DRAFT REPORT

TRITON ALLIANCE LIMITED

SUBSURFACE INVESTIGATION

THE OAK ISLAND EXPLORATION

OAK ISLAND NOVA SCOTIA

Distribution:

2 copies - Triton Alliance Limited,
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Mississauga, Ontario.

April, 1971. 69126

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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.

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Encl.

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 1×10^{-2} cm/sec. and that there is fairly good hydraulic communication throughout the lower pervious strata.

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 south-west 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.

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

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 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 Hamilto 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.

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 catagories. 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.

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 sho

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).

In borehole 103 (put down through the existing Hedden 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

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.

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* 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.

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 "Ancillory 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 I

DESCRIPTION OF DYE

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

* 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 loosened 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

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.

what are results See Pg 31

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

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 oriface 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.

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.

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 forwarde to Brock University in St. Catharines, Ontario for carbor 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

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 respons 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 variably 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".

more likely due to pumping

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 consistantly 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

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.

Note: The water in boreholes and both with tidal cycles

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

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* 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.

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.

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.

Fig 7 Missing

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 timbe 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 identificatio and to Brock University for carbon dating.

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 ofthe 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.

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 1×10^{-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, Ka, 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.

JBD:jg
69126
April 28, 1971.

H. Q. Golder, P. Eng.

APPENDIX I

SUMMARY OF PREVIOUS EXPLORATION OPERATIONS

OAK ISLAND NOVA SCOTIA

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

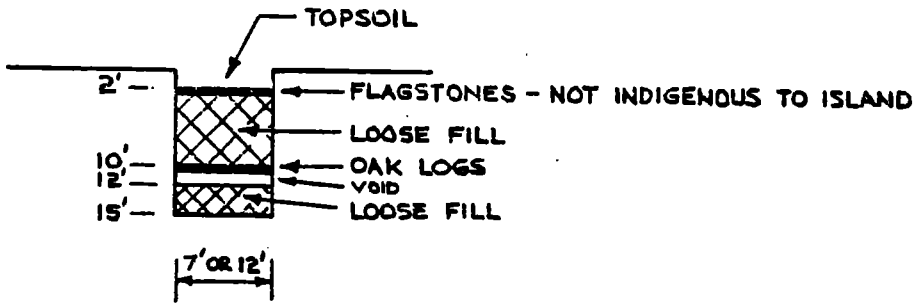
1. The entrance to the Money Pit was discovered by a local youth. The entrance was located in a cleared area near the base of an oak tree. A large forked branch of this tree extended over the clearing and a tackle block was affixed to the fork.

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'



STEP NO. 2

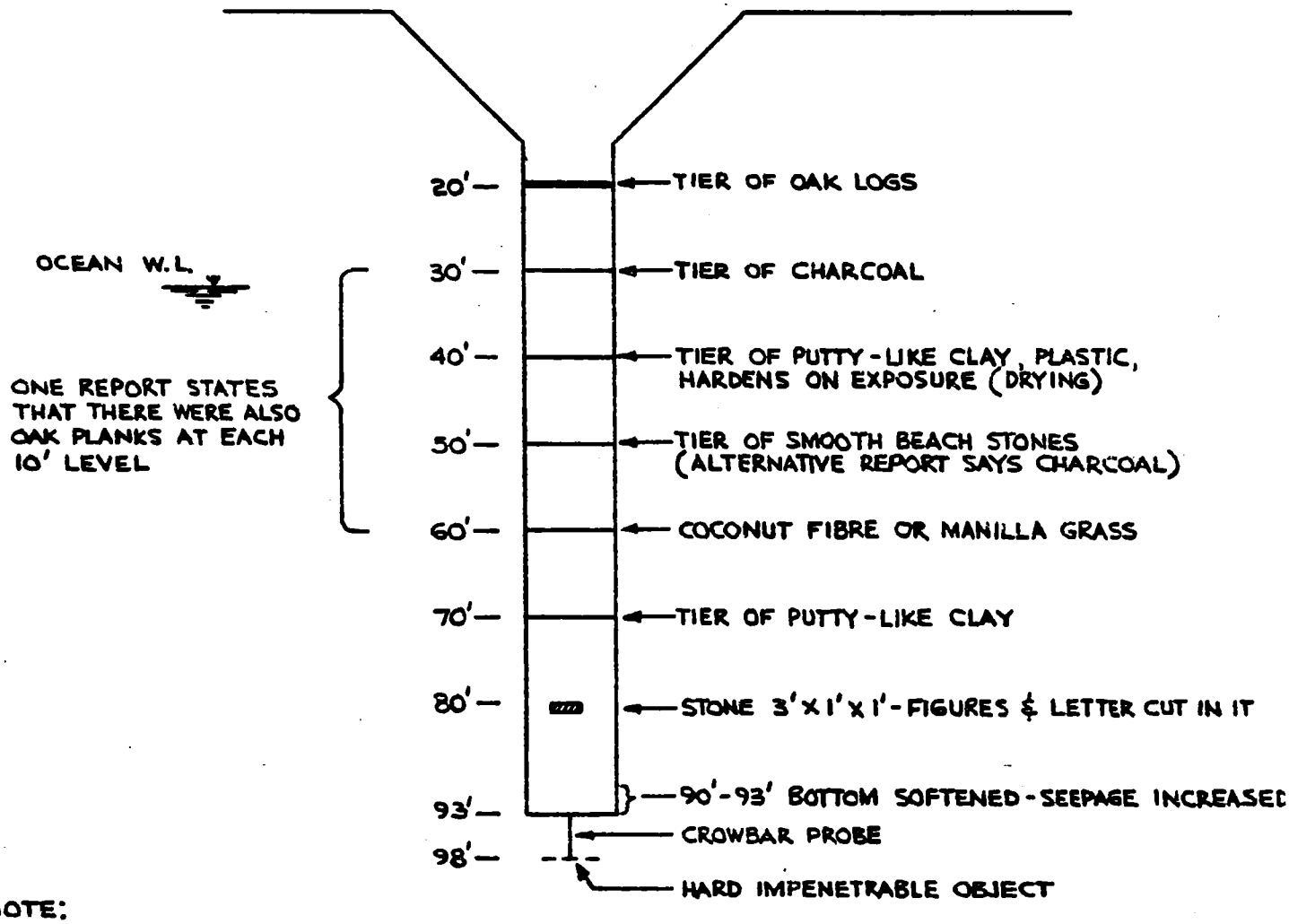
Date - 1804 (Onslow Co.)

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'



NOTE:
W.L. ROSE IN SHAFT TO ABOUT 32FT. BELOW GROUND SURFACE. ATTEMPTS TO PUMP OUT SHAFT FAILED.

STEP NO. 3

Date - 1805 (Onslow Co.)

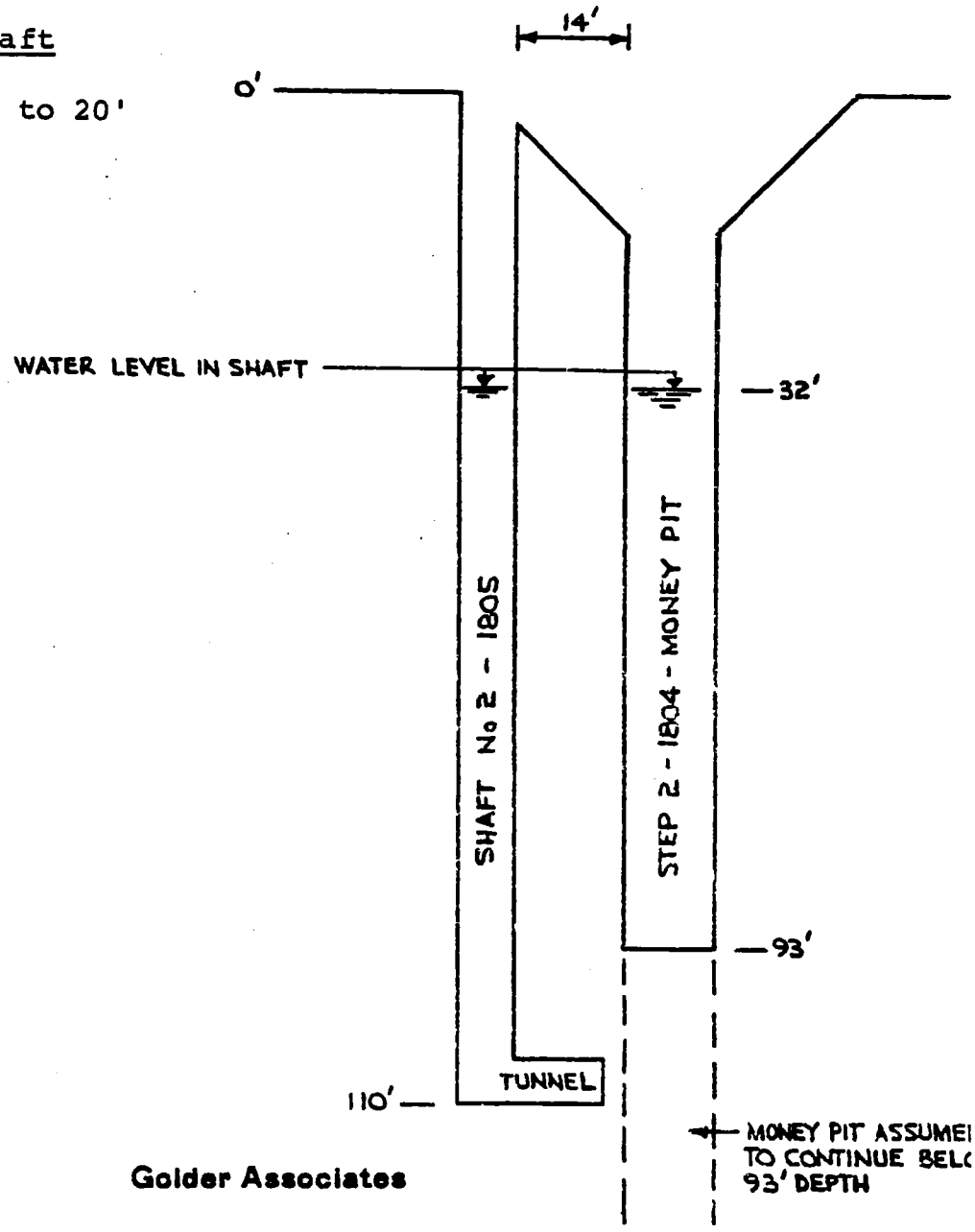
Shaft No. 2 - for location see Fig. I-1

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'



STEP NO. 4

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

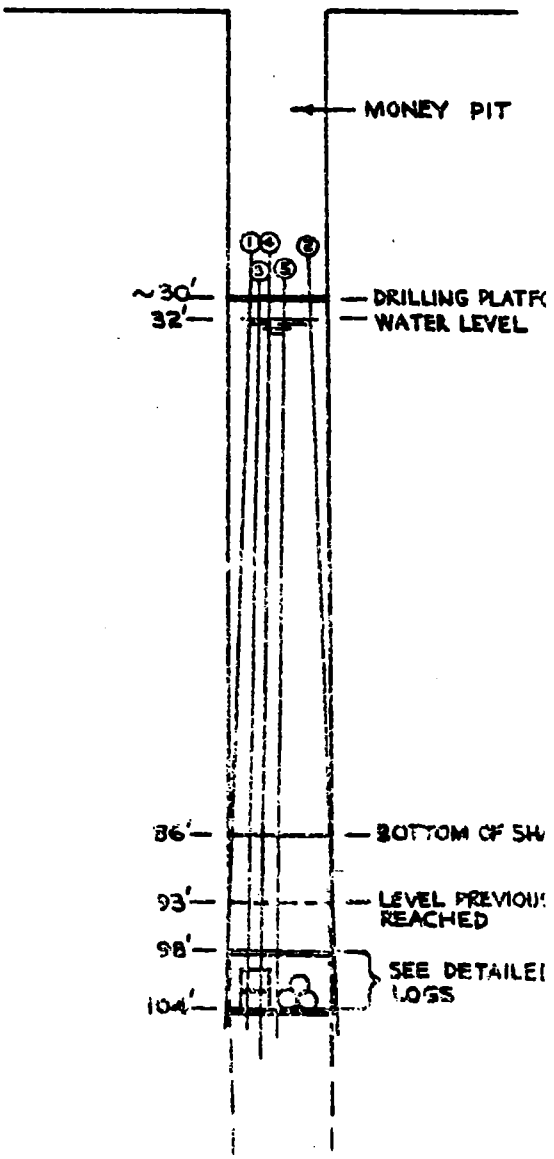
BH 3
- 98'-0" - 98'-5" - spruce timber
- 98'-5" - 99'-5" - void
- 99'-5" - 99'-9" - oak
- 99'-9" -101'-7" - loose metal
- 101'-7" -101'-11"- oak
- 101'-11"-102'-3" - oak
- 102'-3" -104'-1" - loose metal
- 104'-1" -104'-5" - oak
- 104'-5" -104'-11"- spruce timber
- 104'-11"-110'-11"- clay

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'



STEP NO. 5

Date - 1850 (Truro Co.)

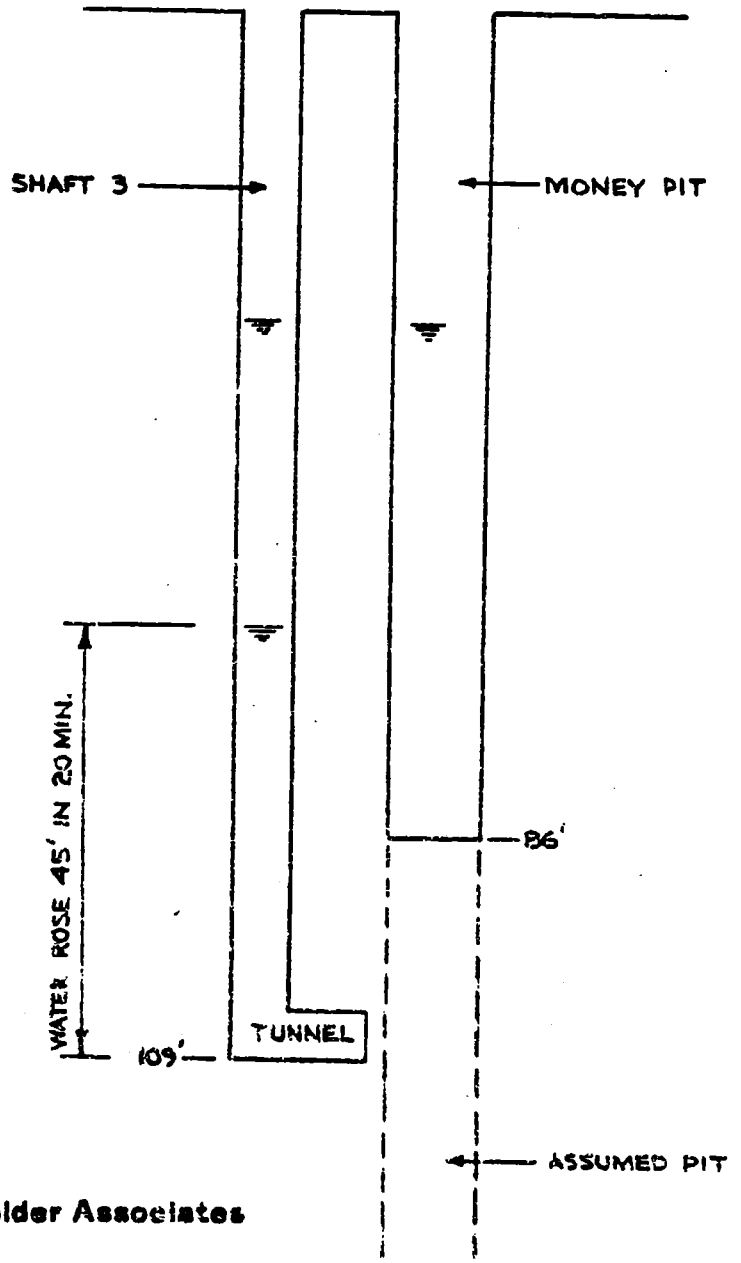
Shaft No. 3 - for location see Fig. I-1

1. Shaft No. 3 was excavated to a depth of 109 ft. in hard red clay. No water was encountered. The searchers tunnelled 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'



STEP NO. 6

Date - 1850 (Truro Co.)

