DRAFT REPORT
TRITON ALLIANCE LIMITED
SUBSURFACE INVESTIGATION
THE OAK ISLAND EXPLORATION
OAK ISLAND       NOVA SCOTIA

Distribution:

2 copies - Triton Alliance Limited,
Montreal, P.Q.

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

April, 1971.

69126

Golder Associates
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>COVERING LETTER</td>
<td>1</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>2</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>DESCRIPTION OF PROJECT</td>
<td>5</td>
</tr>
<tr>
<td>DESCRIPTION OF SITE</td>
<td>6</td>
</tr>
<tr>
<td>GEOLOGY OF AREA</td>
<td>8</td>
</tr>
<tr>
<td>i) Pleistocene Geology</td>
<td>6</td>
</tr>
<tr>
<td>ii) Bedrock Geology</td>
<td>8</td>
</tr>
<tr>
<td>PROCEDURE</td>
<td>8</td>
</tr>
<tr>
<td>i) Geotechnical Borings</td>
<td>9</td>
</tr>
<tr>
<td>ii) Archeological Borings</td>
<td>11</td>
</tr>
<tr>
<td>iii) Dye Testing</td>
<td>14</td>
</tr>
<tr>
<td>iv) Pumping Test</td>
<td>17</td>
</tr>
<tr>
<td>v) Ancillary Laboratory Testing</td>
<td>20</td>
</tr>
<tr>
<td>vi) Elevations</td>
<td>21</td>
</tr>
<tr>
<td>SOIL AND BEDROCK CONDITIONS</td>
<td>21</td>
</tr>
<tr>
<td>GROUNDWATER CONDITIONS</td>
<td>26</td>
</tr>
<tr>
<td>ARCHEOLOGICAL NOTES</td>
<td>27</td>
</tr>
<tr>
<td>i) Borehole 201</td>
<td>27</td>
</tr>
<tr>
<td>ii) Borehole 202</td>
<td>28</td>
</tr>
<tr>
<td>iii) Borehole 203</td>
<td>29</td>
</tr>
<tr>
<td>iv) Borehole 103</td>
<td>30</td>
</tr>
<tr>
<td>RESULTS OF DYE TESTS</td>
<td>31</td>
</tr>
<tr>
<td>RESULTS OF PUMPING TEST</td>
<td>31</td>
</tr>
<tr>
<td>REVISED EXPLORATION PROGRAMME</td>
<td>33</td>
</tr>
<tr>
<td>NOTES ON EXCAVATION AND DEWATERING</td>
<td>35</td>
</tr>
<tr>
<td>APPENDIX I - Summary of Previous Exploration Operations</td>
<td>In Order Following Page 38.</td>
</tr>
<tr>
<td>APPENDIX II - List of Samples Forwarded for Pollen Analyses</td>
<td></td>
</tr>
<tr>
<td>APPENDIX III - Results of Wood Identification Analyses</td>
<td></td>
</tr>
<tr>
<td>APPENDIX IV - Results of Metal Examination and Analyses</td>
<td></td>
</tr>
<tr>
<td>APPENDIX V - Detailed Groundwater Level Records</td>
<td></td>
</tr>
</tbody>
</table>

Golder Associates
LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORDS OF BOREHOLES

FIGURES:

1. Site and Boring Plan
2. Illustrative Section - "Boulder Theory"
3. Illustrative Section - "Bedrock Theory"
4. Simplified Details of Test Well Installation
5-10. Photographs of Wood and Metal Fragments
11-15. Results of Pumping Test - Rate of Drawdown Curves
16-18. Results of Pumping Test - Distance-Drawdown Curves
19-30. Grain Size Distribution Curves
April 28, 1971.

Triton Alliance Limited,
6200 Grande Allee,
St. Hubert, P. Q.

Attention: Mr. D. C. Tobias

RE: THE OAK ISLAND EXPLORATION

Dear Sirs:

The attached report presents the factual results of a subsurface investigation carried out under our supervision at Oak Island. The report outlines our participation in the project prior to November, 1970 (i.e., prior to the beginning of exploration operations using the Statesman Mining Company equipment).

The majority of this report was prepared in October - November, 1970. At the request of your Mr. Tobias, however, the report was not finalized and issued in November, 1970.

It should be noted that we have not revised the report in the light of information obtained during recent operations at the site (i.e., since November, 1970). Of particular significance in this regard is the fact that our borehole 203 apparently intersected and followed for a short distance the previous borehole 10. This fact explains the loosened zone encountered in borehole 203 and the marked response during the pumping test of the piezometer sealed into this boring.
The attached report is a draft of our final report on this phase of the project and has not as yet been reviewed by Dr. Golder. The report has been issued at this time to give you the opportunity to comment on the information provided and to decide on the number of copies required prior to our issuing a finalized version. We do not anticipate any major changes in the report.

Yours Truly,

H. Q. GOLDER & ASSOCIATES LTD.

J. B. Davis, P. Eng.

Golder Associates
ABSTRACT

This report presents the detailed factual results of a subsurface investigation carried out in connection with The Oak Island Exploration at Oak Island, Nova Scotia. Preliminary notes concerning excavation and dewatering at the site are also given in the report.

More detailed recommendations will be provided when the current (November, 1970) exploratory work is completed and the future exploration programme is finalized by Triton Alliance.

The site is underlain by some 100 to 140 ft. of hard relatively impervious clayey silt till. The till is underlain by some 35 to 45 ft. of very dense silt to sandy silt and the silts grade into generally sandy material at a depth of about 140 to 170 ft. below present ground surface. From the results of this and past investigations it is not clear whether the sandy deposit is some 60 ft. thick and contains massive anhydrite boulders or whether the sands are relatively thin and are underlain by anhydrite bedrock containing a large cavern between depths of about 200 and 240 ft. below ground surface. In either case, sound anhydrite bedrock was encountered in the borings at a depth of about 220 to 240 ft. below ground surface.

Several geotechnical discontinuities in the form of loosened and disturbed zones were encountered as discussed in the report. Further, several artifacts of archeological interest were recovered from the borings.

The groundwater level across the site is at about mean sea level and the piezometric groundwater level in the lower water-bearing stratum reflects tidal fluctuations.

The results of dye tests carried out at the site did not disclose any direct hydraulic communication between the "Money Pit" area and the surrounding ocean. The results of a full scale pumping test indicate that the average coefficient of permeability of the lower water-bearing deposits is about $1 \times 10^{-2}$ cm/sec. and that there is fairly good hydraulic communication throughout the lower pervious strata.

Golder Associates
INTRODUCTION

H. Q. Golder & Associates Ltd. have been retained by Triton Alliance Limited to carry out a subsurface investigation at Oak Island; a small island in Mahone Bay some 40 miles southwest of Halifax, Nova Scotia and located near the village of Western Shore, Nova Scotia. The purpose of the investigation was to determine the soil, bedrock and groundwater conditions at the island and, based on these conditions, to provide recommendations for putting down an exploratory shaft(s) at a location(s) and to a depth(s) specified by Triton Alliance Limited.

As exploratory drilling at the island is still in progress (November 1970) the location(s) and the depth(s) to which the exploratory shaft(s) is to be taken have not been finalized. Consequently, this report presents only the factual results of the investigation and general notes on shaft sinking operations at the site.

Our participation in the project during the current exploratory drilling (27 in. dia. cased observation holes) is of a continuing nature although we do not have a full-time inspector at the site. At present, our comments regarding specific drilling problems are being provided by letter. Geotechnical data obtained through this exploratory drilling (particularly from interim de-watering operations) will be summarized in a subsequent report following completion of this phase of the work.

Similarly, specific recommendations for large scale exploration of the island (excavation of shafts, tunnelling and the like) will be provided when the exploratory programme is
established by Triton Alliance Limited (i.e., when positive indications of original workings at the island are found).

DESCRIPTION OF PROJECT

It is reported that in 1795 a backfilled shaft of apparently considerably earlier origin was accidently discovered near the eastern end of Oak Island by residents of the area. As local tradition indicated that the area had previously been frequented by pirates the "discoverers" apparently concluded (as, in fact, have all "searchers" to the present day) that they had discovered the entrance to a buried treasure. Since the discovery of the backfilled shaft (which has since become known as the "Money Pit") some 25 shafts have been put down at the site and hundreds of feet of tunnels have been excavated by "searchers". A history of previous operations at the island together with a description of their findings and conclusions is given by Mr. R. V. Harris in his book "The Oak Island Mystery" published by the Ryerson Press, Toronto. The first edition of the book (published in 1958) describes operations at the island prior to 1958. The second edition (published in 1967) has been revised and includes operations up to the end of 1966 (i.e., to the beginning of operations by the present group of "searchers", Triton Alliance Limited).

A summary of previous operations at the island as reported by Mr. Harris is included as Appendix I to this report. This summary is our interpretation of Mr. Harris's account and was prepared at the request of Triton Alliance Limited. We in no way vouch for the accuracy of the information given in this appendix.

It is understood that during 1967, 1968 and 1969 some 40 borings were put down at the site by Triton Alliance Limited.

Golder Associates
These borings were advanced using a Becker Drill and direct circulation rotary drilling equipment. These borings were put down to obtain archeological (as opposed to geotechnical) information. In addition, a soil investigation was carried out at the site by Warnock Hersey International Limited in 1969. The results of this investigation are given in Warnock Hersey's report dated July 31, 1969 and in subsequent letters.

The majority of the borings put down by Triton Alliance Limited were located in the area of the "Money Pit" (or where the "Money Pit" is assumed to be, the exact location having been lost several years ago). However, one boring (hole number 10) was put down some 200 ft. north-east of the "Money Pit" area. The results of these borings indicated to Triton Alliance Limited that, in the "Money Pit" area, a cribbed chamber existed in the bedrock at a depth of about 200 ft. below present ground surface (i.e., some 30 ft. below the bedrock surface) and that the "Money Pit" extended down to this depth. Further, "pieces of metal", thought to be from within the bedrock, were recovered from borehole 10 (located some 200 ft. north-east of the "Money Pit").

Based on the above, Triton Alliance Limited concluded that the "original workings" were considerably deeper than had been assumed by previous "searchers" and were in fact in the bedrock. Golder Associates were retained by Triton Alliance Limited to provide recommendations for putting down an exploratory shaft to a depth of about 200 ft. below ground surface and, in particular, to provide recommendations for controlling the groundwater during excavation of the shaft and exploration of the supposed chamber.
During the early stages of the investigation (i.e., prior to field drilling operations) it was concluded, on the basis of information obtained by others, that the proposed access shaft should be put down outside of the area disturbed by previous "searcher's" shafts. The "area of interest" would be reached by means of a tunnel from the access shaft. Consultation with Beaver Construction Company (the contractor selected by Triton Alliance to put down the shaft) indicated that a lined shaft about 25 ft. in diameter should be assumed for preliminary design purposes.

DESCRIPTION OF SITE

Oak Island is one of more than 350 islands in Mahone Bay, a relatively shallow bay on the Atlantic Ocean side of Nova Scotia some 45 miles west of Halifax, Nova Scotia. The island is about 3/4 miles long by about 1/2 mile wide and has an area of about 130 acres. The western end of the island is within about 100 yds. of the mainland and at this point a single lane causeway has been constructed to connect the island to the mainland.

In plan, the island resembles a bar-bell with the long axis in a generally east-west direction. The east and west ends of the island are formed by relatively flat hills which extend some 30 to 40 ft. above sea level. The narrower neck of land connecting these hills is low lying and is swampy.

The "Money Pit" is located on the south slope of the hill forming the eastern end of the island and is some 300 ft. north of the south shoreline of the island. In the immediate vicinity of the "Money Pit" cutting and filling operations by earlier "searchers" have resulted in a relatively flat working area some 24 ft. above sea level. At the "Money Pit" the present

Golder Associates
ground surface appears to be some 10 ft. below original ground surface. South of the flat area the ground surface slopes steeply down to the beach forming the present shoreline, North and east of the flat area the ground surface rises fairly steeply to the original ground level which is sloping upward in a generally north and north-east direction to the crest of the hill.

At the time of the investigation, there were two wooden cabins at the crest of the hill some 180 ft. north-east of the "Money Pit". One of these cabins was habitable and is referred to as "Restall's Shack". In addition to these cabins there was considerable surface evidence (in the form of collapsed and water-filled shafts) of earlier "searcher's" work. Of particular interest is the remains of a timber cribbed shaft put down by a Mr. Hedden in 1937. This shaft is located immediately adjacent to the "Money Pit" location assumed by Triton Alliance. The Hedden Shaft, when constructed, had a plan area of about 12 ft. by 24 ft. and was divided by cross bracing into eight 6 ft. square bays. The shaft was taken to a depth of about 124 ft. In 1942, one bay of the Hedden Shaft was deepened to about 165 ft. by a Mr. Hamilton. It is understood that the top of the Hedden Shaft shifted about 6 ft. to the west during excavation work in 1965. It is reported by your Mr. Blankenship that at that time (1965) the cribbing in the Hamilton shaft was sound but that the cribbing in the Hedden Shaft was sprung.

GEOLOGY OF AREA

i) Pleistocene Geology

Based on available geological information, it is known that the area was heavily glaciated during the latest (Wisconsin) period of glaciation. Evidence from buried peat deposits in Cape Breton Island suggest that the glacial ice sheet retreated from the area about 18,000 years ago.
During the advance of the glacier it appears that the ice sheet "ploughed up" all of the existing overburden and lifted large slabs of rock from the exposed bedrock. These slabs were subsequently re-deposited in the overburden as the glacier retreated. The petrology of the glacially deposited soils in the Mahone Bay area indicate that the material "ploughed up" by the glacier was transported only a short distance before being re-deposited and, consequently, the overburden generally contains the same mineral constituents as the underlying bedrock. Further, boulders measuring 30 ft. long by 20 ft. wide by 20 ft. high and larger have been encountered in drumlins in the Mahone Bay area.

It is further known that during the latest period of glaciation the level of the Atlantic Ocean was several hundred feet lower than present sea level. This is evidenced by drowned forests found in the off-shore area along the Atlantic sea-board.

