D. Tobias to Warnock-Hersey dated Feb. 23, 1970 regarding charges for diamond bit consumption.

f) Letter from Warnock-Hersey to Mr. D. Tobias dated March 10, 1970 containing further details regarding diamond bit consumption

APPENDIX II

TABULATION OF DRILLING FOOTAGE ACCORDING TO WARNOCK-HERSEY LOGS AND REPORTS

Hole No.	Overburden (ft.)	Rock (ft.)	Total (ft.)
1	161	89	250
2	212	39.5	251.5
3	162	86	248
5	172	38	210
6	173	77	250
7	165	53	218
8	35	-	35
(hole drilled to depth of 165.5 ft. by others)			
10	70	5.5	75.5
(hole drilled to depth of 167.0 ft. by others)			
11	145	-	-
(redrill 60 ft. to 145 ft.)	85	-	230
	1380	388	1768

Notes:

1. In borehole 2, at least 165 ft. and possibly all 212 ft. of "overburden" is backfill. On page 10 of the July 31, 1969 report the "amazing loose and soft nature of the material encountered" is noted as well as the "ease of advancement of the borehole".

2. To arrive at the Warnock-Hersey totals for drilling, borehole 10 must be considered as starting at a depth of 167 ft. Yet there is other data which suggests that this hole was initially drilled to a depth of 230 ft. by others, and cased to a depth of 190 ft. This contradicts the statement of 167 ft. on the Warnock-Hersey report but agrees with the statement on the same report that the corebarrel

APPENDIX II (Cont'd.)

was lowered to a depth of 192 ft. in a previously drilled hole. This reduces the footage drilled by 25 ft. and suggests that the next 38 ft. drilled in this hole was in caved material.

3. In borehole 11, the hole was redrilled from 60 to 145 ft. and this 85 ft. is included in the total footage mentioned by Warnock-Hersey in their letter dated March 10, 1970.

4. It is concluded that the total footage drilled should be reduced by 110 ft. (notes 2 and 3) to 1658 ft., of which total up to 250 ft. was in backfill or caved material.

APPENDIX III

SUMMARY OF DIAMOND SET CASING SHOES AND CORING BITS EMPLOYED AS INFERRED FROM LOGS AND REPORTS

1. Casing

In the Warnock-Hersey report of July 31, 1969, Page 6, it is stated that holes were commenced in HX size, with successively smaller sizes of NX, BX and AX casing being telescoped inside, as required. From the logs and reports, the use of the following casing sizes is inferred:

Borehole	HX	NX	BX	AX
1		+	+	+
2	+	+	+	+ (note "a")
3	+	+	+	+ (note "a")
5		+	+	
6	+	+	+	
7	+	+	+	
8		possibly used		
10		+		
11	+	2	2	+
	5	9 or 10	8	2 (note "a")

Note a : AX casing is listed as being used on the logs of boreholes 2 and 3, but the fact that rock was cored in BX size in each hole precludes the use of AX casing.

2. Casing Shoes Consumed as per Warnock-Hersey List of January 7,1970:

HX Casing Shoes: 4 @ 100%, 1 @ 70%, 1 @ 60%, 2 @ 30%

Total = 5.9 bits vs use in 5 boreholes

(Note: There appears to be an error in the Warnock-Hersey Diamond Report, with HX Casing Shoe No. 29316 being listed twice with 100% consumption each time.)

APPENDIX III (Cont'd)

2. Casing Shoes (Cont'd)

NX and NW Casing Shoes: 2 @ 100%, 1 @ 90%, 3 @ 80%, 1 @ 50%, 2 @ 30%

Total = 6.4 bits vs use for 9 or 10 times

BX Casing Shoes: 6 @ 100%, 1 @ 80%, 1 @ 70%, 1 @ 40%

Total = 7.9 bits vs use for 8 times

AX Casing Shoes: 1 @ 100%, 1 @ 50%

Total = 1.5 bits vs use in 2 boreholes

3. Coring Bits

From the logs and reports, the use of the following coring bits is inferred, the figures shown being footages of rock reported drilled in each size:

Borehole	6 in.	NX	BX	AX
1	-	-	20	46
2	-	-	29.5	10
3	-	-	63	-
5	-	-	14	-
6	-	-	77	-
7	-	-	14	-
8	2.5	35	-	-
10	-	5	-	-
11	-	-	-	-
Totals	2.5	40	217.5	56

4. Coring Bits Consumed as per Warnock-Hersey List of January 7,1970:

6 in. bit = 20% consumed

NX bits: 1 @ 100%, 1 @ 60%, 1 @ 10% = 1.7 bits

(Note: The bit listed as 60% used was given as 100% used on job but with 40% use when issued. Thus use cannot exceed 60%; even so, amount charged amounts to 73% consumed and so an error occurred somewhere.)