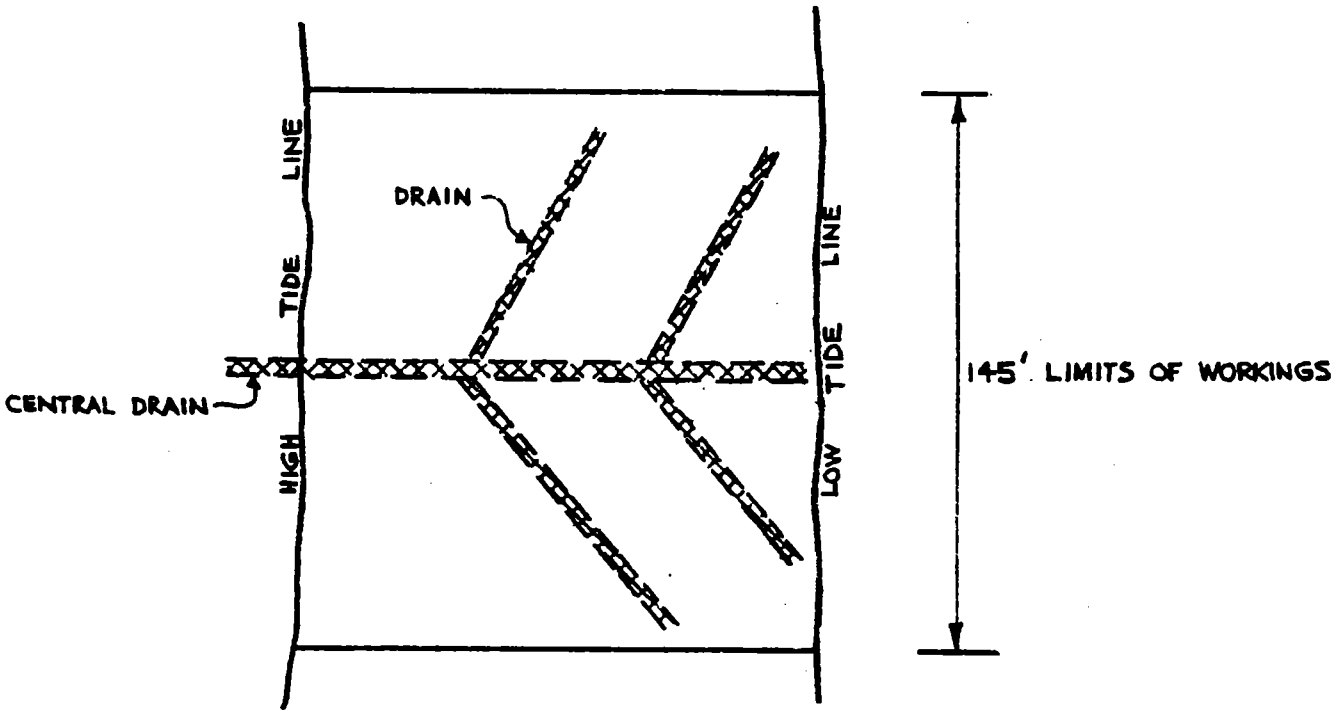
Excavation in Smith's Cove - for location see Fig. I-1

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

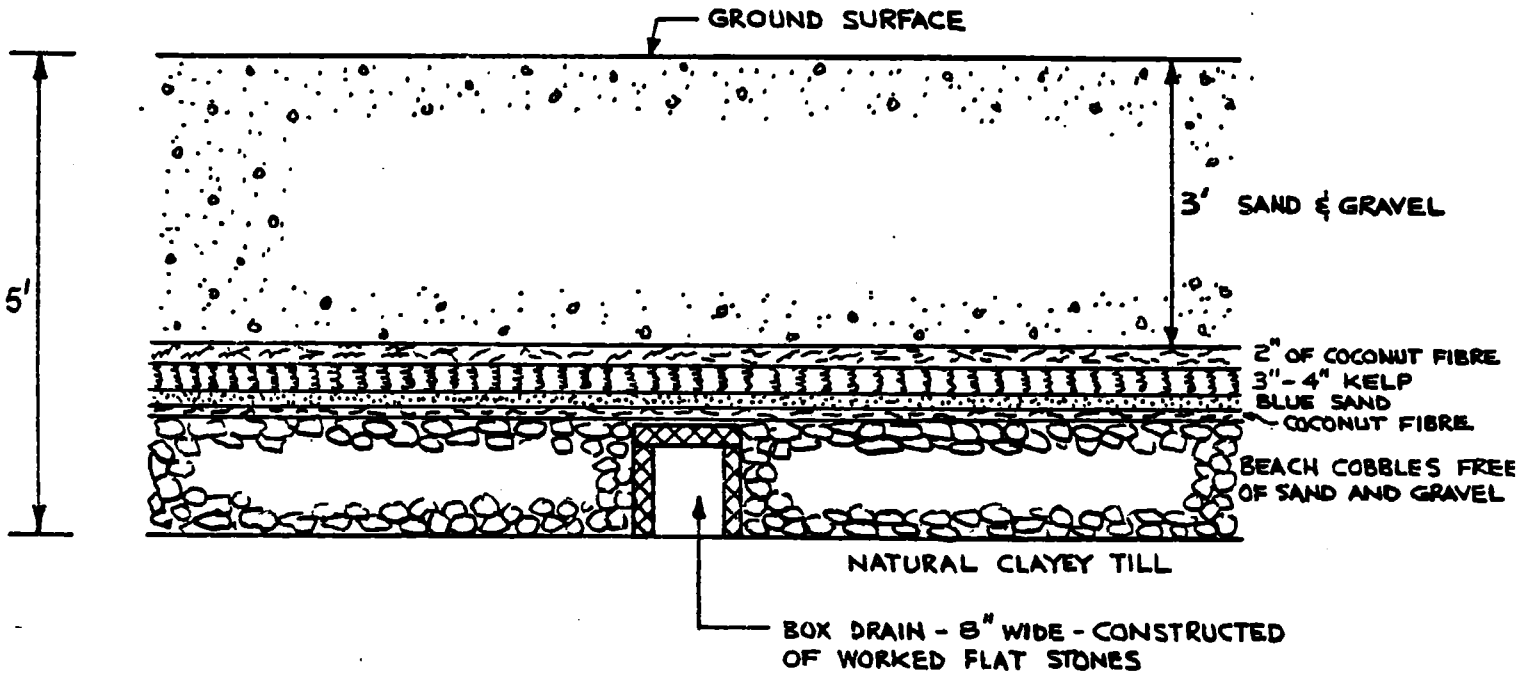
Scale 1" to 50'



STEP NO. 6 Cont'd

Section Through Workings Discovered on Beach

Scale 1" to 2'



STEP NO. 7

Date - 1850 (Truro Co.)

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

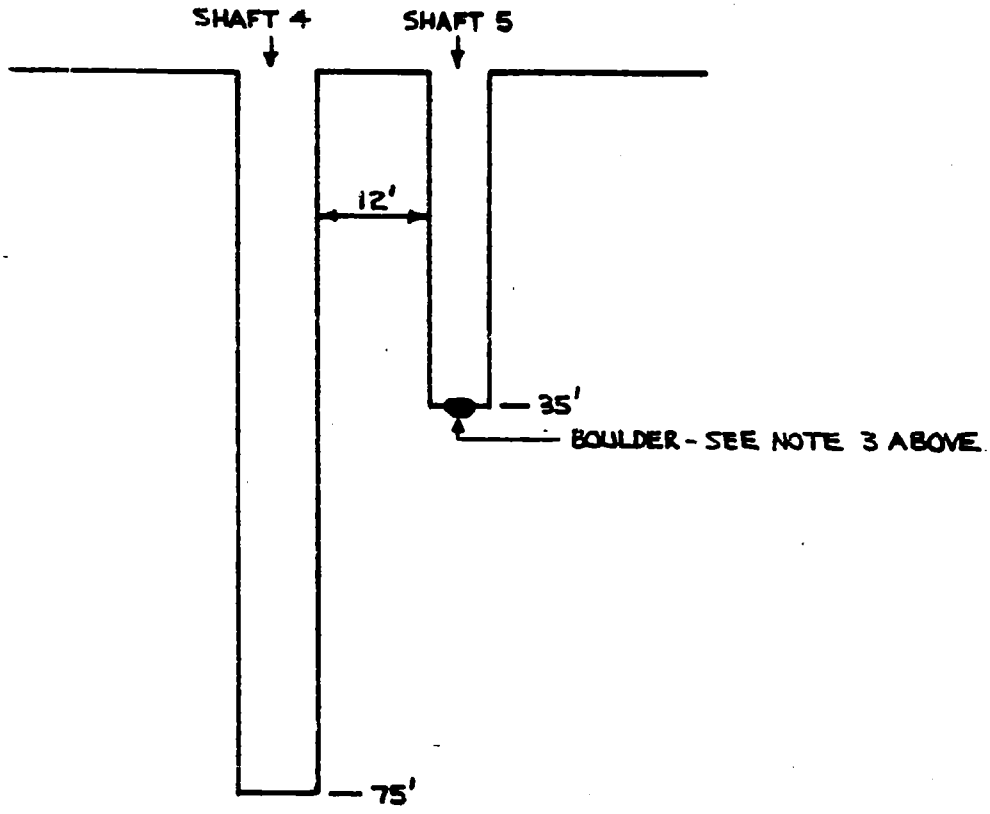
1. In an attempt to intercept the flood tunnel from Smith's Cove to the Money Pit Shafts No. 4 and 5 were put down.

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'



STEP NO. 8

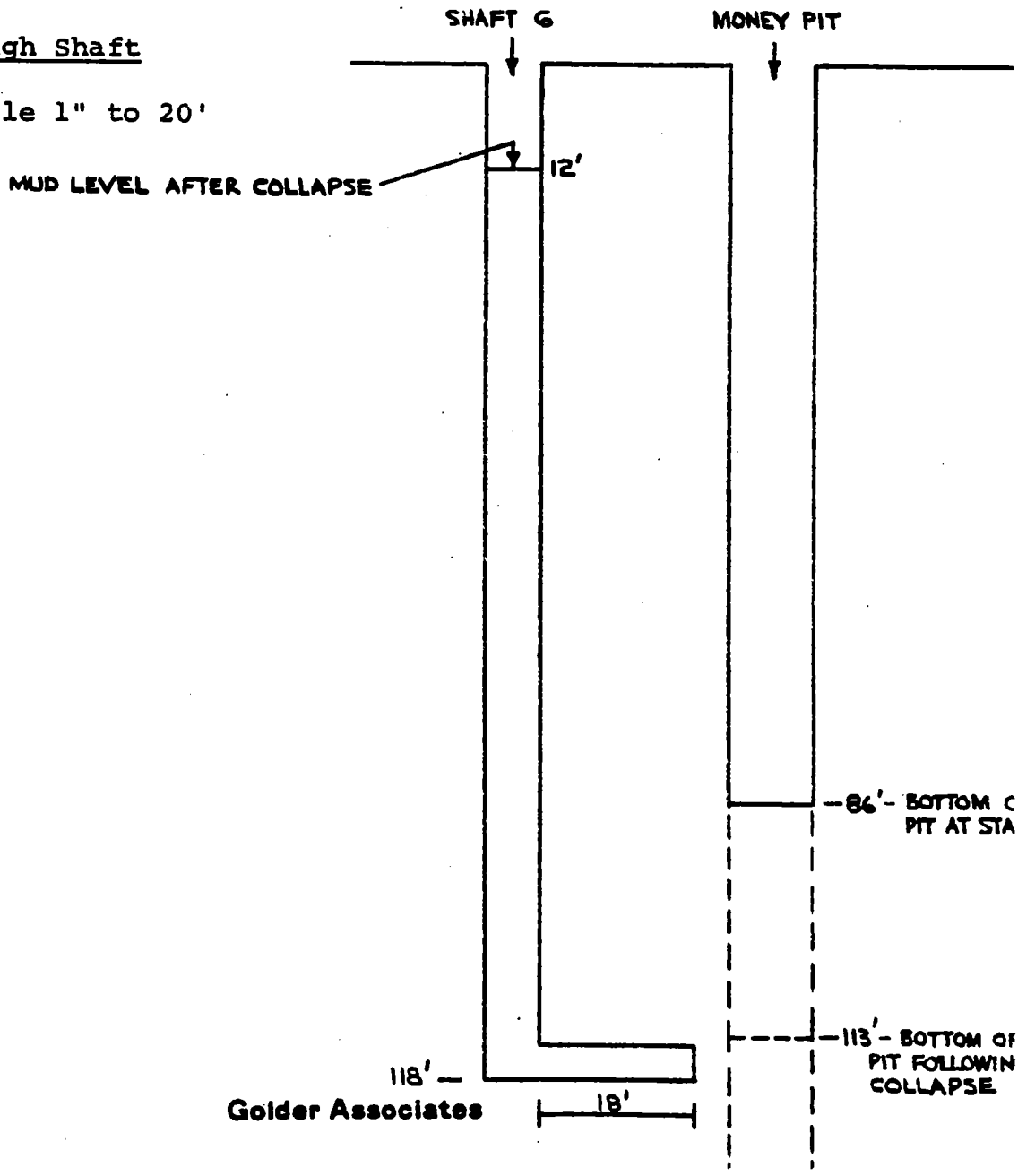
Date - 1850 (Truro Co.)

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'



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.

STEP NO. 10

Date - 1864 (Oak Island Association - Truro)

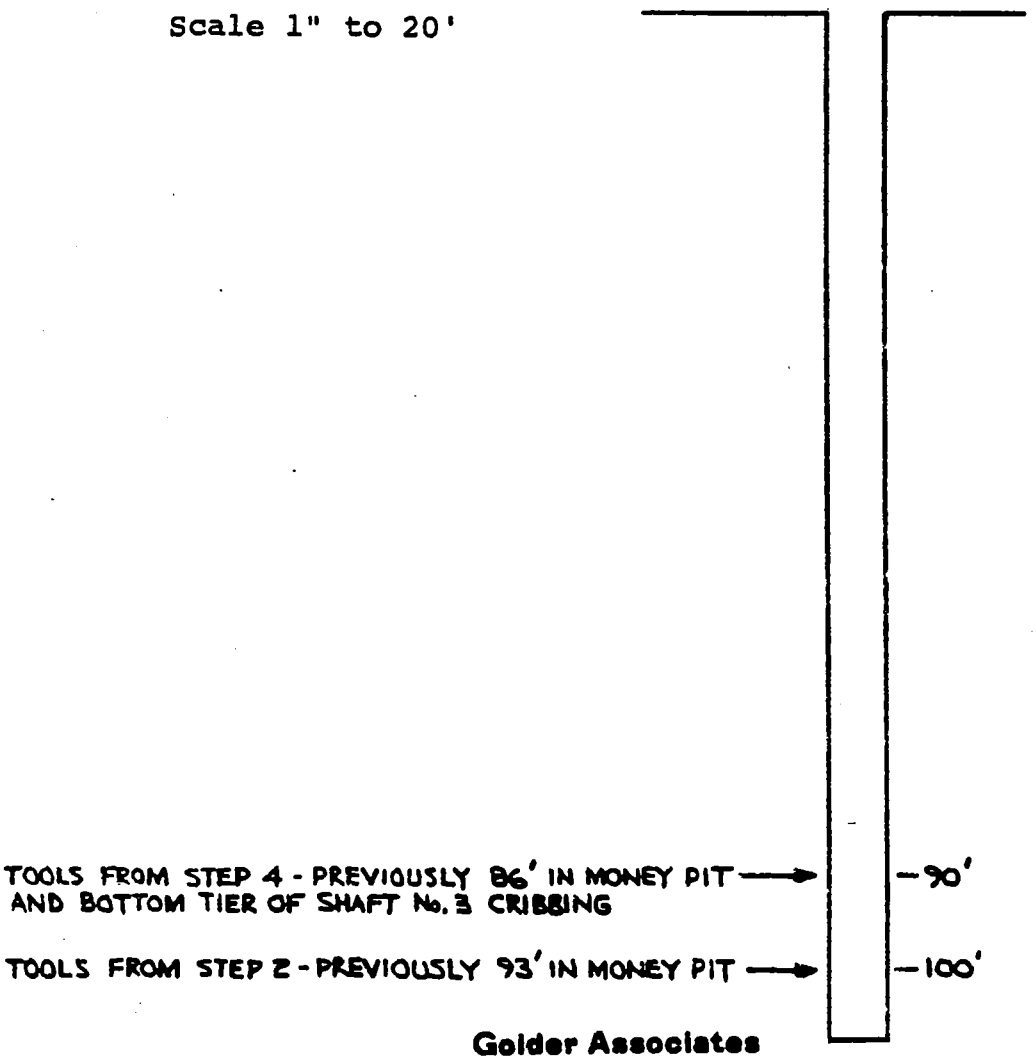
Shafts No. 7 and 8 - for locations see Fig. I-1

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'



STEP NO. 11

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.

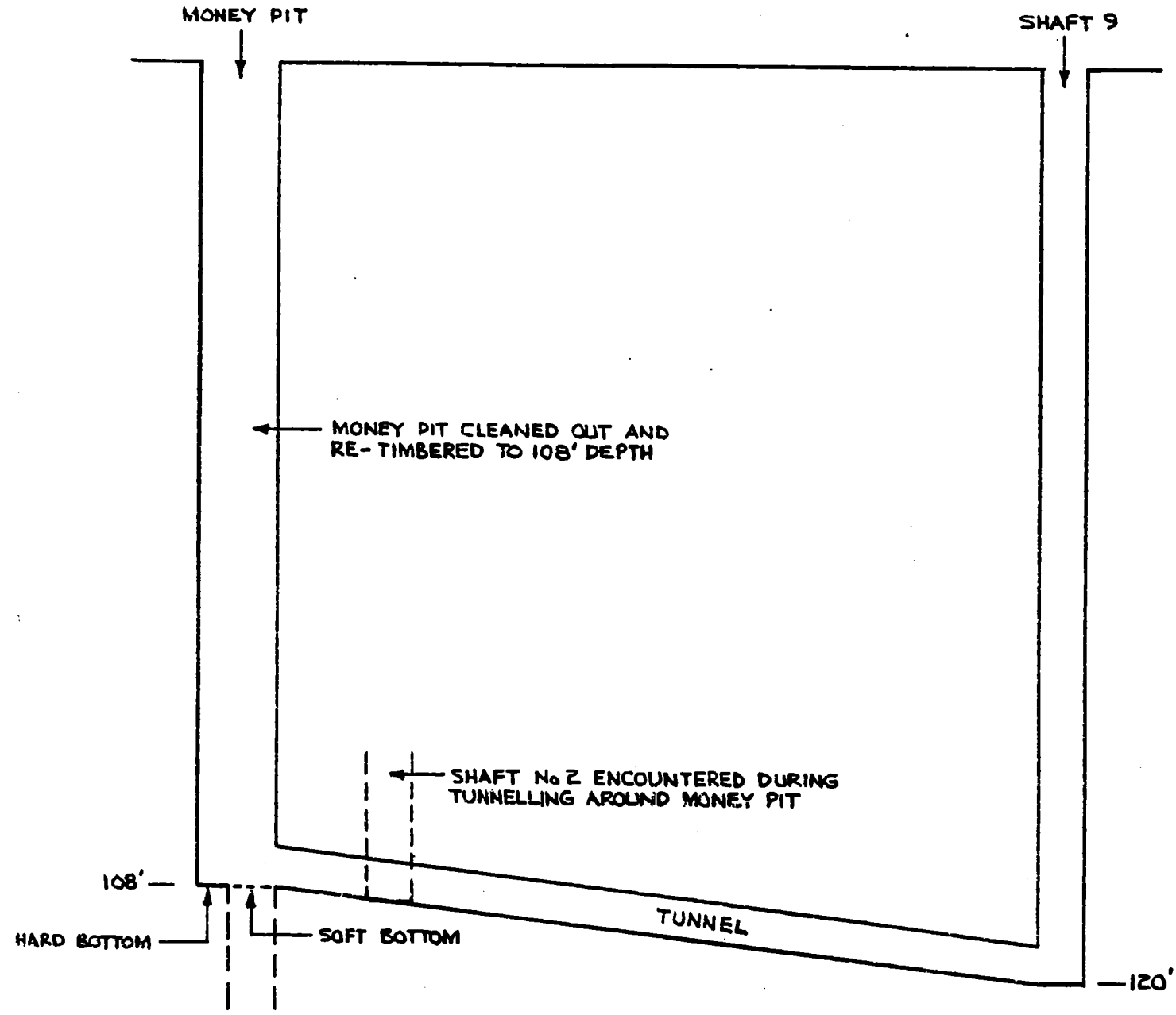
2. A fourth tunnel entered the Money Pit at a depth of 108 ft. and the Money Pit was re-cribbed to a depth of 108 ft.

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.