Although the exact depositional sequence in the vicinity of the site is not known it is probably fairly typical of glacial deposition. As the glaciers began to retreat (melt) outwash streams developed along the ice-bedrock contact. During this period soil material entrapped in the melting ice would be released into the outwash stream. Consequently, directly overlying bedrock there would be material of glacio-fluvial origin. The gradation of the material at any given point would depend on the position of the ice front at the time of deposition; the coarser material being deposited at the head of the outwash stream and the finer material being transported to and beyond the ice front.

As melting continued the finer grained soils and well graded tills would be deposited in situ (i.e., not water transported and would be pre-consolidated by the overlying glacial ice.

Golder Associates
ii) Bedrock Geology

Based on available geological information it appears that Oak Island straddles a geological boundary in the bedrock. This boundary appears to pass beneath the swampy area in the narrower central portion of the island. The western half of the island is underlain by slate of the Halifax Formation. (The slate outcrops on the mainland at the end of the causeway joining the island and the mainland). The slate dips down to the east and, in the eastern end of the island (i.e., in the "Money Pit" area), is overlain by more recent limestone, gypsum and sandstone bedrock of the Windsor Formation. Although the Windsor Formation is predominant in other parts of Nova Scotia it occurs only as a small local deposit in the Mahone Bay area. Geological records suggest that the Windsor Formation is less than about 500 to 1,000 ft. thick in the Mahone Bay area. Although the limestones, gypsum and sandstones are probably considerably thinner near the edges of the deposit, the actual thickness of the deposit in the "Money Pit" area is not known.

PROCEDURE

The field work for this investigation may be divided into four (4) major categories. Initially, we were retained to put down detailed sampled borings to obtain geotechnical information in the area of a proposed 200 ft. deep access shaft (some 50 ft. south of the "Money Pit") and in the "Money Pit" area (i.e., the area into which an exploratory tunnel was to be driven). During the course of the investigation, we were requested to put down borings in two areas of archeological interest. Although these borings were primarily for archeological purposes, considerable geotechnical information was also obtained from the boring results.

Golder Associates
In addition, we were requested to carry out dye tests in an attempt to locate unique connections or tunnels from the "Money Pit" area to the ocean. Finally, a full scale pumping test was carried out in the existing Hedden/Hamilton shaft to establish the hydraulic characteristics of the overburden.

i) Geotechnical Borings

The field work for this phase of the investigation was carried out between March 24, and May 19, 1970 and between May 28 and June 6, 1970. During these periods, four (4) detailed sampled borings (numbered 101, 102, 103 and 104) were put down at the locations shown on Fig. 1. Three (3) of these borings (numbered 101, 102 and 104) were put down in the area of the proposed access shaft and the fourth boring (numbered 103) was put down through the existing Hedden Shaft in the area of the "Money Pit".

All of the geotechnical borings were put down to a depth of about 250 ft. below present ground surface using a skid-mounted machine drillrig (B.B.S. 2) supplied and operated by the F. E. Johnston Drilling Co. Ltd. Due to the presence of cobbles and boulders within the overburden it was necessary to advance the holes using rotary drilling techniques employing tri-cone bits and to advance the casings by rotary drilling using diamond casing shoe...

The holes put down from ground surface were started and advanced to as deep as possible in H casing size (the largest practical casing size). When the diamond shoe or the H casing wore out (generally at a depth of 40 to 50 ft. below ground surface), Nx casing was telescoped to the bottom of the hole and the boring advanced as deep as possible in Nx casing size. A smaller casing (Bx sized casing) was then telescoped and the hole advanced to the upper surface of the gypsum rock (a depth of about 160 ft. below ground surface).

Goldar Associates
In borehole 103 (put down through the existing Hadden Shaft) a 4 in. dia. pipe casing was installed to and seated at the bottom of the shaft. The hole was then advanced to the upper surface of the gypsum rock (a depth of about 156 ft. below ground surface) in Nx casing size.

Within the overburden, standard penetration tests were carried out at about 10 ft. intervals of depth in each boring put down in the proposed access shaft area and samples of the overburden were obtained using 1-1/2 in. I.D. split spoon sampling equipment. In the "Money Pit" area, continuous sampling was carried out using 1-1/2 in. I.D. split spoon sampling equipment.

To determine the permeability characteristics of the overburden in the area of the proposed access shaft, falling head permeability tests were carried out in each of boreholes 101, 102 and 104.

In the area of the proposed access shaft (boreholes 101, 102 and 104) the gypsum rock was core drilled in Bx size. After penetrating some 50 to 60 ft. of rock, however, soil was encountered in each of these borings. Samples of the soil were obtained and the soil zone (some 5 ft. thick) was cased in Ax size casing to prevent caving of the walls of the borings. The holes were then advanced through the gypsum bedrock underlying the soil zone by core drilling in Ax size to a depth of about 250 ft. below ground surface.

In the area of the "Money Pit" (borehole 103) the same sequence was followed but the rock was initially core drilled in Nx size, Bx casing was telescoped and the hole completed in Bx size core.
Following completion of each of the geotechnical borings; wellpoints, standpipes and piezometers were sealed into the hole to permit monitoring of the groundwater level(s) in each of the significant strata encountered in the boring.

The field work for this phase of the investigation was supervised throughout by members of our engineering staff who directed the drilling and sampling operations and logged the borings. All of the samples obtained from the borings were sent to our laboratory for detailed examination and testing.

ii) Archeological Borings

The field work for this phase of the investigation was carried out between May 21 and 28, 1970 and between June 11 and 25, 1970. During these periods a total of four (4) borings (numbered 201, 202, 203 and 204) were put down at the locations shown on Fig. 1. The boring locations were specified by Triton Alliance Limited and are understood to be in areas where artifacts of archeological interest were anticipated.

During the first period (May 21 to 28, 1970) one (1) boring (numbered 201) was put down some 270 ft. north-east of the "Money Pit" area. The boring was advanced to a depth of about 225 ft. below present ground surface using a machine drillrig supplied and operated by the F. E. Johnston Drilling Co. Ltd. The drilling and sampling procedures employed in this hole were similar to those previously outlined for the geotechnical borings.

Initially, we were requested to take the hole to a depth of about 100 ft. below present ground surface. As drilling progressed, we were requested to take the hole to greater and

Golder Associates
greater depths. Due to the presence of cobbles and boulders, however, it was necessary to telescope casings several times and as a result the hole was cased in Ax casing size when the upper surface of the gypsum rock was encountered. The hole was continued through the sound rock in Ax core size but this hole was too small to permit effective sampling of soil encountered below the sound gypsum rock at a depth of about 220 ft. below ground surface. Consequently, the hole was terminated at a depth of 225 ft.

To facilitate drilling operations it was decided by Triton Alliance Limited to put down the remaining archeological borings to a pre-determined depth using a direct circulation rotary well drilling rig* supplied and operated by W. L. Bowmaster Well Drilling Ltd. and to employ conventional sampling and drilling procedures (F. E. Johnston Drilling Co. Ltd. equipment) only through the area of interest. To this end, borehole 202 was put down to a depth of about 184 ft. (i.e., 10 ft. into bedrock) using the well drilling rig. Borehole 202 was located about 3 ft. from Borehole 10 which had been put down by Triton Alliance Limited in 1969. It is understood that pieces of metal (thought to be from the bedrock) were recovered from Borehole 10 and the purpose of Borehole 202 was to attempt to locate and obtain additional samples of this metal. Consequently, after it had been rotary drilled to a depth of 184 ft., Borehole 202 was cased and was taken to a depth of about 245 ft. using conventional drilling and sampling procedures.

During drilling of Borehole 202, an obstruction was encountered at a depth of about 125 ft. below ground surface.

* It was found to be virtually impossible to obtain an accurate stratigraphy profile using this equipment. The equipment is, however, most effective in making a 6 in. dia. hole in the ground, the purpose for which it was designed.

Golder Associates
During drilling of this obstruction, pieces of wood were carried to ground surface by the drilling water. When the obstruction was penetrated the drilling resistance decreased for a depth of about 5 ft. (i.e., between about 125 and 130 ft. below ground surface) and about 50 per cent of the drill water was lost.

To further investigate the area between depths of about 125 and 130 ft. below ground surface Borehole 203 was put down some 6 ft. east of Borehole 202. Borehole 203 was put down to a depth of about 110 ft. using the well drilling rig. The hole was then cased and taken to a depth of about 150 ft. using conventional drilling and sampling procedures.

As the results of laboratory testing carried out by others (see "Ancillary Testing) indicated that the material encountered between depths of about 220 and 225 ft. in Borehole 201 contained traces of "recent" pollen it was decided by Triton Alliance Limited to put down Borehole 204 some 8 ft. east of Borehole 201 to further investigate the area below a depth of about 220 ft. Borehole 204 was advanced to a depth of about 213 ft. using the well drilling rig. At this depth a void was encountered and some 1,200 gals. of bentonite slurry were pumped into this void with no apparent effect. The hole was cased and taken to a depth of about 240 ft. using conventional drilling and sampling procedures.

Following completion of each of the archeological borings; wellpoints, standpipes and/or piezometers were sealed into the hole to permit monitoring of the groundwater level in the significant strata encountered in the boring.
The field work for this phase of the investigation was supervised throughout by a member of our engineering staff. The samples obtained in the borings were sent to our laboratory for detailed examination and testing. Part or all of selected samples were forwarded to specialized laboratories for additional examination and testing (see "Ancillary Testing").

iii) Dye Testing

In an attempt to determine if a unique connection(s) exists between the "Money Pit" area, or other areas of interest, and the ocean, dye tests were carried out. These tests consisted basically of applying a positive head of water in the existing Hedden Shaft (to induce flow from the "Money Pit" area to the ocean) and pumping various coloured dyes into borings selected for testing. Following introduction of the dye, water was pumped into the tested holes to further induce flow from the area tested.

The details of the dyes used for the tests are given in Table I. All of these dyes were supplied in powder form.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Manufacturer</th>
<th>Brand Name</th>
<th>Approximate Mix Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Allied Chemical</td>
<td>Auramine 0 130%</td>
<td>2 lb. dye to 45 gal. water</td>
</tr>
<tr>
<td>Blue</td>
<td>CIBA Co. Ltd.</td>
<td>Kiton Blue A</td>
<td>2 lb. dye to 45 gal. water</td>
</tr>
<tr>
<td>Orange</td>
<td>CIBA Co. Ltd.</td>
<td>Kiton Orange II</td>
<td>2 lb. dye to 45 gal. water</td>
</tr>
<tr>
<td>Red*</td>
<td>C.I.L.</td>
<td>Rhodamine B.N.</td>
<td>2 lb. dye to 800 gal. water Conc. 450</td>
</tr>
</tbody>
</table>

* It is reported that 1 lb. of this dye is capable of visibly colouring 10 million gals. of water.
These dyes were introduced into the following holes:

Yellow Dye: The yellow dye was pumped into Borehole 11A (see Fig. 1 for location). This hole (also referred to as Borehole 24) was put down by Triton Alliance Limited in 1969. It is understood that the hole is cased to a depth of about 198 ft. (6-1/4 in. I.D. casing) and terminates in a cavity (the supposed cribbed chamber previously discussed - see "DESCRIPTION OF PROJECT").

Blue Dye: This dye was pumped into a standpipe installed in Borehole 102. The standpipe is sealed into a loose and pervious zone encountered between depths of about 147 and 156 ft. during boring operations.

Orange Dye: This dye was pumped into borehole 10 located about 180 ft. north-east of the "Money Pit" area. The hole was put down by Triton Alliance Limited in 1969. As previously noted, pieces of metal, assumed to be from within the bedrock, were reportedly recovered from this boring. At the time of the dye tests the hole was cased to a depth of about 189 ft. (i.e., some 15 ft. into rock) with 6-1/4 in. I.D. casing. The hole had originally been taken to a depth of about 236 ft. and below the casing the hole had been dynamited.

Red Dye: During the later stages of the dye tests the red dye was pumped into the existing Hedden Shaft. As previously noted this shaft had been taken to a depth of about 165 ft. by Hedden and Hamilton (see "DESCRIPTIC OF SITE").

The dye tests were started on May 14, 1970. Prior to the tests the water level in the Hedden Shaft was raised about 10 ft. above the stabilized level by pumping water from the "Cave-In

Golder Associates
Pit" into the Hedden Shaft (pumping rate of about 100 gal./min.). During the test approximately 800 gal. of yellow dye was pumped into Borehole 11A, 100 gals. of blue dye was pumped into Borehole 102 and 250 gals. of orange dye was pumped into Borehole 10. Following introduction of the dye, water was pumped into each of the boreholes tested.

A minimum head of about 10 ft. of water was maintained in the Hedden Shaft on May 14 and 15, 1970. On May 16, 1970 the test was repeated. On this date about twice the volume of dye previously pumped into the boreholes was used.

The head of water in the Hedden Shaft was maintained until the evening of May 16, 1970. During the period of May 17 to 25, 1970 testing was continued as weather permitted and during the majority of this period a head of water was maintained in the Hedden Shaft. During this period some 4,500 gals. of red dye was pumped into the Hedden Shaft together with some 2,500 gals. of the other coloured dyes.

During the period of the dye tests a careful watch of the waters surrounding the island was maintained to determine if, where and when dye appeared in the ocean. This watch was maintained at various times by the following:

a) a fixed wing aircraft which flew over the water surrounding the island in different directions at different altitudes and at different times of day.

b) A local fishing boat containing personnel with view boxes.

c) A local row-boat containing people with view boxes.
d) Limited skin diving

e) Personnel walking the shore-line and observing
   the off-shore area from the top of the hill.

A concentrated watch was maintained during and
immediately following each test. Periodic observations were
made between tests as weather conditions permitted.

iv) Pumping Test

A full scale pumping test was carried out to assess
the hydraulic characteristics of pervious water-bearing deposits
which underlie the site. To avoid the expense of putting down a
deep well, the test was carried out from the existing Hedden
Shaft. Initially, it was planned to carry out the pumping test
from the bottom of the Hamilton Shaft. The Hamilton Shaft is a
6 ft. by 6 ft. timber cribbed shaft extending from the bottom of
the Hedden Shaft to a depth of about 165 ft. below ground surface.
The cribbing in this shaft was reportedly sound as late as 1965
and was presumed to still be in good condition.