APPENDIX III (Cont'd)

4. Coring Bits (Cont'd)

BX bits: 1 @ 100%, 2 @ 70%, 1 @ 65%, 1 @ 60%, 1 @ 50%
Total = 4.15 bits

(Note: An apparent error in the extension for bit H13994 where 50% of $132.25 should read $66.13, not $85.96.)

AX bits: 1 @ 70%, 1 @ 60%, 1 @ 50%, 1 @ 25%, 2 @ 20%
Total = 2.45 bits

5. Rate of Consumption of Coring Bits

From items 3 and 4, the average footage (reported) drilled for each bit works out to be:

6 in. bit = 12.5 ft/bit
NX bit = 23.5 ft/bit
BX bit = 52.4 ft/bit
AX bit = 22.8 ft/bit

These figures suggest a high rate of consumption for the type of rock drilled. Coring bits could have been used to clean or ream the casing and thus their use would not have been indicated on the logs. However, if this was the case, it would rate as a very costly method of advancing the borehole.

APPENDIX IV

SUMMARY OF ITEMS CHARGED ON WARNOCK-HERSEY INVOICES

Invoice	Date	Operating Period	Drill Rig Productive (hrs.)	Drill Rig Stand-by (hrs.)	Diamonds (cost =10%)
69489	13/6/69	May	109	26	$ 577.56
69508	21/7/69	June	330	3	3,429.50
69530	15/8/69	July	323	-	1,754.41
69538	8/9/69	to Aug.18	146	29	103.04
69571	11/11/69	Oct.17-31	14	14.5	-
69587	12/12/69	Nov.1-17	105.5	35.5	1,170.68
			1027.5		$7,035.19

ESTIMATE OF FOOTAGE COST OF WARNOCK-HERSEY DRILLING

1. Take productive rate as $17.00 per hour, being the quoted rate of $15.00 per hour plus a prorated amount of $2.00 per hour for vehicle rental ($10.00/day) and room and board ($12.00/day).

2. Total cost of "production" drilling:

   1027.5 x $17.00 = $17,467.50

3. Add diamonds, using the apparently correct charge of $6,457.63 (see text)

4. Charges for productive drilling (sum of items 2 and 3) = $23,925.13

5. Cost per foot for 1658 feet (Appendix II)

   $= \frac{\$23,925.13}{1658} = \$14.43$

6. The cost per foot in item 5 excludes stand-by charges, mobilization charges, and engineering and laboratory charges for field inspection and reporting.

ESTIMATE OF FOOTAGE COST OF BOWMASTER DRILLING

1. Borehole 8 was contracted for at $10.00 per foot plus an extra for casing left in place, at cost.

2. Boreholes 9 and 10 were contracted for at an hourly rate. The charge for an inferred footage drilled of 449.5 feet, apparently including the removal of casing from borehole 9, if any was used, was $4,150. Casing left in place in borehole 10 was again charged at cost.

3. The cost per foot for drilling boreholes 9 and 10 is $\$\frac{4,150}{449.5} = \$9.25$ per foot, including all consumed stores (bits) except casing left in place.

CHARGES FOR ENGINEERING AND EXPENSES

Invoice	Engineering Charges	"Out of Pocket"
69489	120.00	27.60
69508	40.00	12.00
69530	885.02	517.14 (includes lab)
69538	83.33	-
69571	280.00	56.10
69587	550.00	62.90
	$1,958.35	$675.74
	675.74	
	$2,634.09	

(Note: The charges on the first three invoices are more or less related to the scope of work outlined in the Warnock-Hersey report (i.e. the first four holes). These charges amount to $1,601.76.)