STEP NO. 11 Cont'd



STEP NO. 12

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

Money Pit - for location see Fig. I-1

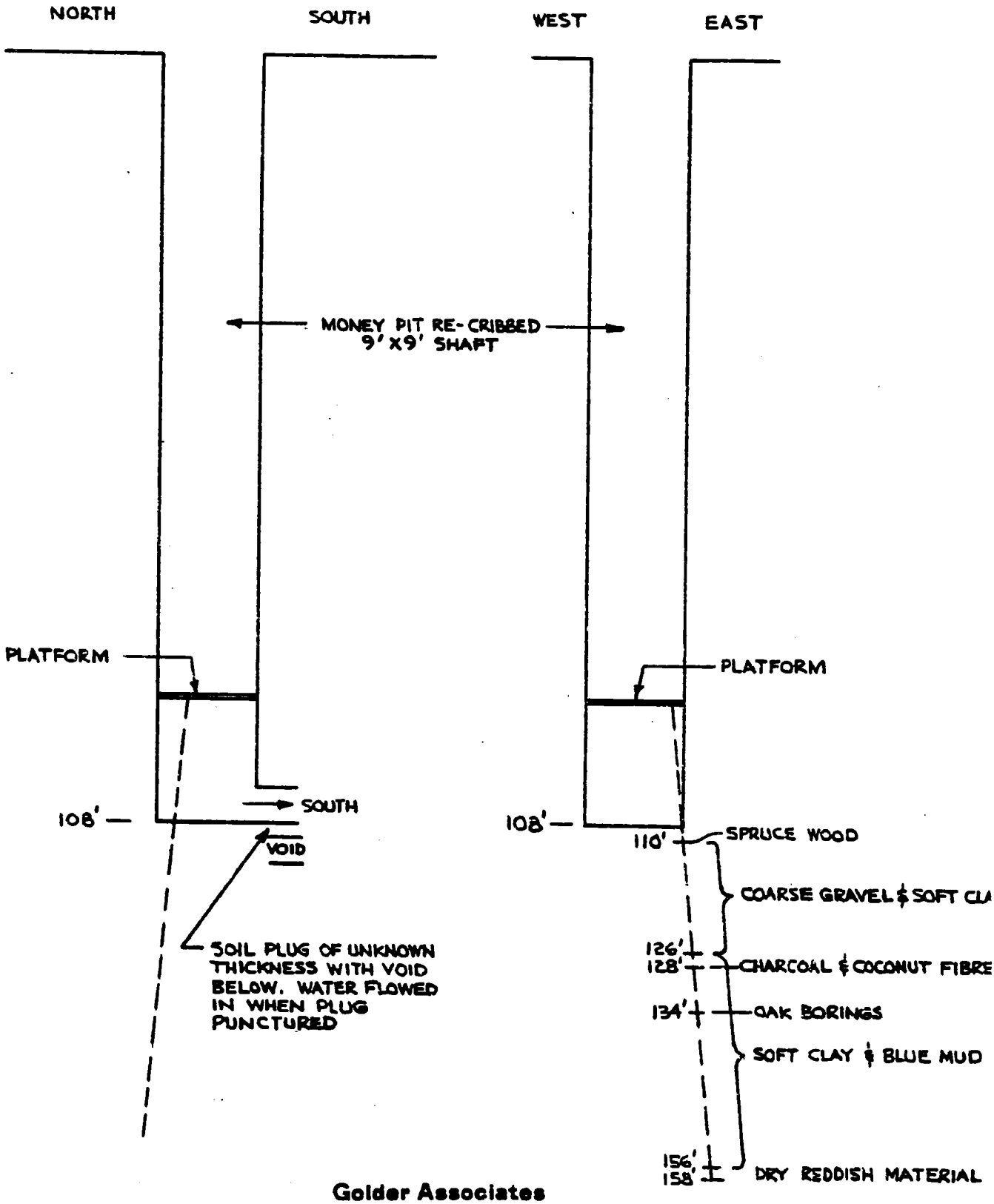
1. The shaft in the Money Pit (see Step 11) was cleared out to a depth of 108 ft. A tunnel was driven south from the bottom of this shaft. The floor of the tunnel was noted to be soft ("a worker at the face felt the earth give way slightly"). A pick was driven into the floor of the tunnel and water seeped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

STEP NO. 12 Cont'd

Section Through Shaft

Scale 1" to 20'



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

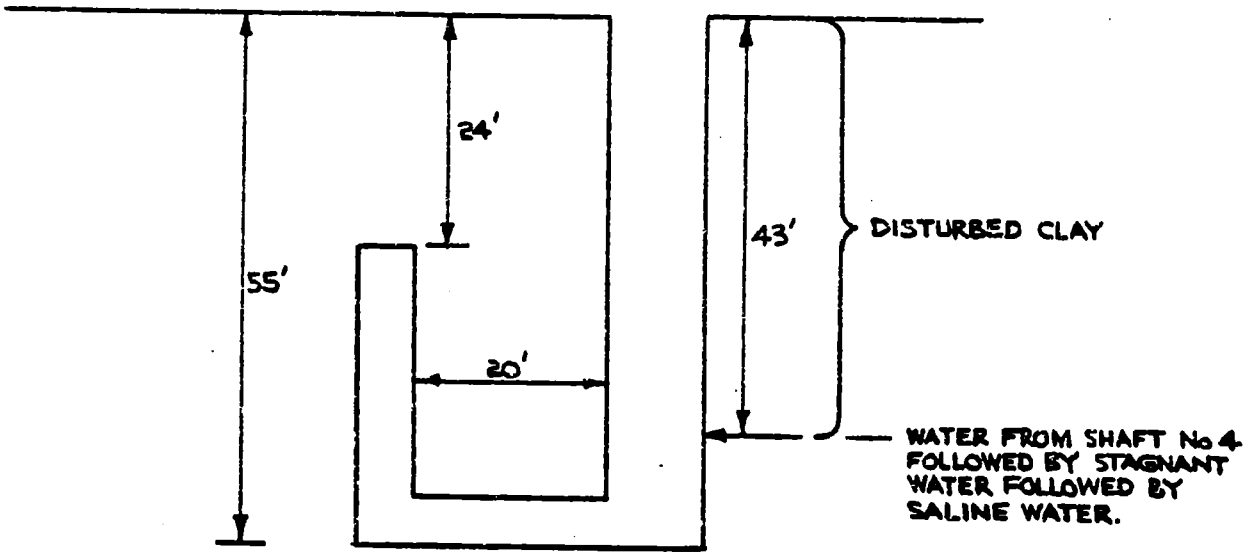
1. Shaft No. 12 was dug to a depth of 43 ft. through porous (disturbed) clay. At this depth water broke in from Shaft No. 4. After bailing out this water, black stagnant water thought to be from the Money Pit entered Shaft No. 12. After the stagnant water was bailed out saline water entered the shaft.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

STEP NO. 18

Date - 1897 (The Oak Island Treasure Co.)

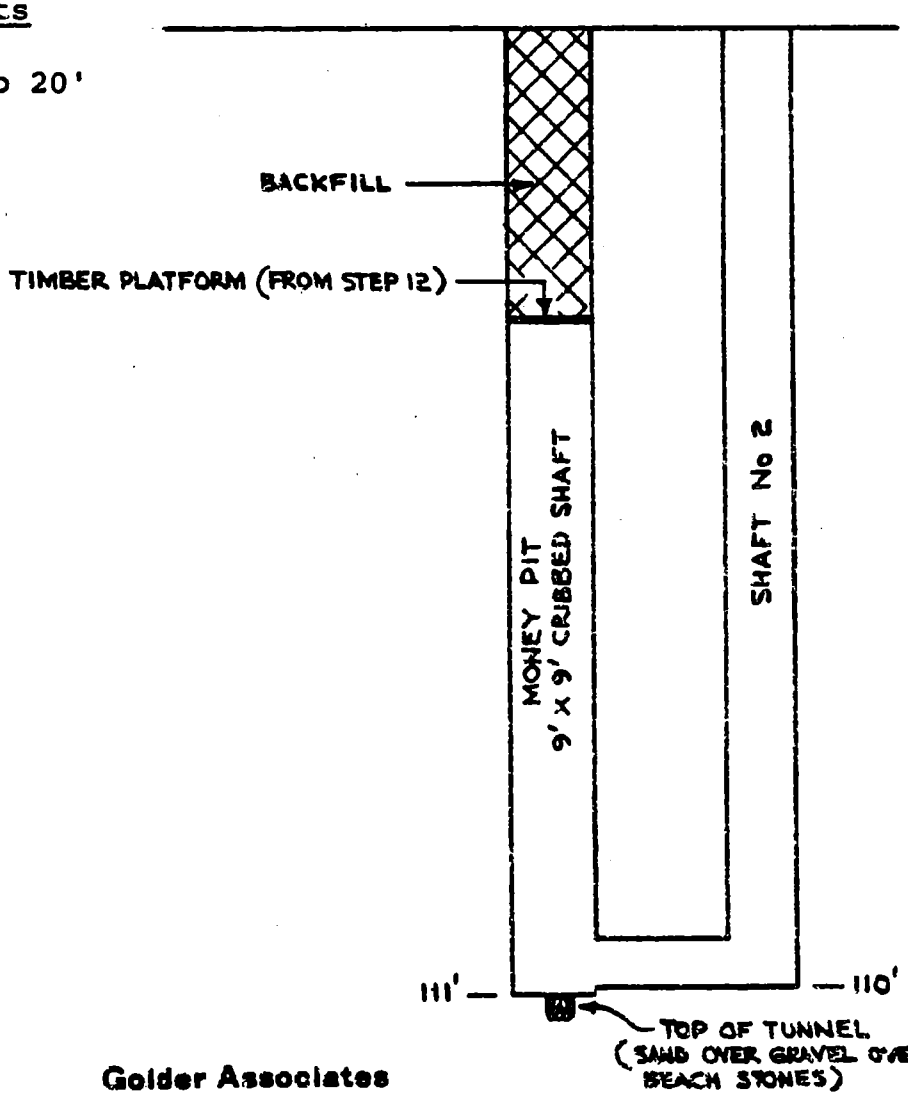
Shaft No. 2 and Money Pit - for location see Fig. I-1

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'



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.

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'-9½"	- void
154'-9½"	- parchment
154'-9½" to 157'-5½"	- loose metal in pieces*
157'-5½"	- soft metal*

* no samples obtained below 154'-9½"

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

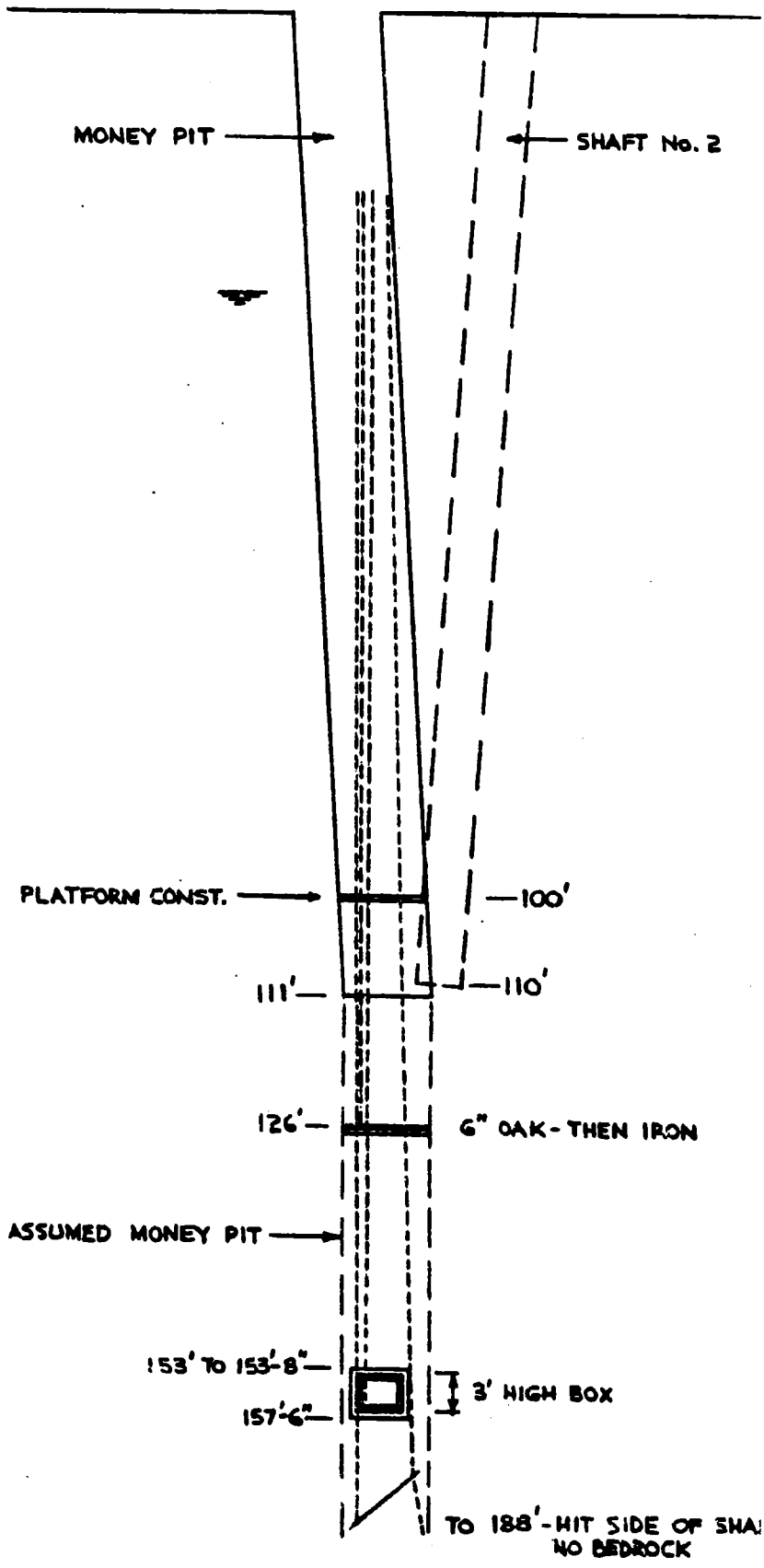
STEP NO. 20 Cont'd

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.

STEP NO. 20 Cont'd

Section Through Shaft

Scale 1" to 20'



STEP NO. 21

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

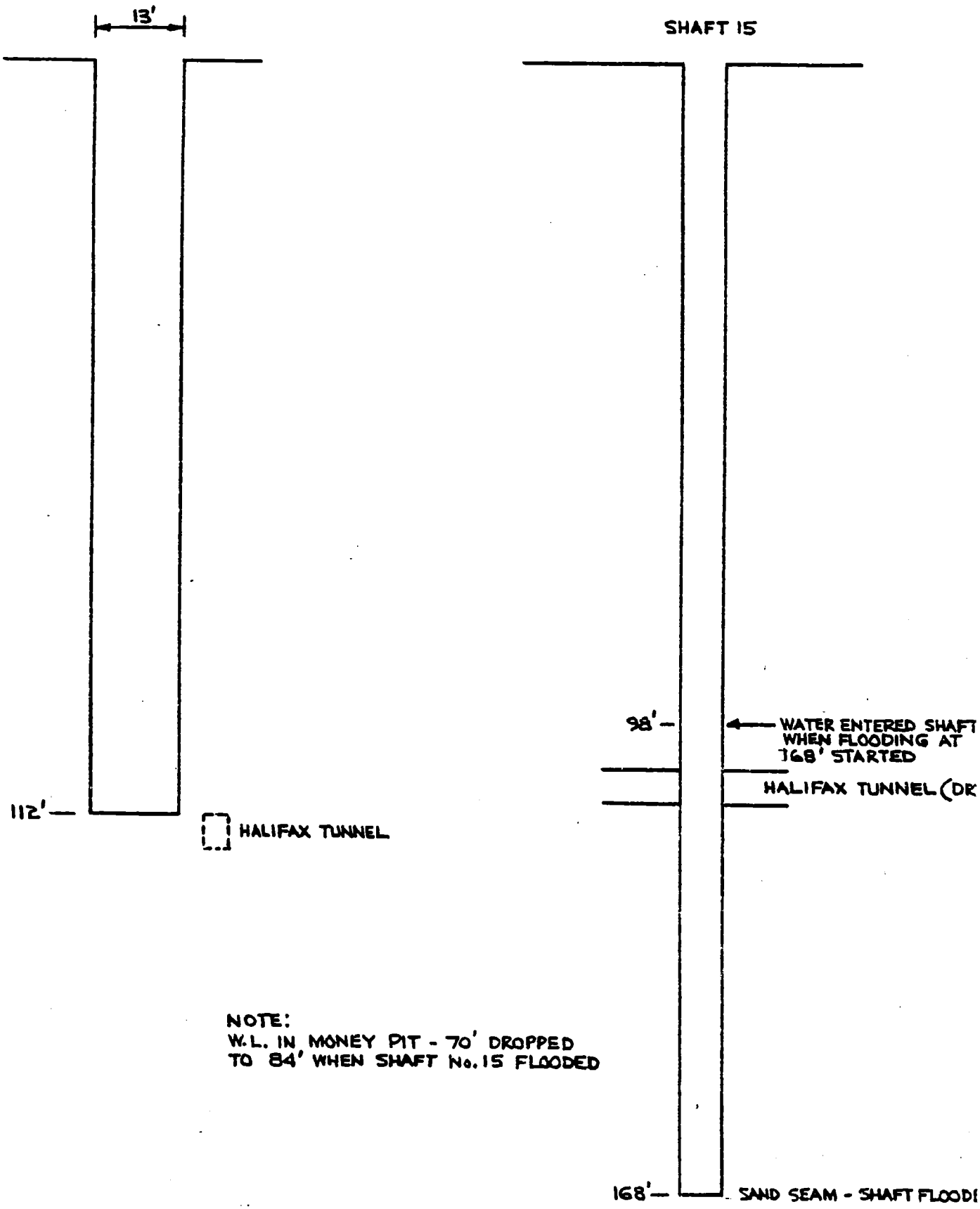
Shafts No. 14, 15, 16, 17, 18 and 19 - for locations see Fig. I-1

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.

STEP NO. 21 Cont'd



STEP NO. 22

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.)