During installation of the test well an obstruction
was encountered in the Hedden Shaft at a depth of about 115 ft.
below the top of the shaft (i.e., about 5 ft. below the bottom
of the shaft). It is probable that this obstruction consists of
timbers and other debris which have fallen into the shaft. Whether
this debris extends to the bottom of the Hamilton Shaft or is only
within the Hedden Shaft is not known.

After several unsuccessful attempts to penetrate the
obstruction, it was decided to carry-out the pumping test from
the Hedden Shaft at a depth of about 115 ft. below the top of the

Golder Associates
shaft. As the timber cribbing in the Hedden Shaft was reported to be in poor condition in 1965 it was thought that the shaft could collapse if unwatered. Consequently, it was agreed to backfill the shaft with clean sand and gravel (beach sand) prior to pumping from the shaft.

The test well was constructed by installing a 16 in. dia. casing to the top of the obstruction in the Hedden Shaft. A 24 ft. length of 10 in. dia. well screen (Doer screen) was welded to a 12 in. dia. casing and was lowered to the bottom of the 16 in. dia. casing. The annular space between the well screen and the 16 in. dia. casing was backfilled with properly graded filter sand. The shaft was backfilled to above the top of the well screen with sand and gravel and the 16 in. dia. casing was then withdrawn to the top of the screen (i.e., the 16 in. dia. casing was pulled back 24 ft.). During withdrawal of the casing the level of filter sand was maintained about 10 ft. above the top of the well screen.

Following withdrawal of the 16 in. dia. casing the shaft was backfilled to within about 30 ft. of ground surface with locally available sand and gravel (beach sand).

The pumping test was carried out using an 8 in. submersible pump driven by a 25 H.P. electric motor. The pump, motor and associated electrical wiring was supplied and operated by Wellpoint Dewatering Corporation. Electric power for the pump was provided by a 60 K.V.A. diesel generator supplied by Beaver Construction Company Limited.

The pump was attached to a 6 in. dia. riser pipe and was lowered to the bottom of the well screen. A valve was installed.
in the horizontal leg of the riser pipe and an orifice weir was provided to measure the discharge rate of the pump. The details of the completed test well installation are shown on Fig. 4.

It should be noted that prior to backfilling the Hedden Shaft a standpipe was installed to a depth of about 110 ft. in an adjacent bay of the shaft to monitor the water level in the shaft backfill. The standpipe was installed by sliding the standpipe down alongside of the riser pipe from the wellpoint previously installed in Borehole 103.

The pump was tested on July 7, 1970 and the pumping test commenced at 8 a.m. on July 8, 1970. Except for a 15 min. shutdown to check the oil level in the generator on July 10, 1970, continuous pumping was carried out until 1 p.m. on July 12, 1970 (i.e., 99 hrs. after the start of pumping).

During the first 24 hrs. of the test (i.e., until 8 a.m. on July 9, 1970) a pumping rate of 130 U.S.G.P.M. was maintained. At 8 a.m. on July 9, 1970, the pump discharge rate was increased to 250 U.S.G.P.M. (the capacity of the test well) and this rate was maintained until the end of the test.

During the pumping test the water levels in the test well, boreholes 10 and 11A and all of the piezometers, standpipes and wellpoints installed at the site were monitored to determine the effect of the test pumping. Following the start of pumping and change in pumping rate water level readings were taken at frequent intervals. However, during long periods of pumping at a constant rate the interval between readings was increased. The rate of recovery in the various observation holes was established in a similar manner after pumping was stopped on July 12, 1970.

Golder Associates
Following completion of the pumping test the test pump was removed from the well. All well casings and the well screen were left in place as it was anticipated that the well would be deepened and incorporated in a final dewatering system during future exploratory work.

v) Ancillary Laboratory Testing

In addition to standard soil classification testing carried out in our laboratory, samples or parts of samples of archeological interest were forwarded to other laboratories for specialized testing.

Pollen Analyses: Based on the type of pollen contained in a soil sample, it is possible to determine the approximate date when the sample was last exposed to the atmosphere. In this way it is possible to determine if the soil is of glacial origin or if it was placed relatively recently (such as backfill in a tunnel or shaft). These tests were carried out by Dr. J. C. Ritchie at Dalhousie University in Halifax, Nova Scotia. The results of these analyses were sent directly to Triton Alliance Limited. A list of the samples forwarded to Dr. Ritchie is given in Appendix II to this report.

Identification of Wood Samples: A sample of the wood obtained at a depth of about 125 ft. in Borehole 202 and a sample of wood obtained at a depth of about 143 ft. in Borehole 103 was forwarded to the Faculty of Forestry, University of Toronto for identification. A sample of wood previously discovered in Smith's Cove by Triton Alliance Limited was also forwarded to the University of Toronto. A report of their findings is given as Appendix III to this report.

Golder Associates
Identification of Metal Samples: A sample of metal obtained at but not necessarily from a depth of 150 ft. in Borehole 202 and several small metal fragments obtained from a depth of about 84 ft. in Borehole 201 were forwarded to The Steel Company of Canada (Mr. A. B. Dove, Senior Development Metallurgist) for examination and testing. A copy of their findings is given as Appendix IV to this report.

Carbon Dating of Wood Samples: Several samples of wood recovered from borings put down under our supervision together with samples of wood recovered from previous borings put down by Triton Alliance Limited were forwarded to Brock University in St. Catharines, Ontario for carbon dating. It is understood that the results of this testing were forwarded directly to Triton Alliance Limited. Golder Associates did not receive a copy of this report.

vi) Elevations
The elevations given in this report are referred to a temporary bench mark consisting of a nail in the root of a cherry tree located about 120 ft. east south-east of the "Money Pit" area (see Fig. 1 for location). The elevation of this bench mark was taken as 1,000.0 (Local datum). It should be noted that mean sea level at Oak Island is about elevation 961.9 (Local datum).

SOIL AND BEDROCK CONDITIONS
The detailed stratigraphy encountered in each of the borings put down under our supervision is given on the Record of Borehole sheets following the text of this report. A section showing the inferred stratigraphy across the site is given on Figs. 2 and 3. It should be noted that two interpretations of the boring
data between depths of about 160 and 240 ft. can be made. These alternative interpretations are shown on Figs. 2 and 3. The results of conventional laboratory testing carried out on samples of the overburden are given on the Record of Borehole sheets and on Figs. 19 to 30 inclusive.

The site is underlain to a depth of between about 100 and 140 ft. by relatively impervious clayey till. The till consists generally of grey clayey silt with sand and some gravel and contains numerous cobbles and boulders, particularly in the upper 10 to 20 ft. Although essentially a clayey material of low plasticity, the till contains occasional seams and layers of sand. In the southern portion of the site (i.e., the proposed access shaft location) the till contains a fairly extensive zone of dark grey to red-brown layered silty clay to layered clayey silt and silty clay.

Based on the results of standard penetration tests, which gave 'N' values ranging from about 30 blows/ft. to in excess of 100 blows/ft., the consistency of the till is hard.

The till is underlain at a depth of between about 100 and 140 ft. by some 35 to 45 ft. of very dense grey to brown silt to sandy silt. The silt stratum contains a trace to some clay throughout and contains some interbedded clayey silt and silty sand seams. The silts frequently exhibit a faintly stratified structure, particularly in the southern portion of the site.

Below a depth of about 140 to 170 ft. the silts grade into a sandy silt to silty sand material. It is within this stratum that alternative stratigraphic conditions have been postulated. The condition illustrated on Fig. 2 assumes that
the sandy stratum extends down to and is underlain by bedrock at a depth of between about 210 and 240 ft. below ground surface. Within this sandy stratum there are massive boulders or bedrock "floats" measuring several tens of feet in plan area and thickness and composed of the same material as the underlying bedrock. The possibility of large boulders occurring in the basal overburden stratum is borne out by the available geological information given previously.

The second stratigraphic condition (illustrated on Fig. 3) assumes that the sandy stratum is relatively thin and is underlain by bedrock at a depth of about 160 to 180 ft. below ground surface. Some 20 to 40 ft. below the upper surface of the bedrock there is either

a) A large continuous cavity some 20 ft. high which has been in-filled with soil or
b) Several relatively large but discontinuous cavities which have been in-filled with soil.

Case (a) is illustrated on Fig. 3. In either case, it appears that at several points the roof of the cavern or cavities has collapsed resulting in "sink holes" in the bedrock cap. The presence of such "sink holes" could explain the in-filling of the cavern or cavities and could explain local loosening of the sands and silts above the bedrock surface. The results of previous borings put down by Hamilton in 1942 and by Triton Alliance Limited suggest that one such "sink hole" exists in the "Money Pit" area and the results of our boring suggest that a second "sink hole" could exist in the area of Boreholes 201 and 204.

The stratigraphic condition which exists between a depth of about 160 and 240 ft. cannot be defined on the basis of

Golder Associates
presently available boring information. For the revised exploration programme (see "REVISED EXPLORATION PROGRAMME") this zone is significant only from a dewatering point of view and the hydraulic response for both stratigraphic conditions will be similar (i.e., even if a cavern does exist in the bedrock, the cap rock has been perforated by "sink holes" permitting hydraulic connection between the cavern and the overlying sands). It should be noted that even though the "Bedrock Theory" is indicated on the Record of Borehole sheets, this does not indicate a particular preference for this theory.

Based on one boring put down by Warnock Hersey International Limited (Borehole 6) it appears that the cavern or boulder zone ends immediately south of the proposed 200 ft. deep access shaft and that south of this area sound bedrock occurs at a depth of about 170 ft. below ground surface (i.e., below the level of the area previously graded by others).

The material beneath the boulders ("Boulder Theory") or the in-fill material in the cavern ("Bedrock Theory") is extremely variable. The material consists of very loose (slurry-like) sands and silts, soft clays, dense sands and silts, hard clays and hard clayey till. This variability in both composition and density is probably due primarily to the method of deposition and erratic pre-consolidation by glacial ice. Some of the loosened zones may, however, be due to loss of ground into deep shafts put down by previous "searchers".

The bedrock (and the large boulders in the case of the "Boulder Theory") consists of sound fine to medium grained anhydrite and gypsum with some dolomite and limestone inclusions.
Although the cap rock above the cavern or the large boulders was found to be relatively impervious, the bedrock below a depth of about 210 to 240 ft. was consistently found to be impervious.

It should be noted that in the southern portion of the site a zone of vesicular bedrock (the vesicles being in-filled generally with hard brown clayey silt to silty clay) or a zone of smaller boulders in a hard clayey silt to silty clay matrix was encountered between depths of about 190 and 220 ft. This zone probably represents the southern edge of the large cavern within the bedrock or of the bouldery basal overburden deposit.

The preceding discussion considers only the generalized or natural subsurface stratigraphy at the site. In the vicinity of the "Money Pit" the natural stratigraphy has been considerably altered by shafts and tunnels constructed by previous "searchers". Within this "disturbed" area, no generalization of the subsurface conditions is possible. The complexity of this disturbed zone is evidenced by Borehole 103 which was put down within a few feet of two previous shafts (Hamilton Shaft and Chappell Shaft). This boring encountered disturbed soil, timbers, pieces of metal and other debris.

In addition to this "disturbed" area, three other apparent discontinuities were encountered in the borings.

a) A 9 ft. thick zone of very loose to loose sand to sand and gravel was encountered between depths of 147 and 156 ft. in Borehole 102. The gravel fraction in this zone consists primarily of very angular sandstone.

b) A 5-1/2 ft. thick zone of very loose sandy material was encountered within the clayey till between depths

Golder Associates
of about 120 and 126 ft. in Borehole 203. A similar loosened zone was apparently encountered beneath a layer of wood or a timber in the adjacent Borehole 202. This zone is discussed in more detail under "Archeological Notes".

c) A 2-1/2 ft. seam of very dense sand underlain by a 3-1/2 ft. thick layer of cobbles and boulders in a reddish-brown clayey silt matrix was encountered between depths of 84 and 90 ft. in Borehole 201. These layers are discussed in more detail under "Archeological Notes".

GROUNDWATER CONDITIONS

Following completion of each of the borings, standpipes, wellpoints and piezometers were installed to permit monitoring of the groundwater level(s) within each of the significant strata encountered during boring operations. The details of these installations are shown on the Record of Borehole sheets together with a summary of the water levels in each of the installations during the period of this investigation. A detailed record of water level readings is given in Appendix V to this report.

During the course of the investigation, attempts were made to determine if the water in the various strata was saline or "fresh". However, as water was being used in the drilling operations it was impossible to obtain representative samples of the groundwater. Mr. Bowmaster (W. L. Bowmaster Well Drilling Ltd.) reports that, from his experience drilling with air, the groundwater above a depth of about 160 to 180 ft. (i.e., the upper level of bedrock on the top of the boulders) is generally "fresh" whereas
the groundwater within the in-filled cavern or the lower portion of the boulder layer is generally saline. The presence of "fresh" water overlying a depressed (i.e., below ocean level) saline water table beneath an island is not uncommon. Further, if any of the permeable strata are in hydraulic communication with the ocean, a reflection of tidal fluctuations in both the "fresh" water zones and saline water zones is to be anticipated. For the case of an artesian aquifer condition* such as exists at Oak Island, this reflection of tidal fluctuations is merely an indication of the transmission of hydrostatic pressures and does not necessarily indicate that large volumes of water are flowing through the more pervious deposit.

ARCHEOLOGICAL NOTES

In addition to the geotechnical information obtained during this investigation, the following artifacts of archeological interest were recovered from the borings put down under our supervision.

i) Borehole 201

During boring operations in this hole, pine needles and wood fragments were observed in the wash water return during drilling from a depth of 84 ft. to 84.9 ft. Further, small flakes of metal were observed in sample 12 (depth of 88.6 to 89.7 ft.). It was originally thought that the pine needles and wood fragments

* An artesian aquifer occurs when a relatively pervious stratum (such as the sands and silts) is overlain by a relatively impervious stratum (such as the clayey till) and the piezometric water level in the pervious stratum is above the base of the impervious stratum.