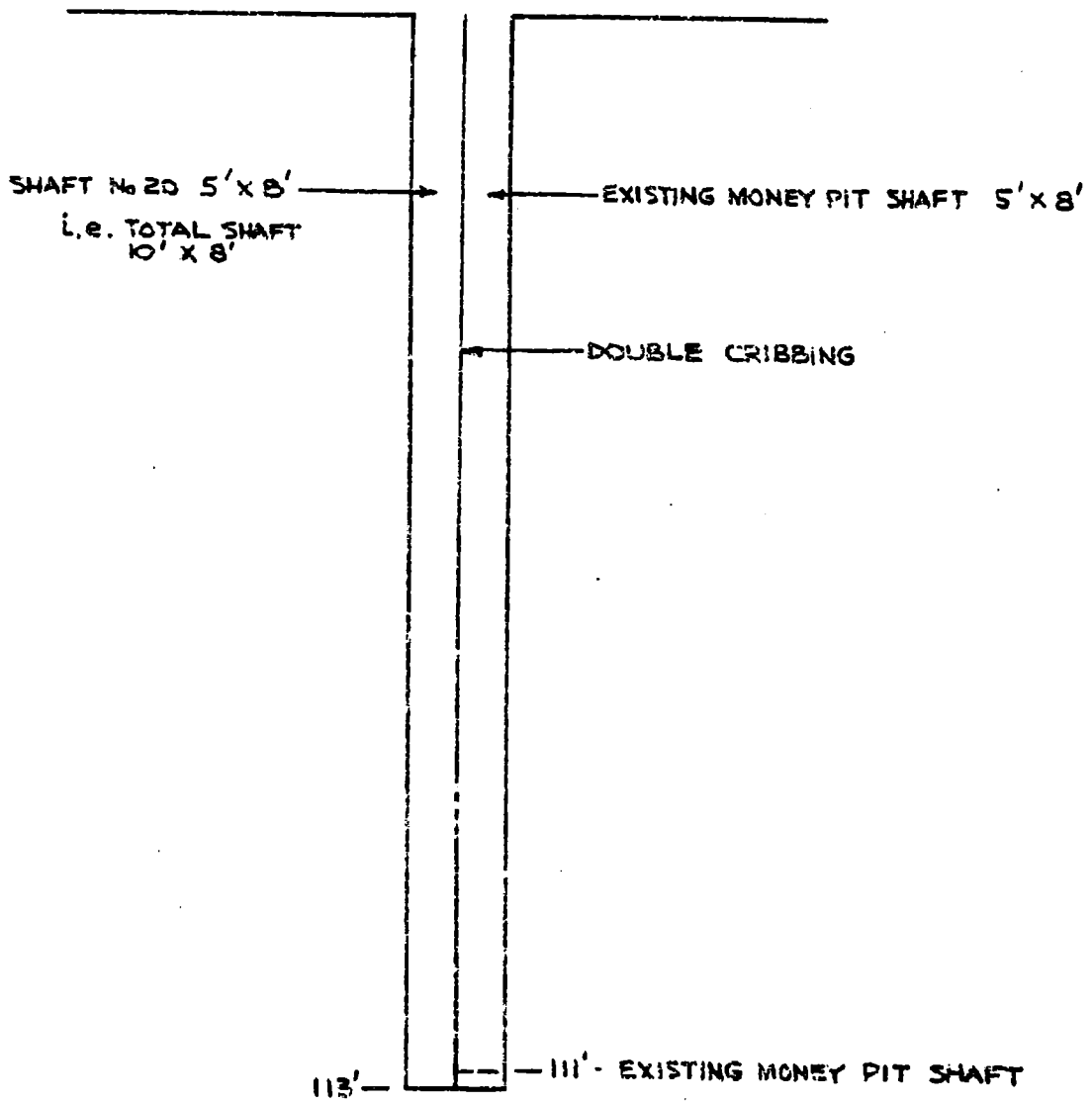
Shaft No. 20 - for location see Fig. I-1

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.

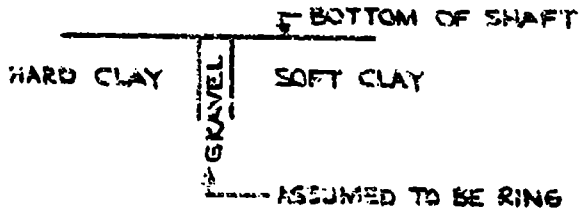
STEP NO. 23 Cont'd



FLOODED OUT BY INRUSH OF WATER AT 113' - FROM GRAVEL (SEE BELOW) - AS WELL AS FROM TUNNEL TO SMITHS COVE - EXPOSE

NOTES:
DURING SINKING OF SHAFT FOUND TIMBERS ON END.

AT SOME DEPTH OR DEPTHS BOTTOM AS BELOW.



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
} ALL HOLES SUPPOSED TO BE IN MONEY PIT

STEP NO. 24

Date - 1931 (William Chappell & Associates Ltd.)

Shaft No. 21 - for location see Fig. I-1

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.

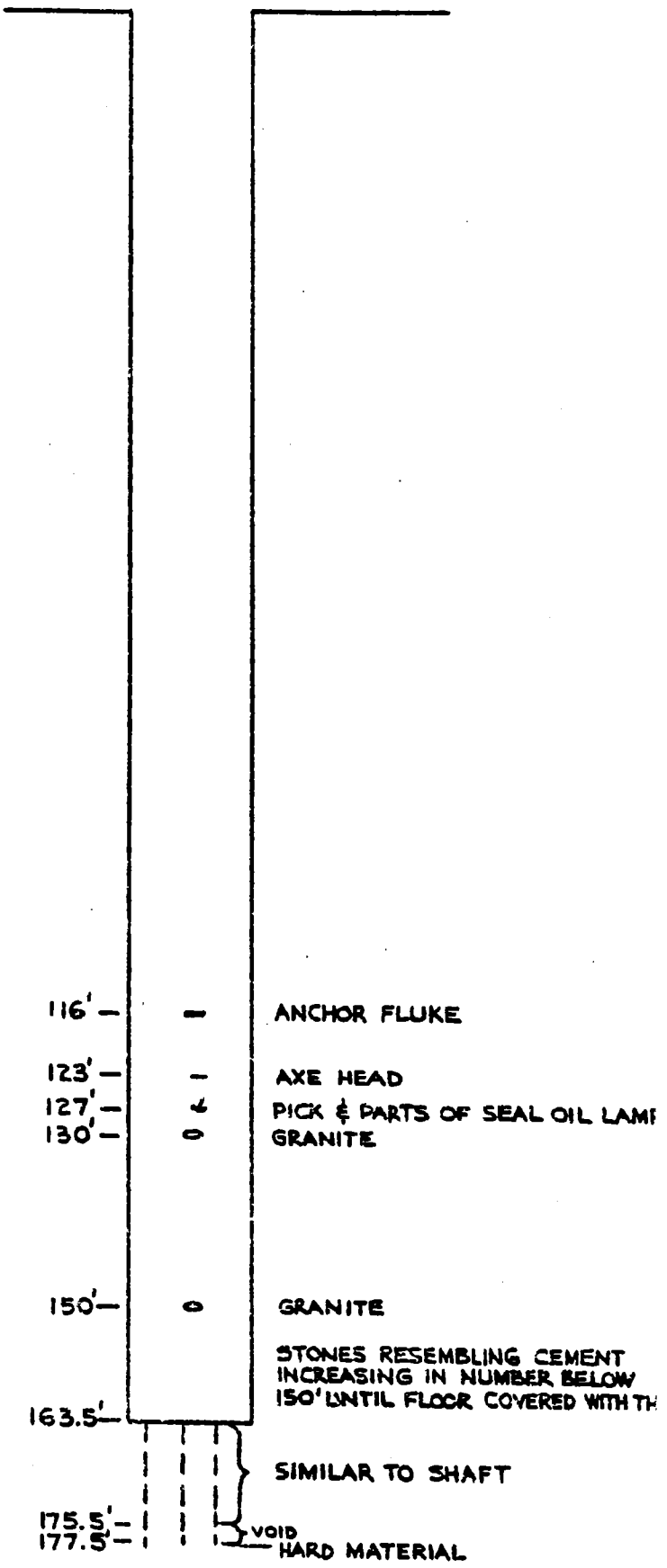
3. At a depth of 163.5 ft., three (3) tunnels were driven laterally. Nothing of interest was found although the soil appeared to be disturbed.

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.

STEP NO. 24 Cont'd

Section Through Shaft

Scale 1" to 20'



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.

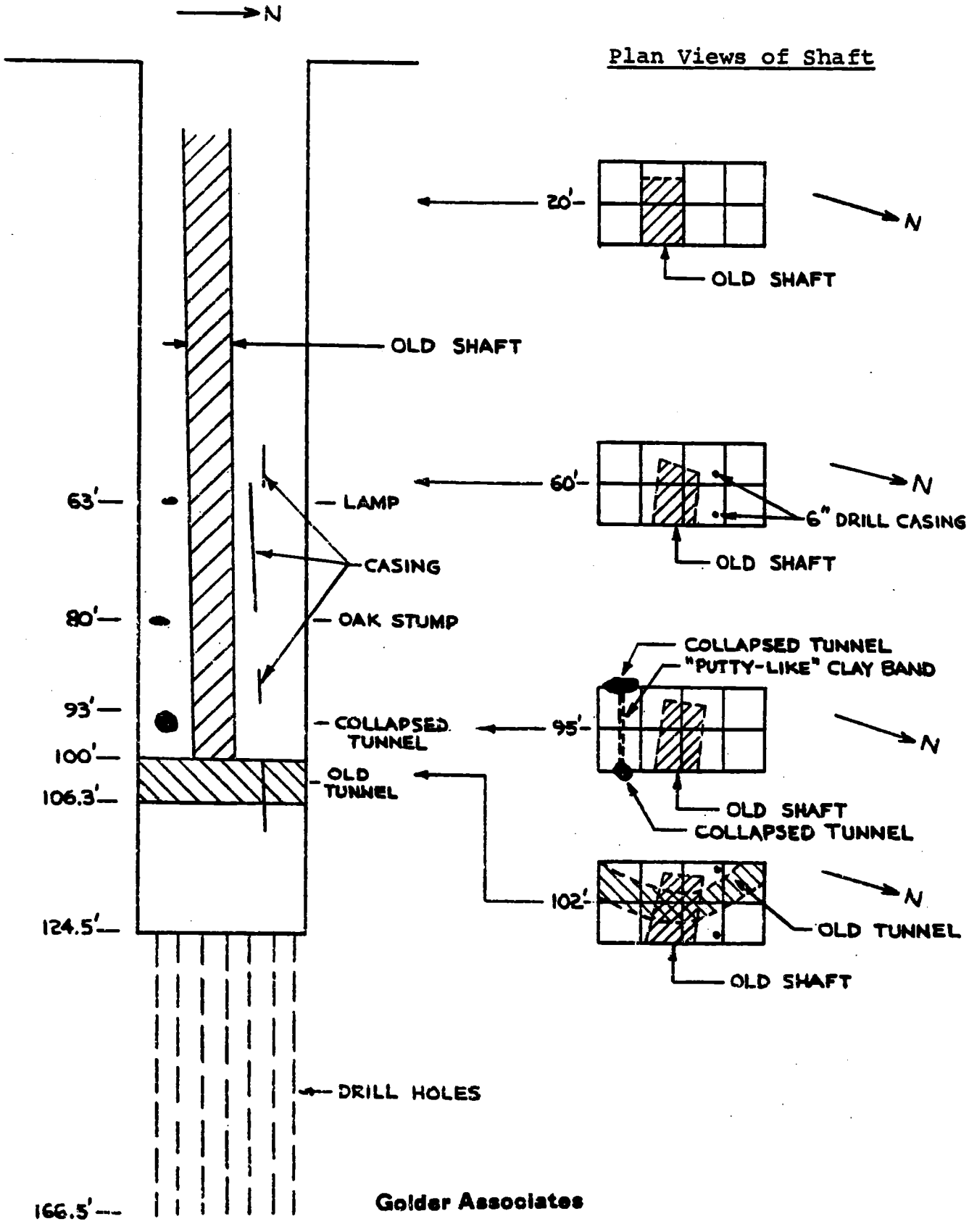
8. At a depth of 104 ft. a tunnel 3'-10" wide and 6'-4" high was found. This tunnel appeared to follow a circular path and intersected the older shaft (possibly a tunnel from Step 11 or 13). The top and outer face of this tunnel was shored but the inner face was not shored.

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.

STEP NO. 25 Cont'd

Section Through Shaft

Scale 1" to 20'



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 bay (6 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.

0' to 100'	- not reported
100'	- 8 in. thick oak timber
100' to 110'	- void
110'	- 8 in. thick oak timber
110' to 155'	- cavity
155' to 190'	- "ordinary clay"

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)

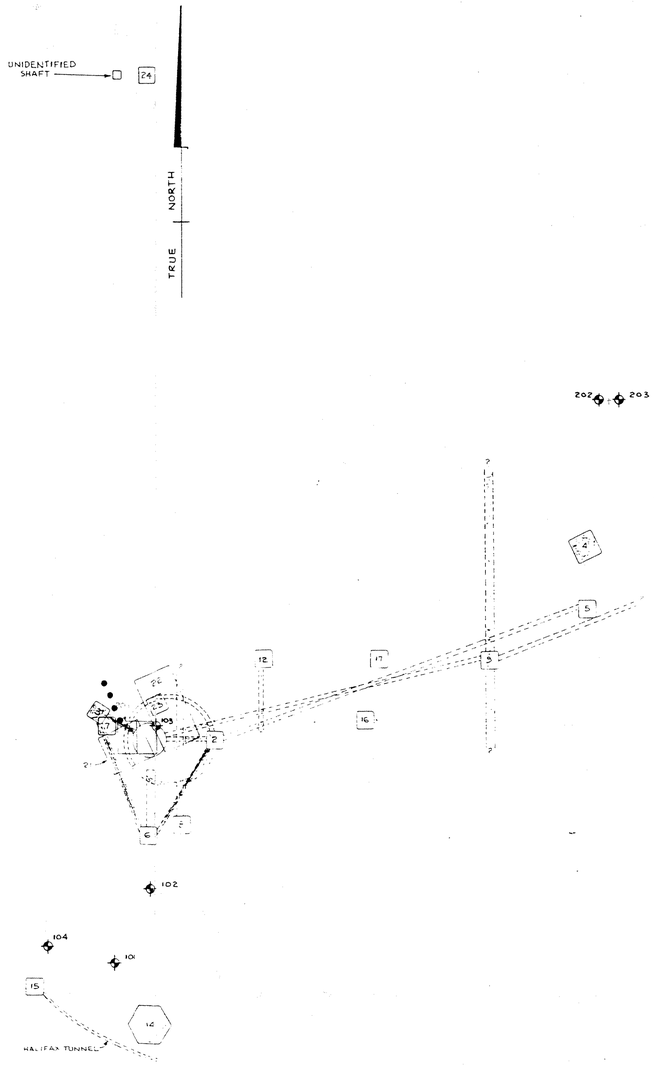
Shaft No. 25 - for location see Fig. I-1

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.

SUMMARY OF PAST SHAFT SINKING AND TUNNELING OPERATIONS

FIGURE 1-1



NOTE: PAST EXPLORATIONS DATA SHOWN IS BASED ON "THE OAK ISLAND MYSTERY" BY R.V. HARRIS.

- MONEY PIT - 7 TO 12 FT DIA. - DISCOVERED 1795 - EXCAVATED IN 1795, 1804 AND 1848
- SHAFT No 2 AND TUNNEL TO MONEY PIT AT 110 FT DEPTH (1805)
- SHAFT No 3 AND TUNNEL TO MONEY PIT AT 109 FT DEPTH (1850)
- SHAFT No 4 - DRY TO 75 FT DEPTH (1850)
- SHAFT No 5 - FLOODED AT 35 FT DEPTH - FILLED TO TIDE LEVEL SALT WATER (1850)
- SHAFT No 6 AND TUNNEL TOWARDS MONEY PIT AT 118 FT. DEPTH (1860)
- TUNNELS CONNECTING BOTTOM OF SHAFTS No 2, 3 AND 6 (1863)
- SHAFT No 7 - TAKEN TO 107 FT. DEPTH - CONSIDERABLE WATER ALL THE WAY (1864)
- SHAFT No 8 AND TUNNEL BENEATH ASSUMED FLOOD TUNNEL - NOT DETAILED BUT PROBABLY ABOUT 100-120 FT. DEPTH. (1864)
- SHAFT No 9 AND TUNNELS AT 120 FT DEPTH - NOTE. TUNNEL ENTERED MONEY PIT AT 108 FT DEPTH. (1865)
- SHAFT No 11 - TAKEN TO 52 FT. DEPTH, BORING TO 63 FT. DEPTH - DRY - WATER BROKE IN FROM SHAFT No. 4. (1894)
- SHAFT No 12 - TAKEN TO 55 FT. DEPTH - CONSIDERABLE WATER - TUNNEL AT 56 FT DEPTH - DEEPENED TO 123 FT AT SAME TIME. (1894)
- TUNNEL OF UNKNOWN ORIGIN - AT 35 FT DEPTH IN SHAFT No 5 (1894)
- DRILL HOLES TO LOCATE AND DYNAMITE FLOOD TUNNEL (1897)
- SHAFT No 14 - TAKEN TO 112 FT. DEPTH - DRY - WITHIN 3 FT OF SEARCHERS TUNNEL AT 112 FT DEPTH - FLOODED OUT. (1897 - 1898)
- SHAFT No 15 - TAKEN TO 168 FT. DEPTH - HIT HALIFAX TUNNEL AT 105 FT. - DRY - HIT SAND SEAM AT 165 FT - FLOODED OUT. (1897 - 1898)
- SHAFT No 16 - TAKEN TO 184 FT DEPTH (1897)
- SHAFT No 17 - TAKEN TO 97 FT DEPTH (1898)
- SHAFT No 20 - 5 FT. x 8 FT. AND 5 FT x 8 FT. EXISTING SHAFT IN MONEY PIT - TAKEN TO 113 FT. DEPTH - FLOODED OUT AT 113 FT DEPTH. (1898)
- SHAFT No 21 - 12 FT. x 14 FT. - TAKEN TO 163.5 FT DEPTH - DRILLING TO 177.5 FT. DEPTH. (1931)
- SHAFT No 22 - 12 FT. x 34 FT. - TAKEN TO 124 FT DEPTH - DRILLING BELOW. (1937)
- SHAFT No 23 - 6 FT. x 6 FT. - TAKEN TO 171 FT DEPTH - DRILLING TO 191 FT. DEPTH - NO BEDROCK (1942)
- SHAFT No. 24 - TAKEN TO 46 FT DEPTH (1951)
- DRILL HOLES NEAR MONEY PIT (1955)
- SHAFT No 25 - TAKEN TO 27 FT. DEPTH (1965)

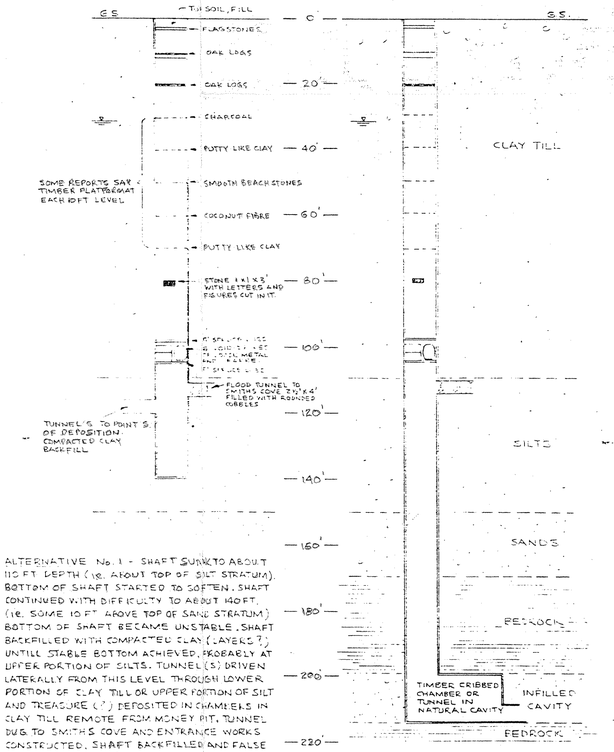
NOTE: SHAFT No 10 - HALIFAX SHAFT (LOCATION NOT KNOWN) (1866 - 1867)
SHAFT No 13 - OMITTED
SHAFT No 18 - TAKEN TO 160 FT. DEPTH (LOCATION NOT KNOWN) (1897 - 1898)
SHAFT No 19 - TAKEN TO 144 FT. DEPTH (LOCATION NOT KNOWN) (1897 - 1898)

- BOREHOLE LOCATION IN PLAN (PRESENT INVESTIGATION)

POSSIBLE SECTIONS OF ORIGINAL WORKINGS

BASED ON "THE OAK ISLAND MYSTERY" BY R.V. HARRIS AND ON DISCUSSION WITH TRITON ALLIANCE LTD.