Golder Associates
were introduced into the boring with the drillwater (pumped from a near-by partially collapsed shaft) and that the metal fragments had come off of the drillrods. During the subsequent laboratory testing programme, however, sample 10 (depth of 84.5 to 86.5 ft.) was passed through a nest of sieves to determine the gradation of the sample. During sieving, several small pieces of metal were retained in the coarsest sieve. As pre-examination of this sample did not disclose the presence of the metal fragments it must be concluded that the metal was embedded in the sample and was not adhering to the sides of the sample. Consequently, it appears unlikely that the metal could have been introduced into the sample during drilling operations. A photograph of the metal fragments is given on Fig. 5. The pieces of metal were forwarded to the Steel Company of Canada for detailed examination and analyses. A copy of their report is given in Appendix IV of this report.

ii) Borehole 202

As previously noted, Borehole 202 was put down to a depth of about 185 ft. using a direct circulation rotary well drilling rig. During drilling operations an obstruction was encountered at a depth of about 125 ft. During drilling through this obstruction several small wood fragments were observed in the drillwater return. A photograph of one of these wood fragments is given on Fig. 6. One of the wood fragments was forwarded to the Faculty of Forestry, University of Toronto for identification. A copy of their report is given in Appendix III to this report. The remaining fragments were forwarded to Brock University for carbon dating. Although we have not received a copy of their report it is understood that the wood is reported to be about 18,000 years old.

Golder Associates
After penetrating the obstruction at a depth of about 125 ft. the drilling pressure decreased for a depth of about 5 ft. (i.e. between depths of about 125 and 130 ft.) and in this zone approximately 50 per cent of the drillwater was lost (i.e., did not return to ground surface). This probably indicates the presence of an approximately 5 ft. thick loosened or disturbed zone.

When the borehole had been advanced to a depth of about 150 ft. below ground surface a blockage occurred in the drill rods. A sample of the soil blocking the central core of the rods was obtained. During subsequent laboratory testing (sieving) of this sample (sample 2) a small piece of metal was retained on the coarsest sieve. This piece of metal, photographs of which are given on Fig. 7, was forwarded to The Steel Company of Canada for detailed examination and analysis. A copy of their report is given in Appendix IV to this report. It should be noted that the depth from which this piece of metal came cannot be accurately established; only that it came from above a depth of 150 ft.

During drilling operations between depths of about 125 ft. and 185 ft. pine needles and wood fragments were periodically observed in the drillwater return. As the hole was uncased all of these wood fragments could have come from a depth of about 125 ft. Further, the pine needles could have been introduced into the boring with the drillwater which was being pumped from a nearby partially collapsed shaft.

iii) **Borehole 203**

Borehole 203 was put down some 6 ft. east of Borehole 202 to further investigate the apparently loosened or disturbed zone encountered between depths of about 125 and 130 ft. in
Borehole 202. As previously noted, a 5-1/2 ft. thick disturbed zone was encountered between depths of about 120 and 126 ft. in Borehole 203. However, no artifacts of archeological interest were recovered either from this disturbed zone or from below the zone.

iv) Borehole 103

Borehole 103 was put down through the bottom of the Hedden Shaft and was located within about 6 ft. of both the Hamilton Shaft and the earlier Chappell Shaft (both of which penetrated to a depth of about 165 ft.). As it is apparent that horizontal drilling and bracing was carried out from both of these previous shafts, any artifacts encountered in Borehole 103 could be attributed to these earlier "searchers".

During drilling operations a piece of metal was recovered from a depth of 138.0 ft. and a second piece of metal was recovered from a depth of 141.5 ft. Between the pieces of metal the boring encountered angular lightly cemented sandstone fragments. Photographs of the two pieces of metal are shown on Figs. 8 and 9. These pieces of metal were forwarded to Triton Alliance Limited.

Between a depth of 143.0 ft. and 144.9 ft. the boring encountered a timber or timbers. A 7 in. long Nx size core of this timber was recovered. As the hole had been taken to a depth of 145 ft. before the timber was encountered it appears that the timber which was embedded in soft clay, moved into the boring.

A photograph of part of the timber recovered from the hole is given on Fig. 10. Samples of the timber were forwarded to the Faculty of Forestry, University of Toronto for identification and to Brock University for carbon dating.

Golder Associates
RESULTS OF DYE TESTS

The results of the dye tests did not provide any positive evidence of a direct hydraulic communication(s) between the "Money Pit" area and the ocean.

On May 22, 1970 yellow material thought to be the dye pumped into Borehole 11A was sighted in Mahone Bay on the south side of the island. This yellow material was also sighted near the causeway leading to the mainland. The yellow material was subsequently found to be yellow pollen from local vegetation rather than the dye pumped into Borehole 11A.

Subsequent to the dye tests it was observed that the water around the entire island had a reddish tint. As it was thought that the reddish colour was due to the dye pumped into the Hedden Shaft, a fixed wing aircraft was employed to obtain a better view of the area. Observations from the aircraft confirmed that the water around the island had a reddish tint but that ponded water on the surrounding land mass also had this colouring. It was subsequently found from local sources that this colouring of the water was an annual event associated with the spring run-off from the surrounding land masses.

RESULTS OF PUMPING TEST

The detailed results of the full scale pumping test carried out from within the Hedden Shaft between July 8 and 12, 1970 are presented in Figs. 11 to 18 inclusive. The rate of drawdown in each of the functioning piezometers, standpipes and wellpoints is given on Figs. 11 to 15 inclusive. The maximum stabilized drawdown achieved at various radial distance from the well for a pumping rate of 250 U.S.G.P.M. is shown on Figs. 16 to 18 inclusive.

Golder Associates
The results of the pumping test indicate the following:

i) Although the well terminated at a depth of about 115 ft. (within the lower portion of the clayey till or upper portion of the relatively impervious silts) pumping from the well had a significant effect on the piezometric water levels in the pervious deposits to a depth of as much as about 240 ft. Thus it appears that the Hamilton Shaft is open (at least to water) and that water from the lower permeable sands flowed up this shaft and into the well. Alternatively, the entire area around the Hedden Shaft is sufficiently disturbed to permit the upward flow of water.

ii) There is a direct hydraulic communication between the sandy zone overlying the bedrock and the cavity in the bedrock ("Bedrock Theory" - see Fig. 3) or, alternatively the lower pervious strata is some 60 to 80 ft. thick and contains massive anhydrite boulders ("Boulder Theory" - see Fig. 2).

iii) The radius of influence of the well in the permeable zone(s) underlying the clayey till and silts north-east of the well is significantly greater than the radius of influence in the same zone(s) south of the well. In other words, a much flatter drawdown curve was achieved to the north-east of the well than was achieved south of the well.

iv) The response time of piezometers installed in the lower permeable zone(s) was rapid. Consequently, provided the piezometric level is above the base of the clayey till, and probably the relatively impervious silts, prolonged pumping will not be required to achieve a significant percentage of the total drawdown of a well.
This is to be anticipated as, in this case, the effect of the well is only to reduce hydrostatic pressure in the permeable zone(s). Should the piezometric water level be lowered to below the upper surface of this permeable zone(s) a considerably longer pumping period will probably be required as in this case it will be necessary to drain or partially drain the pervious deposit.

v) The disturbed zone encountered within the relatively impervious clayey till between depths of about 120 and 130 ft. in Boreholes 202 and 203 was in hydraulic communication with the well. This communication could have been through the underlying pervious zone (i.e., the disturbed zone extends down to the sands) or, alternatively, the disturbed zone may extend horizontally to the "Money Pit" area.

vi) The average coefficient of permeability of the lower pervious zone(s) is about $1 \times 10^{-2}$ cm/sec. However, some portions of this lower zone are probably significantly more pervious than other portions.

**REVISED EXPLORATION PROGRAMME**

During the course of this investigation it was concluded by Triton Alliance Limited that it was unlikely the original "depositors" could have sunk a shaft through the lower water-bearing pervious strata to a depth of some 200 ft. below ground surface. Consequently, it was decided by Triton Alliance Limited to concentrate further exploration work in the relatively impervious clayey till deposit.

At present (November, 1970) two 27 in. dia. observation holes are being put down at the site using a pneumatically activated
grab supplied and operated by the Statesman Mining Company. One of these observation holes (numbered 10x) is being put down in the Borehole 202-203 area to investigate the disturbed zone encountered between depths of about 120 and 130 ft. below ground surface. The second observation hole (numbered 201x) is being put down in the borehole 201-204 area to investigate the area between depths of about 84 and 90 ft. below ground surface where pieces of metal were recovered from Borehole 201. If time permits (the grab has been hired for a specific period of time) additional observation holes will be put down in the "Money Pit" area.

Should any of the observation holes disclose positive indications of "original" workings (presumably in the form of tunnels it is understood that a lined shaft will be put down to the area of interest and a tunnel will be constructed to follow the "original" workings to their termination.

The machine being employed to put down the observation holes is experiencing difficulty due to groundwater inflow. The machine is not capable of operating efficiently if more than about 2 ft. of water collects in the bottom of the hole. This problem is especially acute in the case of observation hole 10x which is following the old Borehole 10. The 6 in. dia. casing has been withdrawn from Borehole 10 and groundwater from the lower pervious zones is flowing up the uncased boring into the bottom of the observation hole.

Limited dewatering operations are presently being carried out by Triton Alliance in an attempt to temporarily lower the groundwater level sufficiently to permit completion of the two observation holes. Should "original" workings be encountered in
either observation hole and a shaft constructed to these workings, it is understood that a proper dewatering system will be installed.

NOTES ON EXCAVATION AND DEWATERING

In areas which have not been disturbed by previous borings, shafts, tunnels and the like, no serious construction problems are anticipated in putting down an exploratory shaft through the hard clayey till to a depth of some 80 ft. below ground surface. To this depth, some minor inflow of groundwater should be anticipated from sand seams within the till and from the clayey till mass itself. However, the inflow should be easily handled by pumping from a sump in the bottom of the shaft.

We suggest that a circular shaft some 15 to 20 ft. in diameter would be the most suitable exploratory shaft. The shaft should be lined with pre-formed bolted steel liner plates and the sides of the shaft should be supported by means of steel ribs as required. The use of circular ribs will eliminate the need for transverse bracing and will maintain a clear working space in the central portion of the shaft. To ensure a relatively uniform pressure distribution around the circular shaft, we suggest that the space between the liners and the wall of the excavation be grouted.

For preliminary design purposes, we recommend the use of an active earth pressure coefficient, $K_a$, equal to 0.3. Within the clayey till, we suggest that grouted liner plates be designed to withstand full hydrostatic pressure. As an alternative, the space between the liners and the wall of the excavation could be properly packed with clean free-draining sand to provide drainage from behind the liner plates.
As the excavation proceeds below a depth of about 80 ft., heave of the base of the excavation due to hydrostatic uplift pressures in the underlying sands and silts may occur. To prevent heave of the base of the shaft during excavation in the lower portion of the clayey till (i.e., between a depth of about 80 ft. and the upper surface of the silts) we suggest that the hydrostatic uplift pressure in the silts and the sands be relieved by means of gravity relief wells installed from the base of the excavation. These relief wells could consist of 12 in. dia. granular wicks extending from the base of the excavation to the upper surface of the bedrock (or the top of the large boulders as the case may be). The relief wells should discharge into a sump in the base of the shaft; the top of the wells being cut-off as the excavation proceeds.

Should the exploratory shaft extend down into the water bearing silts and the sands underlying the clayey till it will be necessary to lower and maintain the groundwater level in the vicinity of the shaft at or below the bottom of the excavation. This can be accomplished by means of properly designed and installed deep pumped wells. It should be noted, however, that a normal well system will not completely dewater the lower portion of the water bearing sand deposit (or alternatively, the cavity in the bedrock). Consequently, if the shaft is to be taken into the sound bedrock encountered at depth, extensive grouting will probably be required.

Should the shaft be put down through relatively undisturbed material into a disturbed zone (such as occurs in the borehole 202-203 area) it will be necessary to dewater the disturbed zone. This dewatering will be required to:

a) Prevent "piping" and heaving of the base of the shaft as it approaches the disturbed zone and
b) To permit visual examination and exploration of the disturbed zone in free-air. This groundwater control can be accomplished by means of properly designed and installed deep pumped wells.

Should a shaft be put down in a disturbed area (such as the "Money Pit" area it will be necessary to either put down borings in the immediate area of the proposed shaft or to over-design the shaft and to revise the design as excavation proceeds and the actual subsurface conditions become known. This latter procedure will require close engineering supervision as excavation proceeds.

It is probable that extensive groundwater control will be required in conjunction with any shaft put down in a disturbed area.

Based on the results of the full scale pumping test it appears that, as long as the piezometric groundwater level within the water-bearing sands (and the cavity in the bedrock if the "Bedrock Theory" is correct) is above the base of the clayey till deposit, a drawdown of approximately 15 ft. may be anticipated for each 100 gals. of water pumped from the aquifer. Consequently, if a 90 ft. drawdown is required to unwater an area of interest, it will be necessary to pump water from the aquifer at a rate of approximately 600 g.p.m. Pumping test results further indicate that due to hydraulic restrictions of both the aquifer and the wells, the capacity of an individual well will be about 200 g.p.m.

From the above, we suggest that for preliminary design purposes a drawdown of approximately 30 ft. per well be assumed.
During installation and initial pumping from the wells, the piezometric groundwater level in the area of interest should be monitored and the well system revised as required. As the drawdown achieved by the wells is relatively uniform over a wide area, the well system need not be installed immediately adjacent to the exploratory shaft but should be in the general vicinity of the shaft. Further, the drawdown should occur rapidly (i.e., prolonged pumping prior to excavation will not be required).

Should the proposed exploratory shaft extend into the waterbearing silts and sands, considerably higher pumping rates will be required. In this case the wells should be installed as close as practical to the shaft location to achieve a maximum drawdown at the shaft. Further, a considerable period of time may be required to achieve a stabilized drawdown condition as it will be necessary to at least partially drain the waterbearing strata.

When a specific exploration programme is proposed by Triton Alliance Limited, we will be pleased to provide specific recommendations for excavating and lining the shaft and for controlling the groundwater in the vicinity of the shaft.