SCALE 1" TO 20'



ALTERNATIVE No. 1 - SHAFT SUNK TO ABOUT 115 FT. DEPTH (IE. ABOUT TOP OF SILT STRATUM). BOTTOM OF SHAFT STARTED TO SOFTEN, SHAFT CONTINUED WITH DIFFICULTY TO ABOUT 140 FT. (IE. SOME 10 FT. ABOVE TOP OF SAND STRATUM). BOTTOM OF SHAFT BECAME UNSTABLE, SHAFT BACKFILLED WITH COMPACTED CLAY (LAYERS 7) UNTILL STABLE BOTTOM ACHIEVED, PROBABLY AT UPPER PORTION OF SILTS. TUNNEL(S) DRIVEN LATERALLY FROM THIS LEVEL THROUGH LOWER PORTION OF CLAY TILL OR UPPER PORTION OF SILT AND TREASURE (?) DEPOSITED IN CHAMBERS IN CLAY TILL REMOTE FROM MONEY PIT. TUNNEL DUG TO SMITH'S COVE AND ENTRANCE WORKS CONSTRUCTED. SHAFT BACKFILLED AND FALSE TREASURE PLACED (THIS COULD BE THE ONLY TREASURE). RELIEVING PLATFORMS CONSTRUCTED AT 20 FT. AND 10 FT. DEPTHS.

ALTERNATIVE No. 2 - SHAFT SUNK TO ABOUT 215 FT. OR TO BOTTOM OF NATURAL CAVITY IN BEDROCK. SHAFT MAY HAVE PENETRATED SOFT BEDROCK OR MAY HAVE BEEN IN NATURAL SINK HOLE. TIMBERED CHAMBER AND/OR TUNNEL CONSTRUCTED IN NATURAL CAVITY. TREASURE DEPOSITED IN CHAMBER OR TUNNEL SHAFT BACKFILLED TO ABOUT 115 FT. DEPTH WITH COMPACTED CLAY (WATERSTOP). FLOOD TUNNEL CONSTRUCTED AND SHAFT BACKFILLED AS IN ALTERNATIVE No. 1

Date SEPT 19/70

Golder Associates

Drawn
Chkd.
Appd.

APPENDIX II

LIST OF SAMPLES FORWARDED FOR POLLEN ANALYSES

OAK ISLAND NOVA SCOTIA

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. Consquently, 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 II-1

LIST OF SAMPLES FORWARDED FOR POLLEN ANALYSES

Borehole Number	Sample Number		Depth of Sample (ft.)	Date Sample Forwarded For Analyses
	Field Numbering System	Final Borehole Log Numbering System		
102	31	36	214.8-216.3	April 28, 1970
102	32	37	217.0-218.5	May 19, 1970
103	29	27	193.0-195.0	"
103	33	30	198.0-200.0	"
201	49	46	224.2-224.8	June 7, 1970
202	18	1	125	June 14, 1970
202	16	16	219.7-219.9	June 18, 1970
202	18	18	224.3-224.5	"
202	20	20	227.8-228.0	June 19, 1970
202	22A	22	229.8-230.0	"
204	6B	6	221.6-222.2	June 23, 1970
204	7	7	222.2-224.2	"
204	8A	8	224.2-225.4	"

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

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.

University of Toronto
TORONTO 5, CANADA

FACULTY OF FORESTRY

8 July, 1970

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 (White 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,

J. J. Balatinecz
Associate Professor

JJB:bm

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.
6200 Granby Allee
ST. HUBERT, 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 13 and 20, having the appelations "Borehole 201, Sample 10" and "Borehole 202, Sample 2" respectively. The small metal fragments contained in Borehole 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 Borehole 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 bicarbonates 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 pry 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 1800. 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 205 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. Had 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

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

ABD/ST
Encl:
Copy to: Mr. J. B. Davis, P. Eng. - Golder 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

Date 1970	Time Hrs.	ELEVATION OF WATER LEVEL IN INSTALLATION																		
		BH 101			BH 102			103	BH 104		BH 201		BH 202		203	BH 204		10	11A	Shaft	Ocean
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
Apr. 19	0700																	966.3	965.6		963.7
" 19	1300																	965.4	964.8		959.7
" 20	0730																	965.9	965.2		963.9
" 20	1330																	965.1	964.6		959.8
" 21	0830																	966.1	965.4		964.0
" 21	1400																	964.8	964.3		959.5
" 22	0900																	966.1	965.5		963.9
" 22	1500																	965.1	964.5		959.8
" 23	1530	969.0	960.9	966.1															964.2		959.8
" 24	1030	968.4	960.9	966.9														965.3	964.7		963.5
" 25	1100	969.3	961.3	967.8														966.2	965.6		964.0
" 25	1700	969.5	961.3	966.5																	959.9
" 28	0900	967.9	961.4	965.7																	959.5
" 29	0930	967.8	961.3	965.4																	959.0
" 29	1500	967.7	0.0	966.9																	963.5
June 3	0600	968.3		968.3		966.0					965.7	995.9						965.1	965.6	969.4	961.7
" 4	1000	967.7		967.6		966.0	967.9	966.0			966.2	995.2						966.2	964.0	970.4	963.5
" 7	0700	967.3		966.3		964.8	967.0	964.9	962.9	961.7	963.8	993.9						964.9	965.6	964.9	961.2
" 9	1230	967.8		967.3		966.0	967.5	966.1	963.2	967.4	964.8	994.3						965.9	966.5	965.9	963.5
" 10	1300	967.1		966.0		964.9	965.2	965.0	963.3	967.6	963.9	995.0						964.6	965.4	963.5	960.4
" 11	1330	966.1		966.8		965.2	965.8	965.3	963.2	967.5	964.2	995.2							965.9	964.9	963.7
" 13	1000	966.1		965.8		964.3	965.0	964.4		967.3									965.1	964.5	960.5
" 14	1730	967.8		966.8		965.5	966.2	964.4	963.0	967.1	962.2	981.3							966.6	964.9	963.5
" 15	1630	966.0		966.5		965.2	965.8	963.9	963.1	968.0	964.2	982.0							966.1	964.9	961.5
" 16	1230	966.8		965.2		964.0	964.6	964.0	962.9	966.9	963.4	982.2			963.3				964.9	963.9	959.5
" 18	2000	966.8		967.3		965.5	966.5	965.6	962.8	966.7	964.7	981.8			965.0				966.6	964.9	964.5
" 19	1800	966.6		966.0		964.5	965.4	964.7	963.1	966.9	964.5	983.4			963.7				965.1	964.2	961.9
" 20	1000	966.6		967.1		965.6	966.2	965.6	963.1	966.8	964.7	983.7			964.5				966.2	966.1	964.2
" 21	1030	966.3		966.9		965.2	966.1	964.4	963.4	966.7	964.7	984.1	964.6						966.1	964.9	964.0
" 22	0900	966.6		966.9		964.7	965.2	964.1	963.7	967.1	965.7	985.4	963.8		963.0				964.8	963.9	962.0
" 23	1830	967.0		966.2		964.7	965.1	964.5	963.5	967.0	965.5	986.0	964.6	978.1	964.3			964.3	965.0	964.1	959.5
" 24	2000	966.8		966.6		964.5	965.0	964.5	963.6	967.0	965.4	986.3	964.0	973.5	964.1			964.4	965.1	964.3	959.6
" 25	1400	966.9		967.7		964.9	966.6	965.6	963.6	967.0	965.6	986.5	965.5	974.1	965.5			965.6	966.2	965.4	964.6
" 28	1230	966.3		965.8		964.2	964.7	964.0	963.4	966.6	965.4	988.1	964.4	965.1	964.0	971.8	964.6	964.0	963.7	964.1	960.0
July 3	1430	969.6		966.3		967.0	967.2	967.3	964.7	966.8	967.0	989.2	965.8	961.6	966.9	970.8	967.3	965.0	967.7		960.2
" 4	1100	969.5		966.8		967.4	967.3	967.9	964.9	966.7	967.4	989.2	967.5		967.5	969.6	967.9		967.8		962.7

NOTE - SEE TABLE V-2 FOR DESCRIPTION OF WATER LEVEL OBSERVATION INSTALLATIONS

TABLE V-2

DESCRIPTION OF WATER LEVEL OBSERVATION INSTALLATIONS

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

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

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

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_u, *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

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:

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

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

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

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(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_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(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_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLE 101

LOCATION See figure 1. BORING DATE MARCH 28 TO APRIL 11, 1970. DATUM LOCAL
SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in. CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD	ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
	986.8	GROUND SURFACE					
ROTARY DRILLING, 5" Ø CASG.	0.0 / 981.8	COBBLES AND BOULDERS IN A BROWN CLAYEY SILT & SAND MATRIX (FILL)					
	5.0	COBBLES AND BOULDERS IN A HARD GREY CLAYEY SILT AND SAND MATRIX.	1	2" D.O.	125/3"		
			2	NXL CORE	–	50	100
	965.8						
H CASING	17.0		3	2" D.O.	122		
			4	NXL CORE	–	30	100
			5	2" D.O.	33		
		HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL AND OCCASIONAL COBBLES AND BOULDERS, OCCASIONAL SAND SEAMS (CLAYEY TILL)	6	"	51		
			7	"	42		
			8	NXL CORE	–	12	100
			9	2" D.O.	87		
			10	NXL CORE	–	8	100
			11	2" D.O.	74		
	903.8						
	83.0	VERY STIFF TO HARD DARK GREY AND RED-BROWN LAYERED SILTY CLAY, TRACE OF SAND AND GRAVEL	12	"	27		
	896.8						
	90.0	HARD GREY CLAYEY SILT, TRACE TO SOME SAND AND GRAVEL, OCCASIONAL COBBLES (TILL)	13	"	37		
	887.8						
NX CASING	99.0	VERY DENSE BROWN (BECOMING GREY BELOW ABOUT 134 FT. DEPTH) SILT TO SANDY SILT, TRACE CLAY, OCCASIONAL ZONES OF HARD BROWN CLAYEY SILT, OCCASIONALLY FAINTLY STRATIFIED STRUCTURE, OCCASIONAL SEAMS OF SAND, SILT AND FINE GRAVEL	14	"	175/10"		
			15	"	112		
			16	"	190/8"		
			17	"	112/6"		
	841.8						
	145.0	VERY DENSE BROWN (BECOMING GREY BELOW ABOUT 156 FT. DEPTH) SANDY SILT TO SILTY SAND WITH A TRACE OF CLAY AND SOME GRAVEL (SILTY TILL)	18	"	163/9"		
			19	"	107/6"		
	823.1						
	163.7		20	"	100/½"		
			21	NXL RC	–	69	100
			22	"	–	100	100
			23	"	–	35	100
			24	"	–	94	100
			25	"	–	100	100
			26	"	–	98	100
		SOUND LIGHT GREY FINE TO MEDIUM GRAINED ANHYDRITE BEDROCK WITH SOME DARK GREY DOLOMITE INCLUSIONS, OCCASIONAL SMALL (ONE INCH DIA.) SOLUTION CAVITIES FILLED WITH CRYSTALLIZED GYPSUM.	27	"	–	92	100
			28	"	–	99	100
			29	"	–	94	100
			30	"	–	98	100
			31	"	–	100	100
NX CORE			32	"	–	100	100
	769.8						
	217.0	ANHYDRITE BEDROCK WITH CAVITIES, CAVITIES FILLED WITH BROWN SILTY CLAY TO CLAYEY SILT	33	"	–	80	100
	763.3		34	"	–	88	100
	223.5	VERY DENSE GREY SILT, TRACE CLAY	35	2" D.O.	75/10" 10%/6"		
	224.6	HARD GREY CLAYEY SILT, SOME SAND					
BX CASING	226.5		37	NXL RC	–	100	80
			38	" BX SHOE	–	30	80
					–	0	80
		SOUND LIGHT GREY MEDIUM GRAINED ANHYDRITE BEDROCK WITH LIMESTONE INCLUSIONS, SEAMS OF WHITE CRYSTALLIZED GYPSUM AND OCCASIONAL HEALED FRACTURES THROUGHOUT.	39	BXL RC	–	84	80
BX CORE			40	"	–	100	80
			41	"	–	100	80
			42	"	–	100	80
	736.5						
	250.3	END OF HOLE					

COEFFICIENT OF PERMEABILITY, (cm./sec.): 1x10⁻³ 1x10⁻⁴ 1x10⁻⁵ 1x10⁻⁶

WATER CONTENT (percent): W_p W W_L; 10 20 30 40

ELEVATION SCALE: 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720

NO TAKE; O NP; O NON PLASTIC LL=1

ADDITIONAL LABORATORY TESTING: MH, H, MH, H, H, H, MH, H, MH

WATER LEVEL OBSERVATIONS: GROUND SURFACE; BENTONITE SLURRY; POLYETHYLENE TUBING; PIEZOMETER; SAND FILL; BENTONITE SEAL; BLACK TUBING; STANDPIPE; CAVED MATERIAL; SAND FILL; STEEL PIPE; WELLPOINT

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.) 5 0 5 10 20

Golder Associates

DRAWN

CHECKED

RECORD OF BOREHOLE 102

LOCATION See figure 1. BORING DATE APRIL 17 TO 28, 1970 DATUM LOCAL
SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD: H CASING; NX CASING; ROTARY DRILLING; BX CASING; BX CORE; AX CASING; AX CORE

ELEV. DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
985.0	GROUND SURFACE						
0.0	COBBLES & BOULDERS IN A LOOSE GREY SILTY SAND MATRIX (FILL)						
3.0	COBBLES AND BOULDERS IN A STIFF BROWN CLAYEY SILT AND SAND MATRIX.		1	2" O.D.	27		
			2	NXL CORE	-	40	100
970.0			3	"	-	70	100
15.0			4	2" O.D.	32		
	HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL AND OCCASIONAL COBBLES AND BOULDERS (CLAYEY TILL)		5	"	23		
			6	"	75		
			7	NXL CORE	-	20	100
			8	2" O.D.	144		
			9	NXL CORE	-	40	100
			10	2" O.D.	124		
			11	"	109		
905.0							
80.0	HARD LAYERED GREY SILTY CLAY AND BROWN CLAYEY SILT, TRACE SAND AND TRACE TO SOME GRAVEL THROUGHOUT		12	"	52		
898.0			13	3" T.P.	Wh		
87.0	HARD RED-GREY CLAYEY SILT AND SAND, SOME GRAVEL (TILL)		14	2" O.D.	156		
893.0			15	NXL CORE		35	100
92.0	DENSE BROWN SAND, OCCASIONAL COBBLES						
888.0							
97.0	VERY DENSE BROWN SANDY SILT WITH SOME CLAYEY SILT LAYERS & OCCASIONAL COBBLES BECOMING WITH DEPTH, HARD BROWN LAYERED CLAYEY SILT WITH SOME SILTY SAND LAYERS & OCCAS. THIN SILT PARTINGS		16	2" O.D.	175/7"		
873.0			17	"	175		
112.0	VERY DENSE BROWN SILT TO SANDY SILT WITH A TRACE TO SOME CLAY, SOME SILTY SAND LAYERS - IRREGULARLY STRATIFIED STRUCTURE WITH SOME GREY LAYERS - OCCASIONAL SHALE AND DOLOMITE GRAVEL - OCCASIONAL GYPSIFEROUS SEAMS		18	"	140/6"		
			19	"	130		
			20	"	147/10"		
838.0							
147.0	VERY LOOSE TO LOOSE BROWN SAND TRACE SILT TO BROWN SAND AND GRAVEL (VERY ANGULAR PARTICLES)		21	"	WR/12"		
829.0			22	"	WR/8"		
156.0	COMPACT TO VERY DENSE BROWN TO GREY SANDY SILT TO SILTY SAND TRACE TO SOME CLAY, SOME GRAVEL (SILTY TILL)				17 65		
822.5			23	"	24		
162.5	SOUND LIGHT GREY FINE TO MEDIUM GRAINED ANHYDRITE BEDROCK WITH OCCASIONAL THIN FRACTURES HEALED WITH GYPSUM - SOME DARK GREY DOLOMITE INCLUSIONS		24	BXL RC	-	100	100
			25	"	-	100	100
			26	"	-	100	90
			27	"	-	100	90
			28	"	-	100	90
			29	"	-	93	90
792.0			30	"	-	86	90
193.0	ANHYDRITE BEDROCK WITH SOLUTION CAVITIES, CAVITIES FILLED WITH BROWN SILTY CLAY TO CLAYEY SILT		31	"	-	30	90
			32	"	-	93	90
			33	"	-	50	90
			34	"	-	35	90
771.0			35	"	-	30	90
214.0	HARD BROWN SILTY CLAY WITH SAND & GRAVEL, SOME SILT ZONES		36	2" O.D.	61		
767.3			37	"	80		
218.7	SOUND LIGHT GREY ANHYDRITE BEDROCK		38	BXL RC	-	68	80
762.5			39	"	-	48	80
222.5	SOFT WHITE GYPSUM		40	AXT RC	-	10	100
758.8							
226.2	SOUND LIGHT GREY FINE GRAINED ANHYDRITE BEDROCK WITH SOME LIMESTONE AND DOLOMITE INCLUSIONS - OCCASIONAL THIN SEAMS OF WHITE SANDSTONE BELOW ABOUT ELEV. 747.		41	"	-	93	100
			42	"	-	100	100
			43	"	-	100	100
			44	"	-	100	100
733.9			45	"	-	100	100
251.1	END OF HOLE						