J. B. Davis, P. Eng.

H. Q. Golder, P. Eng.

JBD:jg
69126
April 28, 1971.

Golder Associates
APPENDIX I

SUMMARY OF PREVIOUS EXPLORATION OPERATIONS

OAK ISLAND

NOVA SCOTIA

Golder Associates
INTRODUCTION

This appendix summarizes the exploratory work carried out at Oak Island prior to 1965. Since 1965 members of Triton Alliance Limited (notably Mr. Blankenship and Mr. Tobias) have been involved with the exploratory work at the island.

This appendix is based on our interpretation of the book "The Oak Island Mystery" (first and second editions) written by R.V. Harris and published by the Ryerson Press, Toronto. We can not vouch for the accuracy of any of the information given in this appendix.

The relative position of various shafts and tunnels referred to in the reference book are indicated on Fig. I-1 at the end of this appendix. Brief notes concerning the exploration sequence are given on the following pages.

It should be noted that the shafts and tunnels discussed in this appendix do not necessarily include all of the work at the island. In the reference book it states "From correspondence carried on by Mr. Blair and from other sources, thirty-eight shafts, large and small, have been sunk of which twelve were close to the original Money Pit and sixteen others near the shore of Smith's Cove". *

It should further be noted that, in the accounts the shafts previous to 1937 (i.e. the Hedden Shaft - see Step 25) it is reported that the water level in flooded shafts near the Money Pit stabilized at a depth of about 32 ft. As the average water level in the Hedden shaft during the course of this investigation was at about elevation 965 (Local datum), which corresponds with the average water levels in the borings, it appears that during the earlier exploratory work the ground surface in the vicinity of the Money Pit was about elevation 997 (Local datum) or some 12 to 13 ft. higher than the present ground surface elevation. The site grading was probably done by Dunfield during his operations at the site in 1965-1966.

* The Oak Island Mystery, first edition, page 198
**STEP NO. 1**

**Date**  -  1795  (Discoverers)

**Shaft No. 1**  (Money Pit)  -  for location see Fig. I-1

1. The entrance to the Money Pit was discovered by a local youth. The entrance was located in a cleared area near the base of an oak tree. A large forked branch of this tree extended over the clearing and a tackle block was affixed to the fork.

2. The remains of a road from the west shore of the island to the cleared area was discovered.

3. The ground surface below the tackle block had settled to form a hollow. The searchers excavated within this sunken area and found the outline of an infilled shaft.

**Section Through Shaft**

Scale 1" to 20'

---

Golder Associates
STEP NO. 2

Date - 1804 (Onslow Co.)

Shaft No. 1 (Money Pit) - for location see Fig. I-1

1. Searchers excavated to a depth of 93 ft. within outline of an infilled shaft (Money Pit). Between depths of 90 and 93 ft. the seepage of water increased. The bottom of the shaft (93 ft. depth) was probed with a bar and encountered a hard impenetrable object at 98 ft. depth. The following morning the shaft was filled with water to within 32 ft. of ground surface and attempts to pump out the shaft failed.

Section Through Shaft

Scale 1" to 20'

Ocean W.L.

One report states that there were also oak planks at each 10' level

Tier of oak logs

Tier of charcoal

Tier of putty-like clay, plastic, hardens on exposure (drying)

Tier of smooth beach stones (alternative report says charcoal)

Coconut fibre or manilla grass

Tier of putty-like clay

Stone 3' x 1' x 1'-figures & letter cut in it

90'-93' bottom softened - seepage increased

Hard impenetrable object

Note:
W.L. rose in shaft to about 32 ft. below ground surface, attempts to pump out shaft failed.

Golder Associates
STEP NO. 3

Date - 1805 (Onslow Co.)

Shaft No. 2 - for location see Fig. I-1

1. Shaft No. 2 was dug to a depth of 110 ft. with intention of taking out treasure from below the area of seepage (see Step 2).

2. Shaft No. 2 was dry to a depth of 110 ft. The searchers tunnelled to within 2 ft. of the Money Pit when water suddenly "broke-in" at the tunnel face ("the workmen barely escaped with their lives"). Shaft No. 2 flooded to within 32 ft. of ground surface.

Section Through Shaft

Scale 1" to 20'

WATER LEVEL IN SHAFT

Golder Associates

MONEY PIT ASSUME TO CONTINUE BELOW 93' DEPTH
Date - 1849  (Truro Co.)

Shaft No. 1  (Money Pit) - for location see Fig. I-1

1. The Money Pit was found to be caved-in. The shaft was re-excavated to a depth of 86 ft. (following the outline of an earlier shaft) when water "broke-in" and flooded the shaft to within 32 ft. of ground surface.

2. A timber platform was constructed at a depth of 30 ft. and five (5) holes were drilled through the bottom of the shaft.

Record of Boreholes

| BH 1  | to 106' - mud & stone |
| BH 2  | to 106' - mud & stone |
| BH 3  | 98'-0" - 98'-5" - spruce timber |
|       | 98'-5" - 99'-5" - void |
|       | 99'-5" - 99'-9" - oak |
|       | 99'-9" - 101'-7" - loose metal |
|       | 101'-7" - 101'-11" - oak |
|       | 101'-11" - 102'-3" - oak |
|       | 102'-3" - 104'-1" - loose metal |
|       | 104'-1" - 104'-5" - oak |
|       | 104'-5" - 104'-11" - spruce timber |
|       | 104'-11" - 110'-11" - clay |
| BH 4  | 98'-0" - 98'-5" - spruce timber |
|       | 98'-5" - 98'-11" - void |
|       | 98'-11" - thought to be side of round cask - auger had jerky motion - several oak splinters recovered |
|       | 104'-5" - 104'-11" - spruce timber |
|       | 104'-11" - 106' - clay |
| BH 5  | No record but apparently similar to BH 3. |

Section Through Shaft

Scale 1" to 20'

Money Pit

Drilling PlatF: Water Level

See Details! Loss

Goldert Associates
STEP NO. 5

Date - 1850  (Truro Co.)

Shaft No. 3 - for location see Fig. I-1

1. Shaft No. 3 was excavated to a depth of 109 ft. in hard red clay. No water was encountered. The searchers tunneled 10 ft. towards the Money Pit when water "broke-in" at the face of the tunnel. In 20 minutes the water level in the shaft rose 45 ft. The shaft could not be pumped below a depth of 80 ft. with four 2-horse gins.

2. The water in Shaft No. 3 and Shaft No. 1 (Money Pit) was saline and the water level rose and fell with the tide.

Section Through Shaft

Scale 1" to 20'

Golder Associates
STEP NO. 6

Date - 1850 (Truro Co.)

Excavation in Smith's Cove - for location see Fig. I-1

1. It was noted that larger stones were absent along one section of the beach in Smith's Cove. It was further noted that as the tide ebbed "large rivulets gushed along the beach as from many bubbling springs".

2. A cofferdam was built and the beach area excavated.

Plan View of Workings Discovered on Beach

Scale 1" to 50'

[Diagram showing plan view with labels for high line, low line, tide line, central drain, and 145' limits of workings]
Section Through Workings Discovered on Beach

Scale 1" to 2'

Ground Surface

3' Sand & Gravel

2" of Coconut Fibre
3"-4" Kelp
Blue Sand
Coconut Fibre

Beach Cobble's Free of Sand and Gravel

Natural Clayey Till

Box Drain - 8" wide - constructed of worked flat stones
**STEP NO. 7**

**Date** - 1850 (Truro Co.)

**Shafts No. 4 and 5** - for location see Fig. I-1

1. In an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit Shafts No. 4 and 5 were put down.

2. Shaft No.4 was dug through clay to a depth of 75 ft. The shaft was dry.

3. Shaft No.5 was dug to a depth of 35 ft. where a large boulder was encountered. The boulder was pried up and water flowed into the shaft. The water was saline and the water level in the shaft rose to the ocean water level. The water level in the shaft rose and fell with the tide.

**Section Through Shaft**

Scale 1" to 20'

---

Golder Associates
STEP NO. 8

Date - 1850 (Truro Co.)

Shaft No. 6 - for location see Fig. I - 1

1. The Money Pit was pumped dry to a depth of 86 ft. (see Step 4).

2. Shaft No. 6 was dug to a depth of 118 ft. The shaft was dry. A tunnel was advanced 18 ft. towards the Money Pit when the face of the tunnel "blew-in". Water and mud rose in Shaft No. 6 to within 12 ft. of ground surface and the bottom of the Money Pit dropped from a depth of 86 ft. to a depth of 113 ft. This "blow-in" and collapse of the Money Pit was not observed.

Section Through Shaft

Scale 1" to 20'

SHAFT G

MONEY PIT

MUD LEVEL AFTER COLLAPSE

12'

Golder Associates

118'

18'

-86' - BOTTOM OF PIT AT STA

-113' - BOTTOM OF PIT FOLLOWING COLLAPSE.
STEP NO. 9

Date - 1863 (Oak Island Association - Truro)

Tunnels - for locations see Fig. I-1

1. Shafts No. 1 (Money Pit) 2, 3 and 6 were cleared out and connected by means of tunnels (depth of tunnels not known).

2. The water level in the shafts was lowered to a depth of 82 ft. below ground surface by means of twelve (12) 70 gal. bailing casks.

3. Soft mud flowed into the tunnel joining Shaft No. 2 and the Money Pit on three occasions. Finally, the bottom of the Money Pit subsided and this shaft (No. 1) was declared unsafe. Consequently, the work was terminated.
Date - 1864 (Oak Island Association - Truro)

Shafts No. 7 and 8 - for locations see Fig. I-1

1. Shaft No. 7 dug to a depth of 107 ft. At a depth of 90 ft. tools previously left at a depth of 96 ft. in the Money Pit (Step 4) and the bottom tier of the Shaft No. 3 cribbing were found. At a depth of 100 ft. tools previously left at a depth of 93 ft. in the Money Pit (see Step 2) were found. Shaft No. 7 was terminated at a depth of 107 ft. as water continued to "come-in from below".

2. Shaft No. 8 was dug to an unknown depth and a tunnel was driven to the north in an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit. This tunnel was not located.

Section Through Shaft No. 7

Scale 1" to 20'
Date - 1865  (Oak Island Association - Truro)

Shaft No. 9  - for location see Fig. I-1

1. Shaft No. 9 was dug to a depth of 120 ft. At this depth tunnels were driven north, south and towards Smith's Cove in an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit.

2. A fourth tunnel entered the Money Pit at a depth of 108 ft. and the Money Pit was re-cribbed to a depth of 108 ft.

3. A tunnel was driven around the bottom of the Money Pit outside of the cribbing. This tunnel encountered Shaft No. 2.

4. On one side of the Money Pit the bottom of the shaft was hard but on the other side of the pit the ground was soft.

5. During operations in the Money Pit area, the water level was controlled by pumping from Shaft No. 7.
MONEY PIT

MONEY PIT CLEANED OUT AND
RE-TIMBERED TO 108' DEPTH

SHAFT NO. 2 ENCOUNTERED DURING
TUNNELING AROUND MONEY PIT

108' HARD BOTTOM

SHAFT 9

120' SOFT BOTTOM

TUNNEL

Goldar Associates
STEP NO. 12

Date - 1866-1867 (Oak Island Eldorado Co. - Halifax Co.)

Money Pit - for location see Fig. I-1

1. The shaft in the Money Pit (see Step 11) was cleared out to a depth of 108 ft. A tunnel was driven south from the bottom of this shaft. The floor of the tunnel was noted to be soft ("a worker at the face felt the earth give way slightly"). A pick was driven into the floor of the tunnel and water seeped out of the hole. The hole was enlarged and a large cavity was found. The inflow of water from this cavity flooded the tunnel and shaft.

2. A platform was constructed at a depth of 90 ft. in the shaft. Three holes were drilled from this platform. Two of these holes did not encounter anything of interest. The results of the third hole are indicated below.
Section Through Shaft

Scale 1" to 20'

- Money Pit re-cribbed 9' x 9' Shaft
- Soil plug of unknown thickness with void below, water flowed in when plug punctured

Golder Associates
STEP NO. 13

Date - 1866-1867  (Oak Island Eldorado Co. - Halifax Co.)

Shaft No. 10 and Tunnels - insufficient information to establish shaft location

1. Shaft No. 10 was dug to a depth of 110 ft. The shaft was located about 175 ft. south of the flood tunnel from Smith's Cove to the Money Pit.

2. Two tunnels encircling the Money Pit were driven at a depth of 95 ft. below ground surface. No records regarding these tunnels were kept.

3. Extensive tunnelling was carried out at a depth of 110 ft. below ground surface. Although no records of these tunnels were kept, one tunnel encircling the Money Pit apparently intercepted the flood tunnel from Smith's Cove to the Money Pit. The point of interception was apparently at the edge of the Money Pit. When clay was placed in the intake at Smith's Cove (see Step 6) the water in the Money Pit became muddy within 30 minutes.

4. The flood tunnel was 2-1/2 ft. wide, 4 ft. high and sloped down at 22-1/2 deg. towards the Money Pit. The tunnel was filled with rounded beach cobbles and boulders.

STEP NO. 14

Date - 1878

Cave-in Pit - for location see Fig. I-1

1. A sink hole some 6 to 8 ft. in diameter and 10 to 12 ft. deep developed. The hole was on the assumed line of the flood tunnel from Smith's Cove to the Money Pit.
STEP NO 15

Date - 1894 (The Oak Island Treasure Co.)

Shaft No. 11 - for location see Fig. I-1

1. Shaft No. 11 was dug to a depth of 52 ft. at the location of "cave-in pit". The shaft apparently followed a previous 6 to 8 ft. dia. shaft. Within this previous shaft the ground was soft but the walls of the previous shaft were hard clay.

2. A hole was drilled from the bottom of the shaft to a depth of 68 ft. below ground surface without encountering anything of note.

3. Water broke into Shaft No. 11 from Shaft No. 4 and flooded Shaft No. 11 to mean tide level.

STEP NO. 16

Date - 1894 (The Oak Island Treasure Co.)

Shaft No. 12 - for location see Fig. I-1

1. Shaft No. 12 was dug to a depth of 43 ft. through porous (disturbed) clay. At this depth water broke in from Shaft No. 4. After bailing out this water, black stagnant water thought to be from the Money Pit entered Shaft No. 12. After the stagnant water was bailed out saline water entered the shaft. The saline water was also bailed out of the shaft and Shaft No. 12 was dug to a depth of 55 ft.

2. A tunnel was driven from the bottom of the shaft to a point 20 ft. south of the shaft. A vertical raise was then driven to within 24 ft. of ground surface in an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit. The flood tunnel was not encountered.
STEP NO. 16 Cont'd

Section Through Shaft

Scale 1" to 20'

STEP NO. 17

Date – 1894 (The Oak Island Treasure Co.)

Shaft No. 5 and Tunnel – for location see Fig. I-1

1. Shaft No. 5 was re-opened and at a depth of about 30 ft. (probably 35 ft., see Step 7) a tunnel was discovered. This tunnel was followed to what was thought to be the Money Pit but what later proved to be Shaft No. 2. No details concerning the structure of the tunnel are given.

Golder Associates
Date - 1897 (The Oak Island Treasure Co.)

Shaft No. 2 and Money Pit - for location see Fig. I-1

1. Shaft No. 2 (thought to be the Money Pit, see Step 17) was re-opened and taken to a depth of 110 ft. below ground surface. At this depth, a tunnel leading from the working shaft into the actual Money Pit was discovered (possibly the 1805 tunnel, see Step 3).

2. During work in the Money Pit the top of a tunnel 2-1/2 ft. wide with square cut sides and filled with beach stones, beach gravel and sand (the sand being on top) was discovered. Saline water flowed from this tunnel and when the pump broke down the water in the Money Pit quickly rose to tide level.

Section Through Shafts

Scale 1" to 20'

Diagram: Backfill, Timber Platform (from Step 12), Money Pit, Shaft No. 2, Top of Tunnel (sand over gravel over beach stones)
Date - 1897  (The Oak Island Treasure Co.)

Drill Holes Across Flood Tunnel - for location see Fig. I-1

1. In an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit, five (5) holes were drilled across the assumed line of the tunnel.

   Hole No. 1 - Drilled to 95 ft. depth - dry
   Hole No. 2 - Drilled to 90 ft. depth - dry
   Hole No. 3 - Drilled to 80 ft. depth - cobbles were encountered at this depth and saline water rose in the hole to tide level. The water level rose and fell with the tide.
   Hole No. 4 - Drilled to 90 ft. depth - dry
   Hole No. 5 - Drilled to 95 ft. depth - dry

2. The bottom of holes 1, 2, 4 and 5 were loaded with dynamite, the holes were filled with water and the dynamite was exploded. The only effect was that the water shot out of the holes.

3. The bottom of hole 3 was loaded with 160 lb. of dynamite and the dynamite was exploded. No water came out of the drillhole but the water in the Money Pit and the cave-in pit "boiled" and foamed for a considerable period to time.

Golder Associates
STEP NO. 20

Date - 1897  (The Oak Island Treasure Co.)

Drill Holes in Money Pit

1. A platform was constructed in the Money Pit at a depth of 100 ft. below ground surface. Both the Money Pit and Shaft No. 2 were out of line and the shafts intersected.

2. At least six (6) holes were drilled through the bottom of the Money Pit.

Hole No. 1 - Taken to a depth of 132 ft. below ground surface.
126'-0" to 126'-5" - oak
126'-5" - iron
126'-5" to 132" - hole deflected off iron obstruction

Hole No. 2 - Taken to a depth of 157'-5-1/2" below ground surface.
126' - iron
126' to 153'-8" - soft clay
153'-8" to 154'-3" - soft stone or cement
154'-3" to 154'-8" - oak
154'-8" to 154'-9 1/2" - void
154'-9 1/2" - parchment
154'-9 1/2" to 157'-5 1/2" - loose metal in pieces*
157'-5 1/2" - soft metal*

* no samples obtained below 154'-9 1/2"

Hole No. 3 Taken to a depth of 171 ft. below ground surface.
122' - wood
153' to 157'-6" - soft stone or cement, oak on one side of hole for about 3 ft.
157'-6" to 168'-6" - blue puddle clay
171" - iron - could not penetrate

Hole No. 4 Taken to a depth of 188 ft. below ground surface.
166' - iron, drill deflected off iron
166' to 188' - soft clay
188' - hard clay - drill about 6 ft. out of line

Golder Associates
STEP NO. 20  Cont'd

Hole No. 5  Taken to a depth of 175 ft. below ground surface. No new results, soft rock or clay from 150 ft. to 170 ft.

Hole No. 6  Taken to a depth of 126 ft. below ground surface. - 126' hit water course - flow up 3-1/2 in. dia. drill pipe estimated to be about 400 gal./min.
Section Through Shaft

Scale 1" to 20'

MONEY PIT

PLATFORM CONST.

126'

111'

ASSUMED MONEY PIT

153' to 153'-8"

157'-6"

3' HIGH BOX

100'

110'

G6" OAK-THEN IRON

SHALLOW SIDE OF SHAFT NO BEDROCK

Golder Associates
Date - 1897 - 1898  (The Oak Island Treasure Co.)

Shafts No. 14, 15, 16, 17, 18 and 19 - for locations see Fig. I-1

1. Shaft No. 14 was dug to a depth of 112 ft. where it approached to within about 3 ft. of a previous searcher's tunnel (Halifax Tunnel). Water from this tunnel broke into the shaft and flooded the shaft.

2. Shaft No. 15 was dug to a depth of 168 ft. At a depth of 105 ft. a dry tunnel (Halifax Tunnel) was encountered. At a depth of 168 ft. a sand seam was encountered and saline water flooded the shaft.

3. Shafts No. 16, 17, 18 and 19 were dug to depths of 134 ft., 95., 160 ft. and 144 ft., respectively. No details of these shafts are known. However, all shafts were flooded or became unsafe due to movement of the cribbing.
NOTE:
W.L. IN MONEY PIT - 7G' DROPPED TO 84' WHEN SHAFT NO. 15 FLOODED
Date – 1898  (The Oak Island Treasure Co.)

Dye Tests – Shaft No. 18 and Money Pit

1. Shaft No. 18 (160 ft. deep shaft) was pumped full of water. The water level quickly fell back to tide level. Muddy water was observed at three (3) separate widely spaced points on the south shore of the island at about the low water mark.

2. The Money Pit (111 ft. deep shaft with drill holes extending to a depth of 188 ft.) was pumped full of water. The water level in the shaft fell at a rate of about 4 ft./hr. The results of this test are not recorded.

3. Test 2 above was repeated. Again the results of the test are not recorded.

4. Red dye was introduced into the Money Pit and the shaft was pumped full of water. The water level in the shaft fell at a rate of 5 in/hr. The dye was observed at three (3) points on the south shore.

5. A charge of dynamite was exploded on the south shore of the island where the muddy water and dye was observed. The water level in the Money Pit was lowered by pumping. The water in the Money Pit soon became muddy.

6. Various other tests were made. In all cases results were observed on the south shore.
STEP NO. 23

Date - 1898 (The Oak Island Treasure Co.)

Shaft No. 20 - for location see Fig. I-1

1. Shaft No. 20 (5 ft. by 8 ft. shaft) was sunk adjacent to existing shaft in the Money Pit giving a total shaft size of 10 ft. by 8 ft.

2. The shaft was dug to a depth of 113 ft. where inflow of water from the flood tunnel (Smith's Cove to the Money Pit) and from a ring of gravel forced end of work. The ring of gravel apparently surrounded the original Money Pit. The soil on the outside of the ring was hard and the soil on the inside of the ring was soft.

3. Seven (7) holes were drilled from the bottom of the shaft within the Money Pit in an attempt to locate the iron previously encountered at a depth of 126 ft. (see Step 19). Two (2) holes stopped on gravel, three (3) holes stopped on cobbles and three (3) holes stopped on hard clay.
NOTES:
DURING SINKING OF SHAFT FOUND TIMBERS ON END.
AT SOME DEPTH OR DEPTHS BOTTOM AS BELOW.

--- ASSUMED TO BE RING OF GRAVEL SURROUNDING MONEY PIT

DRILLED BELOW BOTTOM - TRIED TO FIND IRON AT 126 FT. DEPTH
2 HOLES - STOPPED ON GRAVEL
3 HOLES - STOPPED ON BOULDERS
3 HOLES - STOPPED ON HARD CLAY

Golder Associates
1. Shaft No. 21 (12 ft. by 14 ft. shaft) was dug to a depth of 163.5 ft. Between depths of 116.5 and 155 ft. the soil over one-half the shaft was disturbed. Below a depth of 150 ft. pieces of soft stone resembling cement were found and at a depth of 163 ft. the entire bottom of the shaft was covered with pieces of the material. During excavation, several artifacts left at higher levels were found. These artifacts apparently fell to the depths at which they were found during a collapse of the bottom of the Money Pit.

2. During excavation, numerous horizontal holes were drilled from various levels in the shaft without encountering anything of interest.

3. At a depth of 163.5 ft., three (3) tunnels were driven laterally. Nothing of interest was found although the soil appeared to be disturbed.

4. Holes drilled through the bottom of the shaft encountered about 12 ft. of soft or loosened material (i.e. to a depth of about 175 ft. below ground surface) then a 2 ft. high space (a depth of about 175 ft. to 177 ft.) and then hard material.
Section Through Shaft
Scale 1" to 20'

116' -  ANCHOR FLUKE
123' -  AXE HEAD
127' -  PICK & PARTS OF SEAL OIL LAM
130' -  GRANITE

150' -  STONES RESEMBLING CEMENT INCREASING IN NUMBER BELOW 150' UNTIL FLOOR COVERED WITH TH

163.5' -  SIMILAR TO SHAFT

175.5' -  VOID
177.5' -  HARD MATERIAL

Galder Associates
STEP NO. 25

Date — 1937  (Gilbert D. Hedden)

Shaft No. 22 — for location see Fig. I-1

1. Shaft No. 21 was cleared out and deepened to a depth of 170 ft. so that it could be used as a pumping shaft. Several horizontal holes were drilled from Shaft No. 21 between depths of 128 ft. to 160 ft.

2. Shaft No. 22 was put down to a depth of 124.5 ft. This shaft had a plan area of 24 ft. by 12 ft. and was divided into 8 bays by cross bracing.

3. Below a depth of 10 ft. Shaft No. 22 followed a smaller previous cribbed shaft (possibly Shaft No. 2).

4. At a depth of 50 ft. pieces of rusted drill casing were found.

5. At a depth of 63 ft. a miners lamp and a piece of unexploded dynamite were found.

6. At a depth of 80 ft. a piece of oak stump was found.

7. At a depth of 93 ft. a collapsed tunnel was found and a band of "putty-like" clay was encountered.

8. At a depth of 104 ft. a tunnel 3'-10" wide and 6'-4" high was found. This tunnel appeared to follow a circular path and intersected the older shaft (possibly a tunnel from Step 11 or 13). The top and outer face of this tunnel was shored but the inner face was not shored.

9. Fifteen (15) holes were drilled from the bottom of the shaft to a depth of 166.5 ft. below ground surface. All holes encountered dense sand from 124.5 ft. to about 147 ft. Between depths of 148 ft. and 157 ft. five (5) of the holes encountered oak timbers varying in thickness from 1 in. to 30 in.

Golder Associates
Section Through Shaft
Scale 1" to 20'

Plan Views of Shaft

OLD SHAFT

LAMP

CASING

OAK STUMP

COLLAPSED TUNNEL

OLD TUNNEL

DRILL HOLE

63'

80'

93'

100'

106.3'

124.5'

166.5'

Golder Associates
STEP NO. 26

Date - 1938 - 1942 (Edwin H. Hamilton)

Exploration of Previous Tunnels

1. During the period 1938 to 1942 several tunnels driven by previous searchers (principally the Halifax Co.) were explored. However, sufficient data to accurately locate these tunnels is not given.

2. In addition, parts of Shaft No. 21 were re-cribbed and a tunnel was constructed from Shaft No. 22 around Shaft No. 21. This tunnel intercepted the previous Halifax tunnel (see Step 13) which was explored "to the top of the hill". This was apparently the tunnel encountered at a depth of 104 ft. in Shaft No. 22 (see Step 24).

STEP NO. 27

Date - 1942 (Edwin H. Hamilton)

Shaft No. 23 - for location see Fig. I-1

1. One day (5 ft. by 6 ft.) of Shaft No. 22 was deepened from 124.5 ft. to about 170 ft. (Shaft No. 23).

2. At a depth of 155 ft. two (2) tunnels from Shaft No. 21 were encountered.

3. Holes drilled from the bottom of Shaft No. 23 to a depth of about 190 ft. below ground surface did not encounter bedrock.
STEP NO. 28

Date – 1951  (M.R. Chappell and Associates)

Shaft No. 24  – for location see Fig. I-1

1. Shaft No. 24 was dug to a depth of 46 ft. A disturbed zone was encountered at a depth of about 30 ft. Shaft No. 24 was located about 5 ft. from an earlier undocumented (by Harris) shaft.

STEP NO. 29

Date – 1955  (George J. Greene)

Drill Holes near Money Pit  – for location see Fig. I-1

1. Holes no. 1 to 4, inclusive, were drilled at 2, 6, 10 and 14 ft., respectively, in a line from the north side of Shaft No. 21.

2. In holes no. 1 to 3, inclusive, oak timbers were encountered at 10 ft. intervals of depth. Hole no. 1 was taken to a depth of 190 ft. and encountered occasional voids.