ELEVATION SCALE: 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720

COEFFICIENT OF PERMEABILITY, (cm./sec.): 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent): W_P W W_L; 10 20 30 40

ADDITIONAL LABORATORY TESTING

WATER LEVEL OBSERVATIONS

NO TAKE
NO TAKE
NO TAKE
NO TAKE
5×10^{-2} cm/sec.
NON PLASTIC
NON PLASTIC
MH
MH
MH
MH

GROUND SURFACE
BENTONITE SLURRY
POLYETHYLENE TUBING
PIEZOMETER
SAND FILL
BENTONITE SEAL
SAND FILL
BLACK TUBING
STANDPIPE
SAND-CEMENT GROUT
SAND FILL
STEEL PIPE
WELLPOINT

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.)
5 0 5 10 20

Golder Associates

DRAWN
CHECKED

RECORD OF BOREHOLE 103

LOCATION See figure 1. BORING DATE MAY 1 - 19, 1970 DATUM LOCAL
SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in. CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD	ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
4" DIA. CASING	985.9 / 0.0	TOP OF DRILLING PLATFORM TIMBERS					
		AIR					
	974.9 / 11.0	TIMBERS IN A SOIL MATRIX					
	965.4 / 20.5	WATER					
ROTARY DRILLING NX CASING	865.4	BOTTOM OF SHAFT					
	120.5	VERY LOOSE SILTY SAND TO SANDY SILT					
	123.0 / 855.4	COMPACT TO DENSE BROWN SAND & SILT WITH SOME GRAVEL, TRACE OF CLAY, TIMBER & OCC. PINE NEEDLES	1	2" D.O.	37		
	130.5 / 847.9	DENSE TO VERY DENSE GREY SANDY SILT TO SILTY SAND, SOME GRAVEL, TRACE TO SOME CLAY (SILTY TILL)	2	"	36		
			3	"	47		
			4	"	56		
			5	"	34		
	138.0	ANGULAR, LIGHTLY CEMENTED SANDSTONE FRAGMENTS IN A SANDY SILT, TR. CLAY MATRIX	6	"	74		
	140.5 / 841.0	VERY SOFT DARK GREY TO BLACK CLAY WITH SOME SILT AND GRAVEL, TRACE OF SAND, OCCASIONAL TIMBERS	7	"	1		
			8	2"S.T.	WR	100%	
	144.9 / 829.4	LOOSE TO COMPACT BROWN TO GREY SANDY SILT TO SILTY SAND AND GRAVEL, TRACE OF CLAY THROUGHOUT. (SILTY TILL)	9	NX, RC	-	50	0
			10	3" T.P.	PM		
			11		PM		
			12	2" D.O.	16		
			13	"	14		
			14	"	22		
			15	"	5		
	156.5	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS, OCCASIONAL SEAMS OF CRYSTALLINE GYPSUM UP TO 1/4 IN. THICK.	16	NX, RC	-	100	
			17	NX, RC	-	100	
			18	NX RC	-	100	
			19	"	-	97	
			20	"	-	20	100
		4 IN. THICK SEAM OF FRACTURED LIMESTONE AT ABOUT ELEV. 810.0, FRACTURES PARTIALLY HEALED WITH CRYSTALLINE GYPSUM.	21	"	-	100	
BX CASING	805.4 / 180.5 / 801.4	FRACTURED ANHYDRITE BEDROCK OR SOFT GYPSUM BEDROCK.	22	"	-	30	
	184.5	VERY LOOSE BROWN SANDY SILT WITH SOME CLAY TO VERY SOFT CLAYEY SILT AND SAND, TRACE TO SOME GRAVEL THROUGHOUT - LOOSE GRAVEL LAYER FROM ELEV. 794.9 TO 793.9	23	"	-	0	0
			24	2" D.O.	WH		
			25	2" S.T.	P.M.		
	791.9		26	2" T.O.	WH		
	194.0	COMPACT TO DENSE BROWN TO GREY SILT WITH SOME SAND, TRACE TO SOME CLAY. GRAVEL LAYER AT ABOUT ELEV. 790	27	2" D.O.	24		
			28	"	220		
	785.9		29	"	49		
			30	"	26		
	200.0 / 780.0	VERY DENSE BROWN TO GREY SILTY SAND, SOME GRAVEL, TRACE CLAY	31	"	66		
			32	"	114		
			33	"	112/9"	72%	
	205.3	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS - SOME GYPSUM SEAMS AND INCLUSIONS. - SOME FULLY HEALED AND PARTIALLY HEALED FRACTURES UP TO 1/8 IN. THICK, FRACTURES HEALED WITH CRYSTALLINE GYPSUM. - SLIGHTLY VUGULAR STRUCTURE WITHIN PARTIALLY HEALED FRACTURES	34	BXT RC	-	88%	
			35	"	-	93	100
			36	"	-	100	
			37	"	-	85	
			38	"	-	100	25
			39	"	-	100	
			40	"	-	84	
			41	"	-	98	0
			42	"	-	100	
			43	"	-	100	
	737.3		44	"	-		
	248.6	END OF HOLE					

COEFFICIENT OF PERMEABILITY, (cm./sec.): 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent): W_P W W_L — 10 20 30 40

ELEVATION SCALE: 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720

MH

PIECE OF METAL RECOVERED FROM ELEV. 847.9

PIECE OF METAL RECOVERED FROM ELEV. 844.4

WOOD FROM ELEV. 842.9 TO 841.0, TIMBER APPARENTLY MOVED INTO HOLE AFTER SA.8 OBTAINED.

NO TAKE

NO TAKE

ADDITIONAL LABORATORY TESTING

WATER LEVEL OBSERVATIONS

STEEL PIPE
BENTONITE SEAL
CAVED MATERIAL
WELLPOINT
CEMENT SEAL
BLACK TUBING
SAND FILL
STANDPIPE
CEMENT SEAL

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.)
5 0 5 10 20

Golder Associates

DRAWN
CHECKED

PROJECT 6912

RECORD OF BOREHOLE 104

LOCATION See figure BORING DATE MAY 28 TO JUNE 6, 1970 DATUM LOCAL
SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in. CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD	ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
	986.9	GROUND SURFACE					
H CASING	0.0	COBBLES AND BOULDERS IN A STIFF TO VERY STIFF BROWN TO GREY CLAYEY SILT AND SAND MATRIX	1	NX CORE	-	42	100
			2	"	-	12	100
			3	2" D.O.	15		
			4	NX CORE	-	42	100
			5	"	-	39	100
	966.9		6	2" D.O.	-	515	100
NX CASING	20.0	HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL, COBBLES AND BOULDERS THROUGHOUT. (CLAYEY TILL)	7	"	90		
			8	"	64		
			9	"	89/8"		
			10	NX CORE	-	10	100
			11	"	-	12	100
			12	2" D.O.	80		
			13	"	100		
			14	"	142		
	904.4		15	"	47		
ROTARY DRILLING BX CASING	82.5	VERY STIFF TO HARD LAYERED GREY SILTY CLAY AND BROWN CLAYEY SILT, OCCASIONAL SILT SEAMS, TRACE TO SOME SAND THROUGHOUT	16	"	39		
	885.0		17	"	27		
	101.9	VERY DENSE BROWN SILT TO SANDY SILT WITH A TRACE TO SOME CLAY AND GRAVEL - OCCASIONAL SAND SEAMS ABOVE ABOUT ELEV. 877, 2 FT. THICK CLAYEY SILT SEAM BETWEEN ABOUT ELEV. 877 AND 875	18	"	58		
			19	"	172/11"		
			20	"	167/11"		
	846.0		21	"	137/11"		
	140.9	VERY DENSE BROWN (BECOMING GREY BELOW ABOUT ELEV. 832) SANDY SILT TO SILTY SAND WITH A TRACE OF CLAY AND SOME GRAVEL. (SILTY TILL)	22	"	126		
	825.4		23	"	18		
BXT CORE	161.5	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME LIMESTONE AND DOLOMITIC INCLUSIONS, SOME GYPSUM INCLUSIONS AND SEAMS - 10 IN. THICK SAND SEAM BETWEEN ELEV. 823.8 AND 822.9	24	BXT RC	-	81	50 / 0
			25	"	-	95	100
			26	"	-	95	100
			27	"	-	89	100 / 70 / 100
			28	"	-	98	100
	798.6		29	"	-	100	100
	188.3	ANHYDRITE BEDROCK WITH CAVITIES, CAVITIES FILLED WITH BROWN SILTY CLAY TO CLAYEY SILT	30	"	-	80	100
	793.3						
	193.6	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME LIMESTONE AND DOLOMITE INCLUSIONS - SOME GYPSUM INCLUSIONS AND LAYERS	31	"	-	95	100
			32	"	-	100	100 / 0
			33	"	-	100	100
	778.1		34	"	-	50	
AX CA.	208.8	HARD RED-BROWN (BECOMING GREY BELOW ABOUT 212 FT. DEPTH) SILTY CLAY TO CLAYEY SILT AND SAND, TRACE TO SOME GRAVEL THROUGHOUT.	35	2" D.O.	41		
			36	"	67		
	771.2		37	"	106/9"		
AXT CORE	215.7	BEDROCK WITH CAVITIES INTACT BEDROCK GENERALLY LIMESTONE OR DOLOMITE CAVITIES FILLED WITH BROWN CLAYEY SILT TO SILTY CLAY, TRACE IRON PYRITE	38	AXT RC	-	88 / 11	100 / 100
			39	"	-		
			40	"	-	23	100 / 0 / 0
	762.0		41	"	-	100	100
	224.9	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS, SOME GYPSUM INCLUSIONS AND LAYERS.	42	"	-	94	
			43	"	-		
			44	"	-	100	
			45	"	-	95	0
			46	"	-	87	
			47	"	-	94	
			48	"	-	88	
			49	"	-	95	
	734.4						
	252.5	END OF HOLE					

COEFFICIENT OF PERMEABILITY, (cm./sec.) — 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent) — W_P W W_L — 10 20 30 40

ELEVATION SCALE: 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730

NO TAKE

NO TAKE

WATER LEVEL OBSERVATIONS

GROUND SURFACE
SAND FILL
BENTONITE SEAL
POLYETHYLENE TUBING
STANDPIPE 'B'
CAVED MATERIAL
CONCRETE SEAL
STEEL PIPE
SAND FILL
STANDPIPE 'A'

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.)
5 0 5 10 20

Golder Associates

DRAWN M.W.

PROJECT 69126

RECORD OF BOREHOLE 201

LOCATION See figure BORING DATE MAY 21 TO 28, 1970 DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in. CASING HAMMER WEIGHT 350 lb., DROP 20 in.

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
1009.2	GROUND SURFACE					
0.0	VERY STIFF BROWN CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL COBBLES & BOULDERS	1	2" O.D.	29		
992.2		2	"	99		
17.0	HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL, OCCASIONAL COBBLES & BOULDERS (CLAYEY TILL)	3	"	105		
		4	"	90		
960.2						
49.0	VERY DENSE GREY SAND WITH SOME SILT AND A TRACE OF GRAVEL	5	"	84		
948.2		6	"	109		
61.0	HARD GREY CLAYEY SILT AND SAND WITH SOME GRAVEL, OCC. COBBLES AND BOULDERS (CLAYEY TILL)	7	"	120		
		8	"	65/7"		
925.2		9	"	104		
84.0	VERY DENSE GREY SAND, SOME SILT	10	"	121		
86.5	COBBLES AND BOULDERS IN A REDDISH BROWN CLAYEY SILT MATRIX	11	NX CORE	190/8"	5	100
919.2		12	2" D.O.	151/8"		
90.0	HARD RED-BROWN TO RED-GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME COBBLES AND BOULDERS THROUGHOUT.	13	"	100/5"		
		16	"	105/8"		
910.3		17	"	137		
99.1	VERY DENSE BROWN SAND AND GRAVEL.	18	"	146/8"		
		19	"	180/9"		
	HARD GREY SILTY CLAY TO CLAYEY SILT AND SAND WITH SOME GRAVEL AND COBBLES, OCCASIONAL BOULDERS THROUGHOUT (CLAYEY TILL)	20	"	144		
		21	"	160		
885.2		22	"	25		
124.0		23	NX CORE	–	85	100
		24	2" D.O.	103/2"		
	VERY DENSE GREY TO BROWN SILTY SAND TO SANDY SILT WITH A TRACE TO SOME CLAY AND GRAVEL (SILTY TILL)	25	"	100/4"		
		26	"	100/5"		
		27	"	160/8"		
		28	"	185/8"		
		29	"	109/10"		
		30	"	100/8"		
		31	"	174/8"		
		32	1¾" D.O.	117		
		33	"	100/5"		
837.2	SANDY SILT (SLURRY LIKE CONSISTANCY)	34	"	74		
172.5	DENSE TO VERY DENSE SANDY SILT &	35	"	56		
833.2	GRAVEL WITH A TRACE OF CLAY					
176.0	VERY LOOSE SILTY SAND TO SANDY SILT	49	S.T.	–		
829.4	WITH A TRACE TO SOME CLAY & GRAVEL					
179.8		36	DO ST	26		
	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS – OCCASIONAL HEALED FRACTURES FILLED WITH GYPSUM, OCCASIONAL GYPSUM INCLUSIONS	37	AXT RC	–	87	100
		38	"	–	100	100
		39	"	–	100	100
		40	"	–	100	100
		41	"	–	100	100
		42	"	–	100	100
		43	"	–	100	100
		44	"	–	100	100
787.7						
221.5	LIMESTONE & GRANITE COBBLES IN A	45	"	–	60	100
784.2	SILTY SAND & GRAVEL, TRACE CLAY MATRIX	48			60	5
225.5	END OF HOLE					
	GREY SILTY CLAY					

NOTE: SAMPLES 48 AND 49 WERE TAKEN DURING WITHDRAWL OF AX CASING FOLLOWING COMPLETION OF BOREHOLE.

BORING METHOD: H CASING; NX CASING; ROTARY DRILLING; BX CASING; AX CASING; AXT CORE

COEFFICIENT OF PERMEABILITY, (cm./sec.): 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent): W_p W W_L; 10 20 30 40

ELEVATION SCALE: 1010, 1000, 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770

ADDITIONAL LABORATORY TESTING: MH; MH; NO TAKE; MH; MH; MH; MH; MH; MH; MH

NOTES:
1. WHILE DRILLING NX CASING FROM ELEV. 925.2 TO 924.3 PIECES OF WOOD AND PINE NEEDLES WERE OBSERVED IN WASH.
2. DURING LABORATORY TESTING OF SAMPLE 10 SEVERAL SMALL PIECES OF METAL DISCOVERED.
3. SMALL PIECES OF METAL WERE OBSERVED IN SAMPLE 12.
4. WHILE TRICONING FROM ELEV. 914.0 TO 911.7 SMALL PIECES OF METAL AND WOOD CHIPS OBSERVED IN WASH.
5. METAL IN SAMPLE 10 WAS RETAINED ON THE #20 MESH SIEVE. THE METAL WAS MAGNETIC.

$I = 5\times10^{-8}$ cm./sec.

WATER LEVEL OBSERVATIONS: GROUND SURFACE; SURFACE SEAL; SAND FILL; POLYETHYLENE TUBING; STANDPIPE; CAVED MATERIAL; BENTONITE SEAL; BLACK TUBING; STANDPIPE

LOST WATER RETURN

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.) 5 0 5 10 20

Golder Associates

DRAWN M.W.

PROJECT 6912

RECORD OF BOREHOLE 202

LOCATION See figure 1 BORING DATE JUNE 11 - 21, 1970 DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD	ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN	ELEVATION SCALE	COEFFICIENT OF PERMEABILITY, (cm./sec.)	WATER CONTENT (percent)	ADDITIONAL LABORATORY TESTING	WATER LEVEL OBSERVATIONS
	1003.6 / 0.0	GROUND SURFACE							1010	1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}	W_P W W_L 10 20 30 40		GROUND SURFACE
10" Ø		PROBABLY HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND, SOME GRAVEL AND COBBLES, OCC. BOULDERS THROUGHOUT (CLAYEY TILL)							1000				SAND FILL
6 IN. DIA. TRICONE									990				
									980				
									970				
									960				
									950				
									940				
									930				
									920				
									910				POLYETHYLENE TUBING
									900				
									890				
	879±								880				
ROTARY DRILLING	125± / 874±	SEE "SPECIAL NOTES"		1	W.S.	–							
	130± / 864±	PROBABLY HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND, SOME GRAVEL & COBBLES (CLAYEY TILL)							870				
	140±	PROBABLY VERY DENSE GREY SANDY SILT BECOMING SILTY SAND WITH DEPTH, SOME GRAVEL AND OCCASIONAL COBBLES THROUGHOUT (SILTY TILL)		2	C.S.	–			860				
				3	W.S.	–			850				BENTONITE SEAL
	829.6								840				
	174.0	PROBABLY LIGHT GREY ANHYDRITE BEDROCK							830				PIEZOMETER
	819.7			4	" BXT RC	–	100		820				BENTONITE SEAL
BX CORE	183.9	SOUND GREY ANHYDRITE BEDROCK WITH SEAMS OF WHITE GYPSUM THROUGHOUT, OCCASIONAL THIN CLAY FILLED FRACTURES BETWEEN ABOUT ELEVATION 808 AND 803.		6	"	–	98		810				
				7	"	–	98						
					"	–	100	100					
				9	"	–	95		800				
				10	"	–	98						
				11	"	–	100						SAND FILL
	791.3												
	212.3	ANHYDRITE BEDROCK WITH CAVITIES,		12	"	–	92	50	790				
	786.4	CAVITIES FILLED WITH SILTY CLAY		13	2"DO	28/3"	100	0					
	217.2			14	2"DO	26/3"	0	100					BLACK TUBING
AX CASING		SEE * STRATIGRAPHY NOTES"		15	BXT								
				16	2"DO	26/3"							
				17	AXT RC	WR	C 70 0	0	100 780				
				18	1⅛"DO	W.H.							
				19	"	24							
				20	AXT RC	–	80	70					
				21	1⅛"DO	17							
				22	"	35							
				23	"	9/6"							
				24	1⅛"ST	W.H.							
	765.4			25	1⅛"DO	42							
	238.2	SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME WHITE GYPSUM INCLUSIONS.		26		18							
	760.1			27	AXT RC	–	100						
	243.5	END OF HOLE		28	"	–	100	100	760				STANDPIPE
AXT CORE		NOTE: BORING ADVANCED TO ELEVATION 819.7 USING DIRECT CIRCULATION ROTARY DRILLRIG SUPPLIED AND OPERATED BY W.L. BOWMASTER WELL DRILLING LTD.. NO REPRESENTATIVE SAMPLES WERE OBTAINED ABOVE ELEVATION 819.7. SOIL DESCRIPTIONS GIVEN ARE INFERRED FROM DRILL WATER RETURN AND FROM ADJACENT SAMPLED BORINGS.							750				