3. Log of hole no. 4.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0' to 100'</td>
<td>not reported</td>
</tr>
<tr>
<td>100'</td>
<td>8 in. thick oak timber</td>
</tr>
<tr>
<td>100' to 110'</td>
<td>void</td>
</tr>
<tr>
<td>110'</td>
<td>8 in. thick oak timber</td>
</tr>
<tr>
<td>110' to 155'</td>
<td>cavity</td>
</tr>
<tr>
<td>155' to 190'</td>
<td>&quot;ordinary clay&quot;</td>
</tr>
</tbody>
</table>

4. One hundred thousand (100,000) gal. of water were pumped into hole no. 4 with no apparent result.
STEP NO. 30

Date - 1960 - 1965 (R. Restall)

Shaft No. 25 - for location see Fig. I-1

1. Shaft No. 25 (plan area of 6 ft. by 10 ft.) dug to a depth of 27 ft.

2. Lateral exploration to the north from the Hedden Shaft (Shaft No. 22) at a depth of 125 ft. below ground surface.
APPENDIX II

LIST OF SAMPLES FORWARDED FOR POLLEN ANALYSES

OAK ISLAND

NOVA SCOTIA

Golder Associates
INTRODUCTION

A list of the samples, obtained during this investigation, which were forwarded to Dr. J. C. Ritchie at Dalhousie University in Halifax, Nova Scotia for pollen analyses are given in Table II-1. It should be noted that for the sake of clarity on the final logs presented in this report, some sample numbers have been changed from the numbers assigned in the field and marked on the samples which were forwarded to Dr. Ritchie. Consequently, two columns referred to as "Field Numbering System" and "Final Borehole Log Numbering System" are given on Table II-1. Any reports forwarded to you by Dr. Ritchie will refer to sample numbers in the Field Numbering System. To locate these samples on the borehole logs, the Final Borehole Log Numbering System must be used.

As noted in the report, the results of Dr. Ritchie's analyses of the samples have been forwarded directly to Triton Alliance Limited. Except for limited instances, we have not seen these results.
<table>
<thead>
<tr>
<th>Borehole Number</th>
<th>Field Numbering System</th>
<th>Sample Number</th>
<th>Final Borehole Log Numbering System</th>
<th>Depth of Sample (ft.)</th>
<th>Date Sample Forwarded For Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>31</td>
<td>36</td>
<td>214.8-216.3</td>
<td>April 28, 1970</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>32</td>
<td>37</td>
<td>217.0-218.5</td>
<td>May 19, 1970</td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>29</td>
<td>27</td>
<td>193.0-195.0</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>33</td>
<td>30</td>
<td>198.0-200.0</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>49</td>
<td>46</td>
<td>224.2-224.8</td>
<td>June 7, 1970</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>18</td>
<td>1</td>
<td>125</td>
<td>June 14, 1970</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>16</td>
<td>16</td>
<td>219.7-219.9</td>
<td>June 18, 1970</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>18</td>
<td>18</td>
<td>224.3-224.5</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>20</td>
<td>20</td>
<td>227.8-228.0</td>
<td>June 19, 1970</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>22A</td>
<td>22</td>
<td>229.8-230.0</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>6B</td>
<td>6</td>
<td>221.6-222.2</td>
<td>June 23, 1970</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>7</td>
<td>7</td>
<td>222.2-224.2</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>8A</td>
<td>8</td>
<td>224.2-225.4</td>
<td>&quot;</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Trimmings from additional samples may have been forwarded to Dr. Ritchie by Triton Alliance Limited. However, we have no record of any additional samples.
APPENDIX III

RESULTS OF WOOD IDENTIFICATION ANALYSES

OAK ISLAND

NOVA SCOTIA

Golder Associates
INTRODUCTION

During the course of the investigation three (3) samples of wood were forwarded to Dr. J. J. Balatinecz of the Faculty of Forestry, University of Toronto for identification as to species. These samples are identified as:

1) Borehole 103, Sample 9, depth of 143.0 to 144.9 ft. below ground surface. This sample was obtained in a NX size core barrel.

2) Borehole 202, Sample 1, depth of about 125 ft. This sample consisted of wood splinters brought up to ground surface by the drilling fluid while drilling with the direct circulation rotary drilling rig.

3) Sample of wood from the off-shore area in Smith's Cove. This sample was given to us by Triton Alliance Limited (Mr. Blankenship).

A copy of the report submitted by Dr. Balatinecz is attached.
Mr. J. B. Davies, P.Eng.
H. Q. Golder & Associates Limited
3151 Wharton Way
Cooksville, Ontario

Re: Your project No. 69126
Identification of wood species

Dear John:

Further to your request of June 24, 1970, concerning the identification of wood samples from Nova Scotia, we have now completed the identification and the results are as follows:

(1) Sample of timber from BH-103
   (143.0 to 144.9 ft. depth) - species of wood: Eastern spruce, Picea glauca;

(2) a. Samples of timber from BH-202
    (125 ft. depth) - species of wood: Eastern spruce (White spruce, Picea glauca)[communicated to you verbally on June 25, 1970],

    b. Sample of timber from off-shore area -
       species of wood: Eastern spruce (White spruce, Picea glauca).

The sample from BH-103 was substantially oily and greasy.

We hope that this information will be satisfactory to you. If you have any questions concerning the results, do not hesitate to call.

Sincerely yours,

[Signature]

J. J. Balatinecz
Associate Professor
encl.
APPENDIX IV

RESULTS OF METAL EXAMINATION AND ANALYSES

OAK ISLAND

NOVA SCOTIA
INTRODUCTION

At the request of Triton Alliance Limited, the small metal fragments embedded in Sample 10 obtained between depths of 84.5 and 86.5 ft. in borehole 201 and the angular metal fragment embedded in Sample 2 obtained at (but not necessarily originating from) a depth of about 150 ft. in borehole 202 were forwarded to Mr. A. B. Dove, Senior Development Metallurgist, Wire and Fastener Divisions, The Steel Company of Canada Limited in Hamilton, Ontario. A copy of the report submitted by Mr. Dove is attached. It should be noted that in this report Mr. Dove refers also to samples forwarded to him directly by Triton Alliance Limited (Mr. Blankenship).
November 19, 1970

Triton Alliance Ltd.
6800 Granby Stree
St. HENRY, Quebec

Attention: Mr. K. Ellard
The Oak Island Exploration

Dear Mr. Ellard

I am sending this letter directly to you as requested in Mr. Davis' letter of November 6th. With Mr. Davis' letter were included two containers, numbered 19 and 20, having the appellations "Porchole 201, Sample 10" and "Porchole 202, Sample 2" respectively. The small metal fragments contained in Porchole 201, Sample 10 are too friable for any sort of consistent examination but their general structure indicates that they were produced from wrought iron which would date them prior to 1800. The foliation in the corroded samples is quite characteristic of that particular type of material.

The sample indicated as Porchole 202, Sample 2 appears to be a replacement material in which calciferous and siliceous material has replaced iron. Some of the iron is still contained in the calciferous material and, therefore, some portions are still magnetic. Other portions of this particular material are not magnetic at all and this suggests the replacement in sea water of the iron carbonates and of course the siliceous material which is visible. Even though two sides of this small sample appear to be at an angle of 90°, it would be quite difficult to state the origin or age of such a material. Such replacement processes are normally very slow so one could assume a considerable age.

A shipment was received from Mr. Blankenship which contained some pieces of wood thought to have nails embedded therein and a piece of iron bar with one end pointed in a chisel-type point. No nails were found in the wood; indeed, one protruding portion which was thought to be a nail, when opened was found to contain a wood nodule around which the wood had grown. These samples have been taped together again and are being returned to you. Even where iron salts had gathered on the outside of the wood, it will be seen that there is no nail inside, the nail having been chemically changed to soluble salts and transferred throughout the cellulosic material of the wood. The bar contained in this particular shipment, however, was very interesting. It is wrought iron of excellent consistency and very clean stock. It was probably produced in Europe and forged there. It is about the purest bit of iron that I have seen in a long time insofar as early materials is concerned. There would have been little purpose in producing a wrought iron after 1800 for such a tool as this.
The tool could have been used either as a pay bar or as a drift pin for major wooden construction. I was rather surprised that the corrosion had not been as great on this bar as on earlier materials but I would still believe that it was produced prior to 1880. The 500 magnification photographs of the cross-section are shown at photo number 1.

A second sample from Mr. Blankenship which was contained in a Kodak film box accompanied his letter of November 9th. In that letter he stated that the small piece of iron taken from the bit at approximately 130 ft. depth at Borehole 265 was included. This piece was said to be 1-3/4" x 1-3/4" x 5/8" thick and that he had broken off a very small corner. Mr. Blankenship suggested that the metal was similar to material taken from a hole about 7 ft. away. This is not the case. This is the most peculiar piece of metal yet studied as will be seen from photograph number 2. The main body of metal contains what would normally be accepted as a fairly normal iron for the early periods prior to 1760 - dirty, full of holes, and indeed not too abnormal for a piece of melted iron overflow from a furnace. Strangely enough, however, within this matrix there are small spheroids of very good steel - high carbon material - which apparently has resulted from deoxidation and purification of the outer shell. These particles are very small as will be seen from the curvature at 500 magnifications of the light portion of photograph number 2. These small particles of bright metal can be observed throughout the darker matrix. The darker material is overlaid with a fairly heavy scale which is not completely magnetic. This leads to the belief that this metal formed and hardened in an atmosphere low in oxygen, thereby accounting for the lower magnetic value of the outer body and the presence of the unoxidized particles on the outside of the sample. These particles, being almost a martensitic steel, are highly magnetic. I cannot account in any way for the formation of this material except that it was formed at very high temperature and in the absence of oxygen.

Again, in sending this letter, I do not know if I have helped you or hindered you. We can say quite surely that Mr. Blankenship's sample is not at all similar to the samples sent in by Mr. Davis. We can say that the bar is very pure wrought iron and was probably produced in Northern Europe. And we found some nails in the wood, it might have been of considerable help, but the very nature of wood tends to draw in moisture and dissolve iron materials, particularly when they are under water as these were.

I am enclosing the photographs numbers 1 and 2 and am sending along the samples which should be reasonably identifiable being in the original containers. I trust that this information will prove of some assistance to you.

Yours very truly,

THE STEEL COMPANY OF CANADA, LIMITED

[Signature]

A. B. Dove
Senior Development Metallurgist
Wire and Fastener Divisions

Add/ST
Encl:
Copy to: Mr. J. B. Davis, P. Eng. - Colter Associates
APPENDIX V

DETAILED GROUNDWATER LEVEL RECORDS

OAK ISLAND NOVA SCOTIA
INTRODUCTION

This appendix presents a detailed record of the groundwater levels measured in the wellpoints, standpipes and piezometers installed in the borings put down under our supervision, in the 6 in. dia. cased holes numbered 10 and 11A put down by Triton Alliance Limited, in the Hedden Shaft and the ocean tidal level at the site.

It should be noted that during May, 1970 there was considerable pumping into and out of various holes and the Hedden Shaft and that during this period the dye tests were carried out. As a result, water levels taken during May, 1970 are not considered representative of the stabilized or natural groundwater conditions at the site and, consequently, these water levels are not presented in this appendix.

The groundwater elevations measured in the installations prior to the pumping test carried out at the site are given in Table V-1 of this appendix. Notes concerning the various installations are given in Table V-2.

DISCUSSION OF GROUNDWATER LEVELS

As indicated in Table V-1, the groundwater level at the site is generally about 4 to 6 ft. above sea-level. Further, the water level in all of the installations fluctuated as a result of tidal fluctuations. Due to the variable permeability of the sub-surface strata, however, the response
time of the installations differ (i.e., the water levels in some installations respond more quickly to a variation in tide level than do the water levels in other installations). Consequently, it is not possible to establish a direct correlation between fluctuations in the tide level and fluctuations in the water levels in the installations.

It should be noted that across an island the occurrence of a groundwater level slightly above ocean level is to be anticipated due to infiltration of "fresh" water (rainfall and the like) into the subsoil. Such infiltration would result in a "cap" of "fresh" water (specific gravity of about 1.00) overlying saline water (specific gravity of about 1.03). This condition is discussed in the main body of this report (see "GROUNDWATER CONDITIONS").

It is interesting to note that for a groundwater level some 4 to 6 ft. above sea level the theoretical thickness of the "fresh" water cap would be in the order of 150 to 200 ft. which is about the thickness reported by Mr. Bowmaster (see "GROUNDWATER CONDITIONS").
## Table V-1