SPECIAL NOTES:
1. DRILLING PRESSURE INCREASED AT ABOUT ELEV. 879. — M
2. SAMPLE 1 CONTAINED WOOD FRAGMENTS & PINE NEEDLES AND ONE PINE CONE. ← WOOD CARBON DATED AT 18,000 YEARS OLD.
3. DRILLING PRESSURE DECREASED BETWEEN ABOUT ELEV. 879 AND 874. LOST 50% OF DRILL WATER RETURN. PINE NEEDLES COULD HAVE BEEN INTRODUCED INTO BOREHOLE WITH DRILL WATER PUMPED FROM EXISTING SHAFT. — M

NOTES;
1. SAMPLE 2 CONTAINED WOOD FRAGMENTS AND ONE ANGULAR PIECE OF METAL.
2. SAMPLE 3 CONTAINED PINE NEEDLES AND WOOD FRAGMENTS. SAMPLE 2 OBTAINED FROM INSIDE OF DRILL RODS WHEN RODS REMOVED FROM HOLE TO CLEAR BLOCKAGE. — M
3. SAMPLE 4 CONTAINED PINE NEEDLES AND WOOD FRAGMENTS — M

STRATIGRAPHY NOTES;
ELEV. 786.4 TO 785.8 – COMPACT BROWN SILTY SAND WITH SOME GRAVEL — MH
ELEV. 785.8 TO 784.6 – GYPSUM — MH
ELEV. 784.6 TO 783.8 – STIFF TO HARD BROWN CLAY — MH
ELEV. 783.8 TO 782.7 – GYPSUM — MH
ELEV. 782.7 TO 782.1 – VERY LOOSE SILT
ELEV. 782.1 TO 777.8 – FIRM TO STIFF GREY TO BROWN CLAY
ELEV. 777.8 TO 777.3 – VERY LOOSE SILTS
ELEV. 777.8 TO 776.4 – GYPSUM
ELEV. 776.4 TO 773.6 – FIRM TO STIFF BROWN CLAY WITH SOME GRAVEL
ELEV. 773.6 TO 768.1 – VERY LOOSE TO LOOSE GREY SANDY SILT WITH SOME GYPSUM COBBLES
ELEV. 768.1 TO 765.4 – DENSE GREY SANDY SILT TO SILTY SAND WITH SOME GRAVEL, TRACE OF CLAY THROUGHOUT

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.)
5 0 5 10 20

Golder Associates

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PROJECT 6912

RECORD OF BOREHOLE 203

LOCATION See figure 1 BORING DATE JUNE 12 - 16, 1970 DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in. CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD: ROTARY DRILLING; 6 IN. DIA. TRICONE; NX CASING; 3" TRICONE

ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
1003.5 / 0.0	GROUND SURFACE						
	PROBABLY HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND WITH SOME GRAVEL, COBBLES AND BOULDERS THROUGHOUT (CLAYEY TILL)		1	WS	—		
893.0 / 110.5	HARD GREY CLAYEY SILT WITH SAND AND SOME GRAVEL, OCC. BLACK SILTY CLAY POCKETS AND FINE SAND SEAMS THROUGHOUT		2	8" D.O.	34		
113.6	DENSE GREY SILT, TRACE OF CLAY						
116.0 / 883.0	HARD DARK GREY TO BLACK CLAYEY SILT WITH SAND AND SOME GRAVEL, OCC. SMALL BLACK SILTY CLAY POCKETS		3	"	35		
120.5 / 877.5	VERY LOOSE GREY SAND WITH SOME SILT AND GRAVEL (SLURRY LIKE CONSISTENCY)		4	S.T.	WR		
126.0			5	2" D.O.	WH		
			6	T.P.	WR		
	LOOSE GREY SAND WITH SOME SILT TO SILTY SAND, TRACE OF CLAY AND SOME GRAVEL THROUGHOUT		7	2" D.O.	5		
			8	"	6		
			9	"	7		
865.0 / 138.5			10	"	9		
	COMPACT (BECOMING VERY DENSE WITH DEPTH) GREY SANDY SILT TO SILTY SAND, TRACE OF CLAY SOME GRAVEL AND OCC. COBBLES THROUGHOUT. (SILTY TILL)		11	"	15		
851.0 / 1525	END OF HOLE		12	"	89		

NOTE: BORING ADVANCED TO ELEVATION 893.0 USING DIRECT CIRCULATION ROTARY DRILLRIG SUPPLIED AND OPERATED BY W.L. BOWMASTER WELL DRILLING LTD.. NO REPRESENTATIVE SAMPLES WERE OBTAINED ABOVE ELEV. 893. SOIL DESCRIPTIONS GIVEN ARE INFERRED FROM DRILL WATER RETURN AND FROM ADJACENT SAMPLED BORINGS.

ELEVATION SCALE: 1010, 1000, 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840

COEFFICIENT OF PERMEABILITY, (cm./sec.): 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent): W_P W W_L; 10 20 30 40

ADDITIONAL LABORATORY TESTING: MH MH MH MH

WATER LEVEL OBSERVATIONS: GROUND SURFACE; SAND FILL; POLYETHYLENE TUBING; CAVED MATERIAL; BENTONITE SEAL; PIEZOMETER

FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT.) 5 0 5 10 20

Golder Associates

DRAWN

RECORD OF BOREHOLE 204

LOCATION See figure 1 BORING DATE JUNE 12 - 25, 1970 DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 lb., DROP 30 in CASING HAMMER WEIGHT 350 lb., DROP 20 in.

BORING METHOD	ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS / FOOT	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN
6 IN. DIA. TRICONE AND CASING	1008.8 / 0.0	GROUND SURFACE						
		PROBABLY HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND SOME GRAVEL, COBBLES AND OCC. BOULDERS THROUGHOUT (CLAYEY TILL)						
ROTARY DRILLING 6 IN. DIA.	884 ± / 125 ±	PROBABLY VERY DENSE SANDY SILT TO SILTY SAND (SILTY TILL)		1	M.S.	–		
	810.8 / 198.0	PROBABLY SOUND ANHYDRITE BEDROCK		3	"	–		
	797.8 / 211.0	PROBABLE CAVITY						
BX CASING	213.0 / 791.8	PROBABLY STIFF SILTY CLAY		4	2" O.D.	44		
	217.0	HARD LIGHT BROWN, OCCAS. STRATIFIED, SILTY CLAY WITH A TRACE OF SAND		5	"	36		
				6	"	34		
	783.6			7	"	40		
	781.3	ANHYDRITE BEDROCK WITH CAVITIES		8	"	99/8"		
		BROWN SILTY CLAY, SOME SAND, GRAVEL		9	BXL CORE	–	28	100
	228.4	VERY DENSE LIGHT GREY TO BROWN SANDY SILT TO SILTY SAND, TRACE TO SOME GRAVEL THROUGHOUT		10	2" O.D.	67		
				11	"	78		
	773.3			12	"	100/10"		
	235.5	ANHYDRITE BEDROCK WITH CAVITIES		13	"	35		
AXT CORE	237.8	SOUND LIGHT GREY ANHYDRITE		14	AXT RC	–	90	100
	766.2	BEDROCK, SOME GYPSUM INCLUSIONS			"	–	100	
	242.6	END OF HOLE						

NOTE: BORING ADVANCED TO ELEVATION 796 USING DIRECT CIRCULATION ROTARY DRILLRIG SUPPLIED AND OPERATED BY W.L. BOWMASTER WELL DRILLING LTD.. NO REPRESENTATIVE SAMPLES WERE OBTAINED ABOVE ELEV. 796. SOIL DESCRIPTIONS GIVEN ARE INFERRED FROM DRILL WATER RETURN AND FROM ADJACENT SAMPLED BORINGS.

ELEVATION SCALE: 1010, 1000, 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760

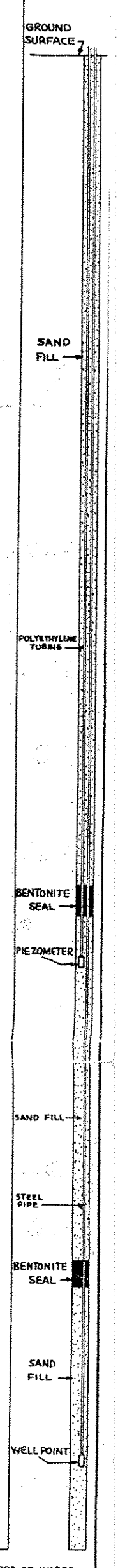
COEFFICIENT OF PERMEABILITY, (cm./sec.): 1×10^{-3} 1×10^{-4} 1×10^{-5} 1×10^{-6}

WATER CONTENT (percent): W_p W W_L; 10 20 30 40

ADDITIONAL LABORATORY TESTING

WATER LEVEL OBSERVATIONS

SPECIAL NOTES:
1. HOLE DRILLED TO ELEV. 797.8, DURING CLEARING, RODS DROPPED TO ELEV. 795.8. LOST WATER RETURN. PUMPED IN 1,200 GAL. AND BENTONITE. NO RETURN.
2. BX CASING DROPPED DURING INSTALLATION, SANK FROM ELEV. 795.8 TO 791.8.



FOR RECORD OF WATER LEVELS SEE APPENDIX V

VERTICAL SCALE (FT)
5 0 5 10 20

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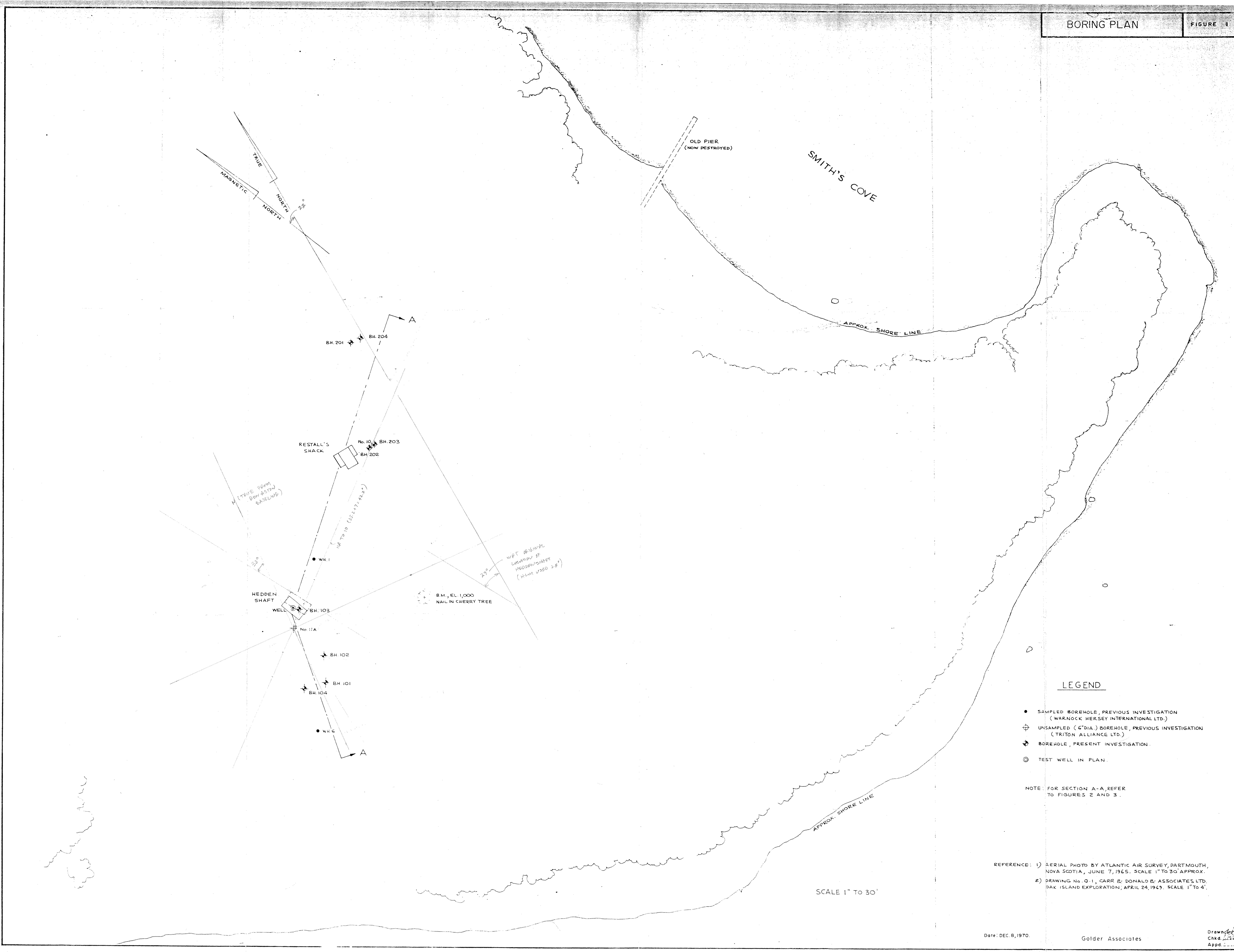
BORING PLAN

FIGURE 1



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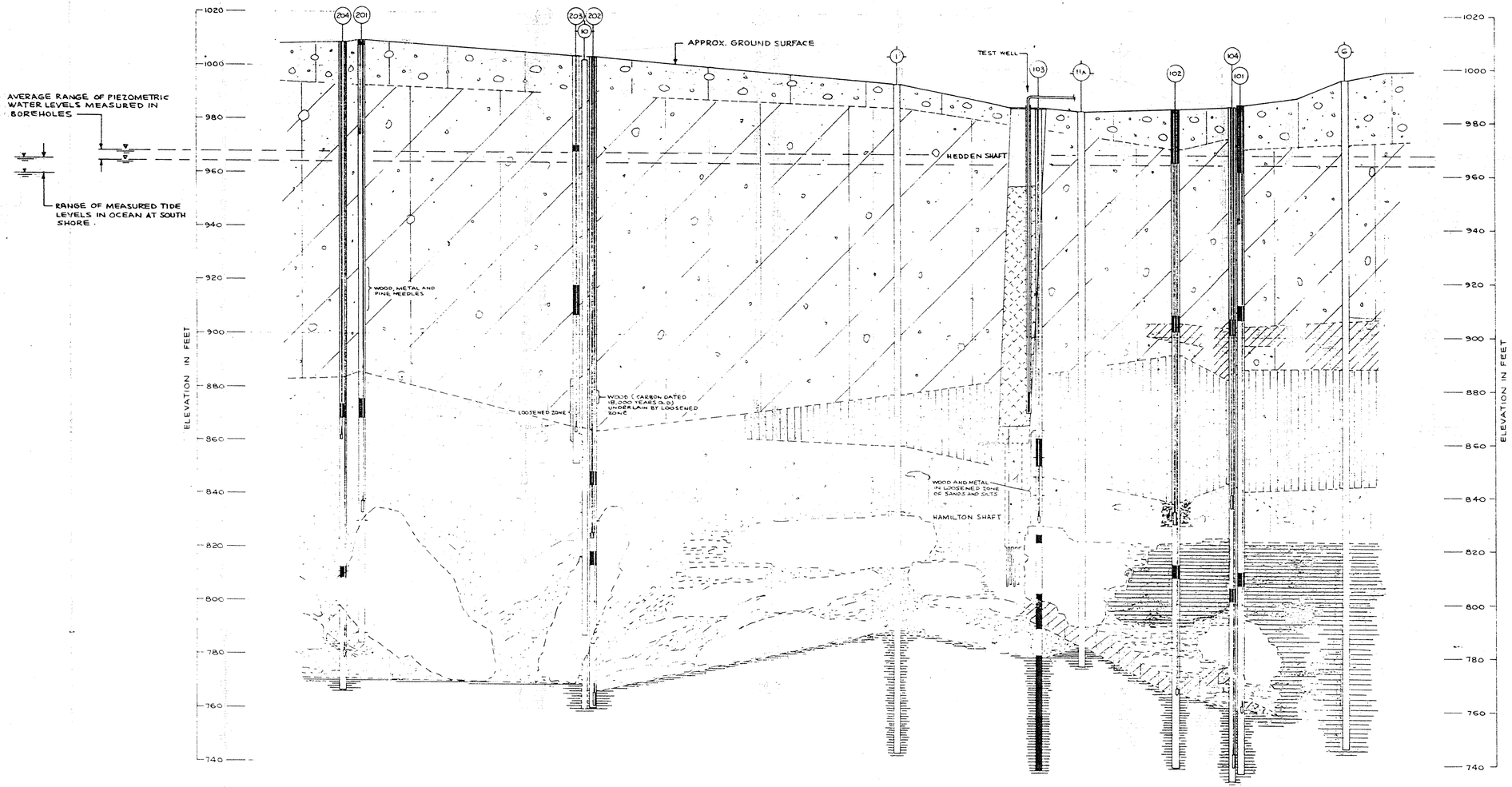
ILLUSTRATIVE SECTION "BOULDER THEORY"

FIGURE 2



SCHEMATIC SECTION A-A

SCALE 1" TO 20'

LEGEND

201 — BOREHOLE IN ELEVATION, PRESENT INVESTIGATION

STANDPIPE, PIEZOMETER OR WELL POINT INSTALLATION

BENTONITE SEAL

11A — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION

STRATIGRAPHY

HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND, SOME GRAVEL, OCCASIONAL COBBLES AND BOULDERS THROUGHOUT (NUMEROUS COBBLES AND BOULDERS IN UPPER 10 TO 20 FT.) OCCASIONAL SAND TO SILTY SAND LAYERS (CLAYEY TILL)

VERY STIFF TO HARD GREY TO BROWN LAYERED SILTY CLAY TO LAYERED CLAYEY SILT AND SILTY CLAY, TRACE TO SOME SAND AND GRAVEL

VERY DENSE GREY TO BROWN SILT TO SANDY SILT WITH A TRACE TO SOME CLAY, SOME LAYERS AND ZONES OF CLAYEY SILT, SILTY SAND AND SAND, OCCASIONALLY FAINTLY STRATIFIED STRUCTURE

GENERALLY VERY DENSE (SOME DISTURBED ZONES, PARTICULARLY NEAR PREVIOUS WORKINGS) BROWN TO GREY SANDY SILT TO SILTY SAND WITH A TRACE TO SOME CLAY AND SOME GRAVEL (SILTY TILL)

VERY LOOSE TO LOOSE BROWN SAND TO SAND AND GRAVEL (ANGULAR PARTICLES)

ANHYDRITE BOULDERS OR SLABS (DERIVED FROM AND SIMILAR TO THE UNDERLYING BEDROCK)

SOFT TO HARD BROWN TO GREY SILTY CLAY TO CLAYEY SILT AND SAND, SOME SAND AND GRAVEL INCLUSIONS (MATRIX MATERIAL) *

VERY LOOSE (SLURRY LIKE CONSISTENCY) TO DENSE BROWN TO GREY SILT TO SILTY SAND, SOME GRAVEL AND A TRACE OF CLAY (MATRIX MATERIAL) *

SOUND, GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS, OCCASIONAL FRACTURES AND CAVITIES FILLED WITH CRYSTALLIZED GYPSUM.