**Record of Groundwater Levels**

<table>
<thead>
<tr>
<th>Date 1970</th>
<th>Time Hrs.</th>
<th>BH 101</th>
<th>BH 102</th>
<th>103</th>
<th>BH 104</th>
<th>BH 201</th>
<th>BH 202</th>
<th>BH 203</th>
<th>BH 204</th>
<th>10</th>
<th>11A</th>
<th>Shaft</th>
<th>Ocean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 19</td>
<td>0700</td>
<td>966.3</td>
<td>965.6</td>
<td>963.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0700</td>
<td>965.4</td>
<td>964.8</td>
<td>959.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0700</td>
<td>965.9</td>
<td>965.2</td>
<td>963.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0730</td>
<td>965.1</td>
<td>964.6</td>
<td>959.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>0830</td>
<td>966.1</td>
<td>965.4</td>
<td>964.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1400</td>
<td>964.0</td>
<td>964.3</td>
<td>959.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0900</td>
<td>966.1</td>
<td>965.5</td>
<td>963.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>1500</td>
<td>965.1</td>
<td>964.5</td>
<td>959.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>1530</td>
<td>969.0</td>
<td>960.9</td>
<td>966.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1030</td>
<td>966.4</td>
<td>960.9</td>
<td>966.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1100</td>
<td>969.3</td>
<td>961.3</td>
<td>967.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1700</td>
<td>969.5</td>
<td>961.3</td>
<td>966.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>0900</td>
<td>967.9</td>
<td>961.4</td>
<td>965.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>0930</td>
<td>967.8</td>
<td>961.3</td>
<td>965.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>1500</td>
<td>967.7</td>
<td>0.0</td>
<td>966.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 3</td>
<td>0600</td>
<td>968.3</td>
<td>968.3</td>
<td>966.0</td>
<td>966.0</td>
<td>965.7</td>
<td>995.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>967.7</td>
<td>967.6</td>
<td>966.0</td>
<td>967.9</td>
<td>966.0</td>
<td>966.0</td>
<td>966.0</td>
<td>966.2</td>
<td>966.2</td>
<td>966.2</td>
<td>966.2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0700</td>
<td>967.3</td>
<td>966.3</td>
<td>964.8</td>
<td>967.0</td>
<td>964.9</td>
<td>962.9</td>
<td>961.7</td>
<td>963.8</td>
<td>963.8</td>
<td>963.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1230</td>
<td>967.8</td>
<td>967.3</td>
<td>966.0</td>
<td>967.5</td>
<td>966.1</td>
<td>963.2</td>
<td>967.4</td>
<td>964.8</td>
<td>964.8</td>
<td>964.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1300</td>
<td>967.1</td>
<td>966.0</td>
<td>964.9</td>
<td>965.2</td>
<td>965.0</td>
<td>963.3</td>
<td>967.6</td>
<td>963.9</td>
<td>963.9</td>
<td>963.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1330</td>
<td>966.1</td>
<td>966.8</td>
<td>965.2</td>
<td>965.8</td>
<td>965.3</td>
<td>963.2</td>
<td>967.5</td>
<td>964.2</td>
<td>967.5</td>
<td>964.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1000</td>
<td>966.1</td>
<td>965.8</td>
<td>964.3</td>
<td>965.0</td>
<td>964.4</td>
<td>967.3</td>
<td>967.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1730</td>
<td>967.8</td>
<td>966.8</td>
<td>965.5</td>
<td>966.2</td>
<td>964.4</td>
<td>963.0</td>
<td>967.1</td>
<td>962.2</td>
<td>981.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1630</td>
<td>966.0</td>
<td>966.5</td>
<td>965.2</td>
<td>965.8</td>
<td>963.9</td>
<td>963.1</td>
<td>968.0</td>
<td>964.2</td>
<td>902.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1230</td>
<td>966.8</td>
<td>965.2</td>
<td>964.0</td>
<td>964.6</td>
<td>964.0</td>
<td>962.9</td>
<td>966.9</td>
<td>963.4</td>
<td>982.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2000</td>
<td>966.8</td>
<td>967.3</td>
<td>965.5</td>
<td>966.5</td>
<td>965.6</td>
<td>962.6</td>
<td>966.7</td>
<td>964.7</td>
<td>981.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>1830</td>
<td>966.6</td>
<td>967.3</td>
<td>965.4</td>
<td>964.5</td>
<td>963.1</td>
<td>966.9</td>
<td>964.5</td>
<td>983.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1000</td>
<td>966.6</td>
<td>967.1</td>
<td>965.6</td>
<td>966.2</td>
<td>965.6</td>
<td>963.1</td>
<td>966.8</td>
<td>964.7</td>
<td>983.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1030</td>
<td>966.3</td>
<td>966.9</td>
<td>965.2</td>
<td>966.1</td>
<td>964.4</td>
<td>963.4</td>
<td>966.7</td>
<td>964.7</td>
<td>984.1</td>
<td>964.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0900</td>
<td>966.6</td>
<td>966.9</td>
<td>964.7</td>
<td>965.2</td>
<td>964.1</td>
<td>963.7</td>
<td>967.1</td>
<td>965.7</td>
<td>965.4</td>
<td>963.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>1830</td>
<td>967.0</td>
<td>966.2</td>
<td>964.7</td>
<td>965.1</td>
<td>964.5</td>
<td>963.5</td>
<td>967.0</td>
<td>965.5</td>
<td>986.0</td>
<td>964.6</td>
<td>978.1</td>
<td>964.3</td>
</tr>
<tr>
<td>24</td>
<td>2000</td>
<td>966.8</td>
<td>966.6</td>
<td>964.5</td>
<td>965.0</td>
<td>964.5</td>
<td>963.6</td>
<td>967.0</td>
<td>965.4</td>
<td>986.3</td>
<td>964.0</td>
<td>973.5</td>
<td>964.1</td>
</tr>
<tr>
<td>25</td>
<td>1400</td>
<td>969.9</td>
<td>967.7</td>
<td>964.9</td>
<td>966.6</td>
<td>965.6</td>
<td>963.6</td>
<td>967.0</td>
<td>965.6</td>
<td>986.5</td>
<td>965.5</td>
<td>974.1</td>
<td>965.5</td>
</tr>
<tr>
<td>28</td>
<td>1230</td>
<td>966.3</td>
<td>965.8</td>
<td>964.2</td>
<td>964.7</td>
<td>964.0</td>
<td>963.4</td>
<td>966.6</td>
<td>965.4</td>
<td>988.1</td>
<td>964.4</td>
<td>965.1</td>
<td>964.0</td>
</tr>
<tr>
<td>July 3</td>
<td>1430</td>
<td>969.6</td>
<td>966.3</td>
<td>967.0</td>
<td>967.2</td>
<td>967.3</td>
<td>964.7</td>
<td>966.8</td>
<td>967.0</td>
<td>989.2</td>
<td>965.8</td>
<td>961.6</td>
<td>966.9</td>
</tr>
<tr>
<td>4</td>
<td>1100</td>
<td>969.5</td>
<td>968.8</td>
<td>967.4</td>
<td>967.3</td>
<td>967.9</td>
<td>964.9</td>
<td>966.7</td>
<td>967.4</td>
<td>989.2</td>
<td>967.5</td>
<td>967.5</td>
<td>969.6</td>
</tr>
</tbody>
</table>

**Note** - See Table V-2 for description of water level observation installations
<table>
<thead>
<tr>
<th>Installation</th>
<th>Type</th>
<th>Depth (ft.)</th>
<th>Installed in</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.H. 101</td>
<td>Piezometer</td>
<td>44</td>
<td>Clayey Till</td>
<td>Probably represents water level in silt stratum</td>
</tr>
<tr>
<td>(a)</td>
<td>Standpipe</td>
<td>113</td>
<td>Silt Stratum</td>
<td>Standpipe blocked, June 3, 1970</td>
</tr>
<tr>
<td>(b)</td>
<td>Wellpoint</td>
<td>228</td>
<td>Bedrock</td>
<td>Soil zone in bedrock (or between boulders)</td>
</tr>
<tr>
<td>(c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 102</td>
<td>Piezometer</td>
<td>50</td>
<td>Clayey Till</td>
<td>Piezometer blocked during installation</td>
</tr>
<tr>
<td>(d)</td>
<td>Standpipe</td>
<td>155</td>
<td>Gravel Zone</td>
<td>Soil zone in bedrock (or between boulders)</td>
</tr>
<tr>
<td>(e)</td>
<td>Wellpoint</td>
<td>218.5</td>
<td>Bedrock</td>
<td></td>
</tr>
<tr>
<td>(f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 103</td>
<td>Wellpoint</td>
<td>155</td>
<td>Disturbed Material</td>
<td>Standpipe in B.H. 103 blocked during installation</td>
</tr>
<tr>
<td>(g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 104</td>
<td>Standpipe 'B'</td>
<td>150</td>
<td>Silty Till</td>
<td>Soil zone in bedrock (or between boulders)</td>
</tr>
<tr>
<td>(h)</td>
<td>Standpipe 'A'</td>
<td>247</td>
<td>Bedrock</td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 201</td>
<td>Standpipe</td>
<td>35</td>
<td>Clayey Till</td>
<td>Installed in disturbed zone in till</td>
</tr>
<tr>
<td>(j)</td>
<td></td>
<td>177</td>
<td>Silty Till</td>
<td></td>
</tr>
<tr>
<td>(k)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 202</td>
<td>Piezometer</td>
<td>180.5</td>
<td>Silty Till</td>
<td>Soil zone in bedrock (or between boulders)</td>
</tr>
<tr>
<td>(l)</td>
<td>Standpipe</td>
<td>243.5</td>
<td>Bedrock</td>
<td></td>
</tr>
<tr>
<td>(m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 203</td>
<td>Piezometer</td>
<td>140</td>
<td>Disturbed Zone</td>
<td></td>
</tr>
<tr>
<td>(n)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 204</td>
<td>Piezometer</td>
<td>148</td>
<td>Silty Till</td>
<td>Soil zone in bedrock (or between boulders)</td>
</tr>
<tr>
<td>(o)</td>
<td>Wellpoint</td>
<td>229.7</td>
<td>Bedrock</td>
<td></td>
</tr>
<tr>
<td>(p)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 10</td>
<td>Casing</td>
<td>215</td>
<td>Bedrock</td>
<td>Hole terminated in void</td>
</tr>
<tr>
<td>(q)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.H. 11A</td>
<td>Casing</td>
<td>192</td>
<td>Bedrock</td>
<td>Hole terminated in void</td>
</tr>
<tr>
<td>(r)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Shaft</td>
<td>?</td>
<td>?</td>
<td>W.L. in Hedden Shaft</td>
</tr>
<tr>
<td>(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ocean</td>
<td></td>
<td>?</td>
<td>?</td>
<td>Measured on south shore of island opposite &quot;Money Pit&quot; area.</td>
</tr>
<tr>
<td>(t)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

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

I. SAMPLE TYPES

AS  auger sample
CS  chunk sample
DO  drive open
DS  Denison type sample
FS  foil sample
RC  rock core
ST  slotted tube
TO  thin-walled, open
TP  thin-walled, piston
WS  wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Relative Density $N$, blows/ft.

- Very loose: 0 to 4
- Loose: 4 to 10
- Compact: 10 to 30
- Dense: 30 to 50
- Very dense: over 50

(b) Cohesive Soils

Consistency $c_w$, lb./sq. ft.

- Very soft: Less than 250
- Soft: 250 to 500
- Firm: 500 to 1,000
- Stiff: 1,000 to 2,000
- Very stiff: 2,000 to 4,000
- Hard: over 4,000

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

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.

WH  sampler advanced by static weight—weight, hammer
PH  sampler advanced by pressure—pressure, hydraulic
PM  sampler advanced by pressure—pressure, manual

IV. SOIL TESTS

C  consolidation test
H  hydrometer analysis
M  sieve analysis
MH  combined analysis, sieve and hydrometer¹
Q  undrained triaxial²
R  consolidated undrained triaxial³
S  drained triaxial
U  unconfined compression
V  field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
²Undrained triaxial tests in which pore pressures are measured are shown as $Q$ or $R$.

Golder Associates
LIST OF SYMBOLS

I. GENERAL

\( \pi = 3.1416 \)
\( e = \text{base of natural logarithms} 2.7183 \)
\( \log_a \text{ or } \ln a, \text{ natural logarithm of } a \)
\( \log_{10} a \text{ or } \log a, \text{ logarithm of } a \text{ to base } 10 \)

\( t \)  time
\( g \)  acceleration due to gravity
\( V \)  volume
\( W \)  weight
\( M \)  moment
\( F \)  factor of safety

(b) Consistency

\( w_L \)  liquid limit
\( w_P \)  plastic limit
\( I_P \)  plasticity index
\( w_s \)  shrinkage limit
\( I_L \)  liquidity index = \((w - w_P)/I_P \)
\( I_C \)  consistency index = \((w_L - w)/I_P \)
\( e_{\text{max}} \)  void ratio in loosest state
\( e_{\text{min}} \)  void ratio in densest state
\( D_r \)  relative density = \((e_{\text{max}} - \varepsilon)/(e_{\text{max}} - e_{\text{min}}) \)

(c) Permeability

\( h \)  hydraulic head or potential
\( q \)  rate of discharge
\( v \)  velocity of flow
\( i \)  hydraulic gradient
\( k \)  coefficient of permeability
\( j \)  seepage force per unit volume

(d) Consolidation (one-dimensional)

\( m_s \)  coefficient of volume change

\[ m_s = -\Delta e/(1+e) \Delta \sigma' \]
\( C_s \)  compression index = \(-\Delta e/\Delta \log_{10} \sigma' \)
\( c_s \)  coefficient of consolidation
\( T_s \)  time factor = \(c_s/d^3 \)  \( (d, \text{ drainage path}) \)
\( U \)  degree of consolidation

(e) Shear strength

\( \tau_r \)  shear strength
\( c' \)  effective cohesion intercept
\( \phi' \)  effective angle of shearing resistance, or friction
\( c_a \)  apparent cohesion*
\( \phi_a \)  apparent angle of shearing resistance, or friction
\( \mu \)  coefficient of friction
\( S_i \)  sensitivity

*For the case of a saturated cohesive soil, \( \phi_a = 0 \) and the undrained shear strength \( \tau_r = c_a \) is taken as half the undrained compressive strength.

Golder Associates
PHOTOGRAPH OF METAL FRAGMENTS
BOREHOLE 201, SAMPLE 10, DEPTH 84.5 to 86.5 FT.

Golder Associates
PHOTOGRAPH OF METAL FRAGMENT
BOREHOLE 202, SAMPLE 2, DEPTH 150FT.
PHOTOGRAPH OF METAL FRAGMENT
BOREHOLE 103, SAMPLE 6, DEPTH 138 FT.

FIGURE 8
DISTANCE DRAWDOWN CURVE FOR AVERAGE CONDITIONS

LEGEND
- BOREHOLE NO.
- OPEN CASING
- STANDPIPE INSTALLATION
- PIEZOMETER
- WELL POINT

RANGE OF DRAWDOWN

RADIUS OF WELL

DISTANCE FROM PUMPTED WELL (FT)

Golder Associates

Date DEC. 3, 1972

Drawn
Chkd
Appd
GOLDEN ASSOCIATES

GOLDEN ASSOCIATES
GRAIN SIZE DISTRIBUTION
SANDY TO SILTY INFILL MATERIAL

Figure 28

M.I.T. GRAIN SIZE SCALE

Percent Finer Than

Size of opening, inches
U.S. Sieve size, meshes/inch

0.1
1
10
100
1000
10000

100
90
80
70
60
50
40
30
20
10

GRAIN SIZE, MM

Golder Associates
M.I.T. GRAIN SIZE SCALE

Size of opening, inches  U.S.S. Sieve size, meshes/inch

GOLDEN Associates

PERCENT FINER THAN

LEGEND
BOREHOLE SAMPLE ELEVATION
- 103  31  785.0
x 103  32  763.0
o 2.01  46  784.5
t 2.02  23  772.0

GRAIN SIZE, MM

COBBLE SIZE
- COARSE  MEDIUM  FINE
- GRAVEL SIZE

COARSE SIZE
- MEDIUM  FINE
- SAND SIZE

FINE SIZE
- Silt Size

CLAY SIZE
- FINE GRAINED

FIGURE 29