* NOTE: THIS MATERIAL PROBABLY REPRESENTS THE LOWER PORTION OF THE SILTY TILL WHICH HAS BEEN RE-WORKED AND RE-DEPOSITED (PROBABLY THROUGH WATER) BETWEEN THE SLABS. MATERIAL BENEATH FULLY SUPPORTED ROCK SLABS HAS NOT BEEN CONSOLIDATED BY WEIGHT OF OVERLYING SOIL AND GLACIAL ICE.

NOTE: FOR LOCATION OF SECTION A-A, REFER TO FIGURE 1.

NOTE

Data concerning the various strata have been obtained at borehole locations only. The soil stratigraphy between the boreholes has been inferred from geological evidence and so may vary from that shown.

For detailed stratigraphy at each borehole location refer to the record of borehole sheets.

Date DEC. 10, 1970.

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Appd.

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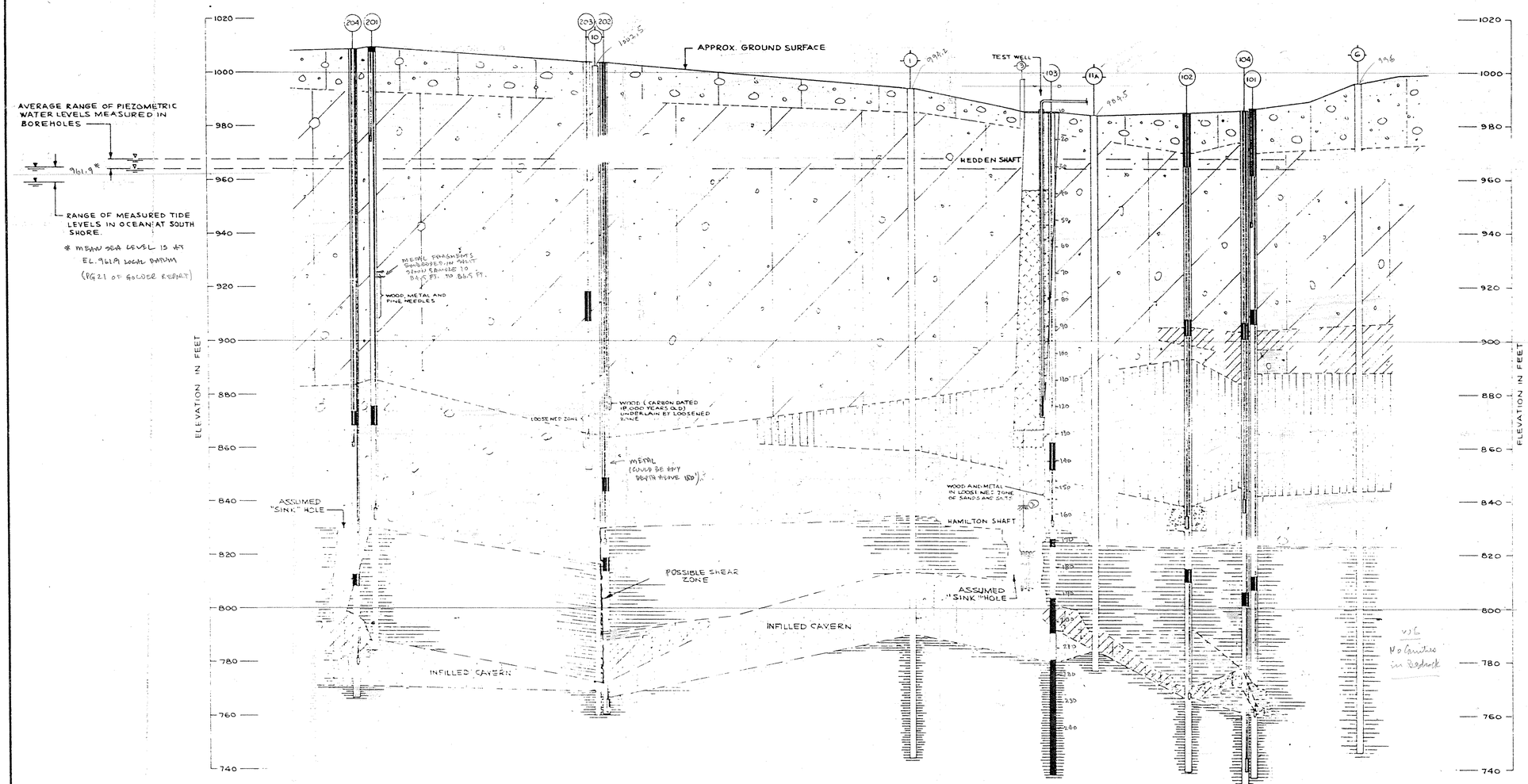
ILLUSTRATIVE SECTION "BEDROCK THEORY"

FIGURE 3



SCHEMATIC SECTION A-A

SCALE 1" TO 20'

LEGEND

101 BOREHOLE IN ELEVATION, PRESENT INVESTIGATION

STANDPIPE, PIEZOMETER OR WELL POINT INSTALLATION

BENTONITE SEAL

11A BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION

STRATIGRAPHY

HARD GREY CLAYEY SILT TO CLAYEY SILT AND SAND, SOME GRAVEL, OCCASIONAL COBBLES & BOULDERS THROUGHOUT (NUMEROUS COBBLES & BOULDERS IN UPPER 10 TO 20 FT.) OCCASIONAL SAND TO SILTY SAND LAYERS. (CLAYEY TILL)

VERY STIFF TO HARD GREY TO BROWN LAYERED SILTY CLAY TO LAYERED CLAYEY SILT AND SILTY CLAY, TRACE TO SOME SAND AND GRAVEL

VERY DENSE GREY TO BROWN SILT TO SANDY SILT, TRACE TO SOME CLAY, SOME LAYERS AND ZONES OF CLAYEY SILT, SILTY SAND AND SAND, OCCASIONALLY FAINTLY STRATIFIED STRUCTURE

GENERALLY VERY DENSE (SOME DISTURBED ZONES, PARTICULARLY NEAR PREVIOUS WORKINGS) BROWN TO GREY SANDY SILT TO SILTY SAND WITH A TRACE TO SOME CLAY AND SOME GRAVEL (SILTY TILL)

VERY LOOSE TO LOOSE BROWN SAND TO SAND AND GRAVEL (ANGULAR PARTICLES)

SOUND LIGHT GREY ANHYDRITE BEDROCK WITH SOME DOLOMITE AND LIMESTONE INCLUSIONS, OCCASIONAL FRACTURES AND CAVITIES FILLED WITH CRYSTALLIZED GYPSUM

ANHYDRITE BEDROCK WITH CAVITIES, CAVITIES FILLED WITH HARD SILTY CLAY TO CLAYEY SILT OR DENSE SAND AND SILT

SOFT TO HARD BROWN TO GREY SILTY CLAY TO CLAYEY SILT AND SAND, SOME SAND AND GRAVEL INCLUSIONS (CAVERN INFILL MATERIAL)

VERY LOOSE (SLURRY LIKE CONSISTENCY) TO DENSE BROWN TO GREY SILT TO SILTY SAND, SOME GRAVEL AND A TRACE OF CLAY (CAVERN INFILL MATERIAL)

NOTE: FOR LOCATION OF SECTION A-A, REFER TO FIGURE 1.

NOTE

Data concerning the various strata have been obtained at borehole locations only. The soil stratigraphy between the boreholes has been inferred from geological criteria and as may vary from that shown.

For detailed stratigraphy at each borehole location refer to the records of borehole sheets.

Date DEC. 10, 1970.

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Drawn
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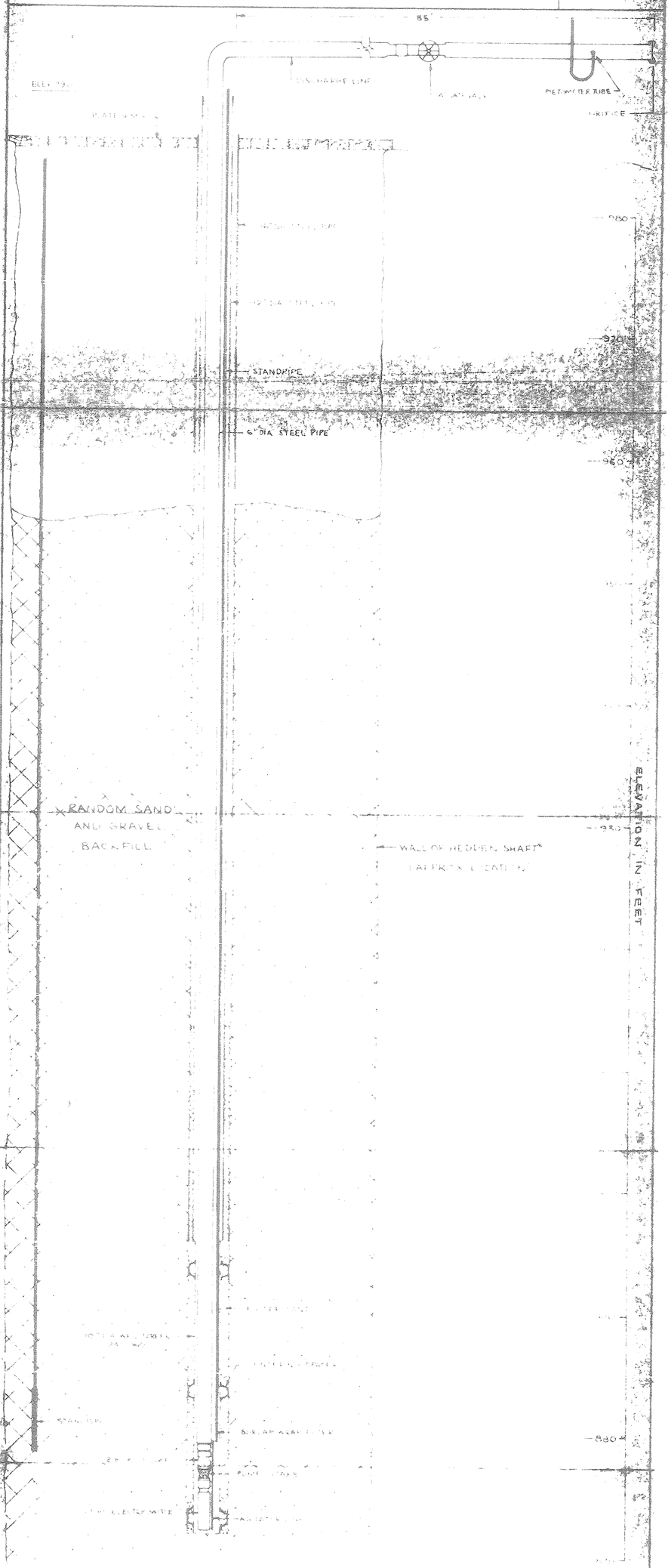
Appd.

DETAILS OF TEST WELL INSTALLATION

FIGURE 4



SCALE
HORIZONTAL 1" TO 2'
VERTICAL 1" TO 5'

DRAWN
CHK'D
APP'D

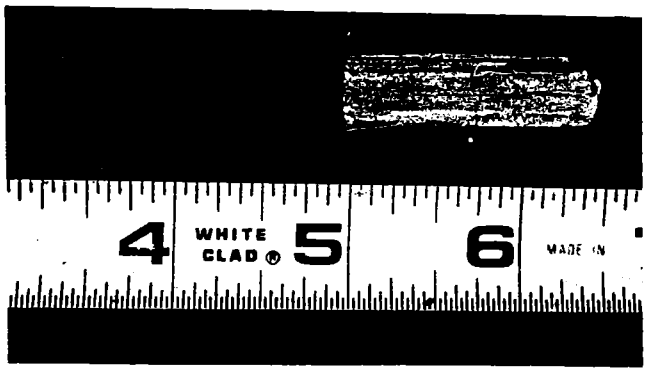
PHOTOGRAPH OF METAL FRAGMENTS
BOREHOLE 201, SAMPLE 10, DEPTH 84.5 to 86.5 FT.

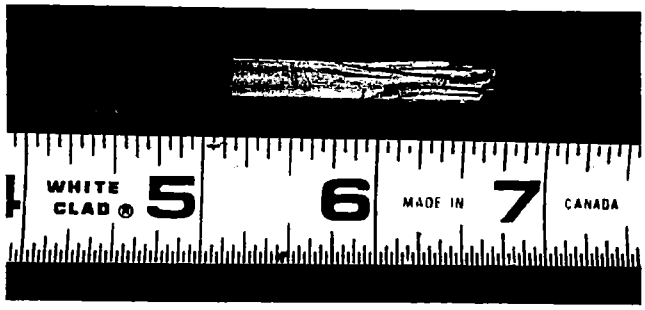
FIGURE 5

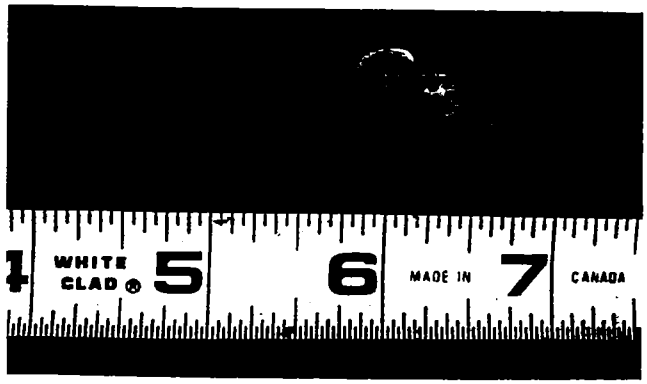
Golder Associates

PHOTOGRAPH OF WOOD SAMPLE
BOREHOLE 202, SAMPLE 1, DEPTH 125FT.

FIGURE 6





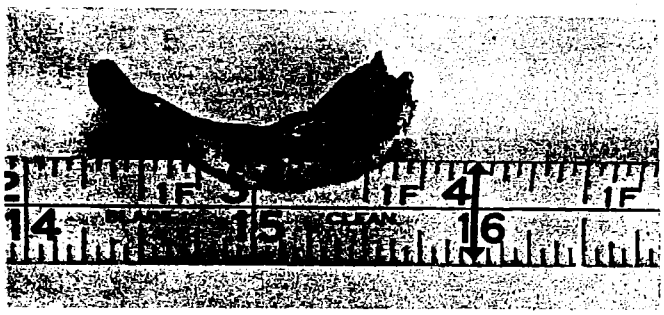


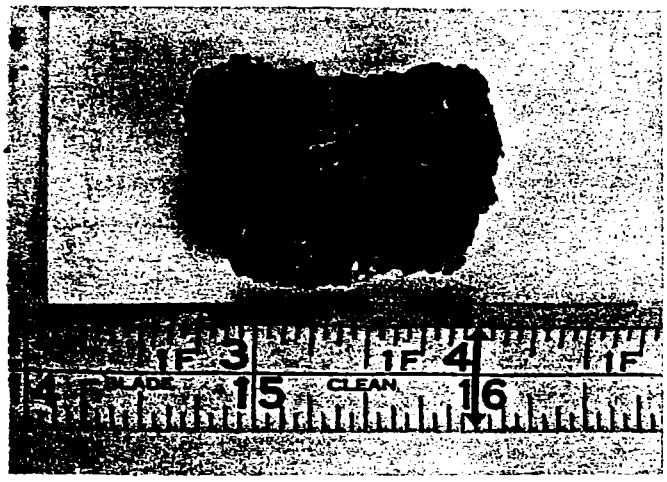
PHOTOGRAPH OF METAL FRAGMENT
BOREHOLE 202, SAMPLE 2, DEPTH 150FT.

FIGURE 7

PHOTOGRAPH OF METAL FRAGMENT
BOREHOLE 103, SAMPLE 6, DEPTH 138FT.

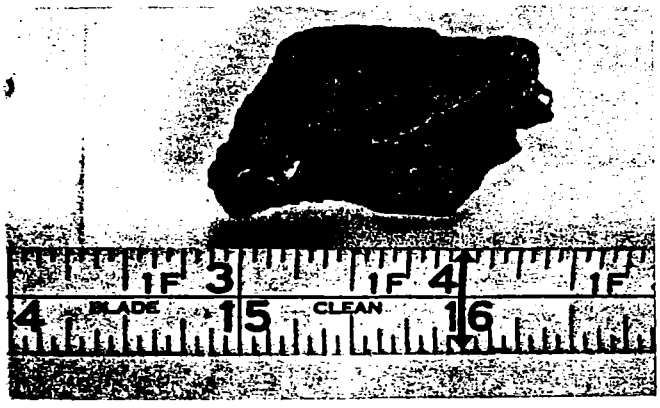
FIGURE 8





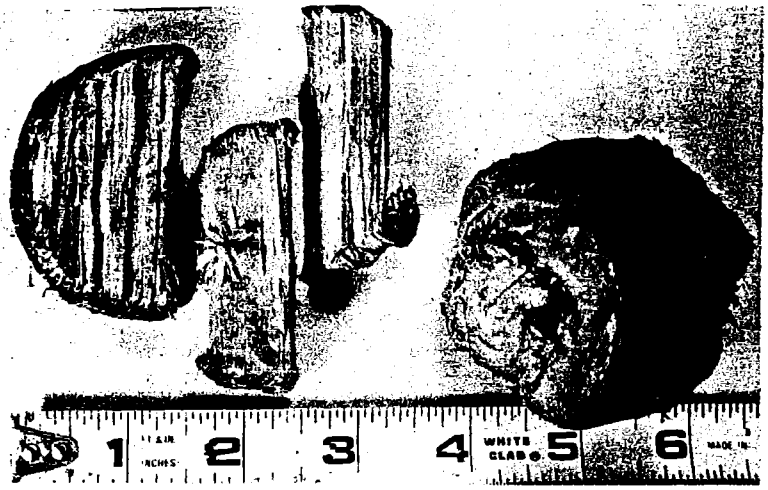
PHOTOGRAPH OF METAL FRAGMENT
BOREHOLE 103, SAMPLE 7, DEPTH 141.5FT.

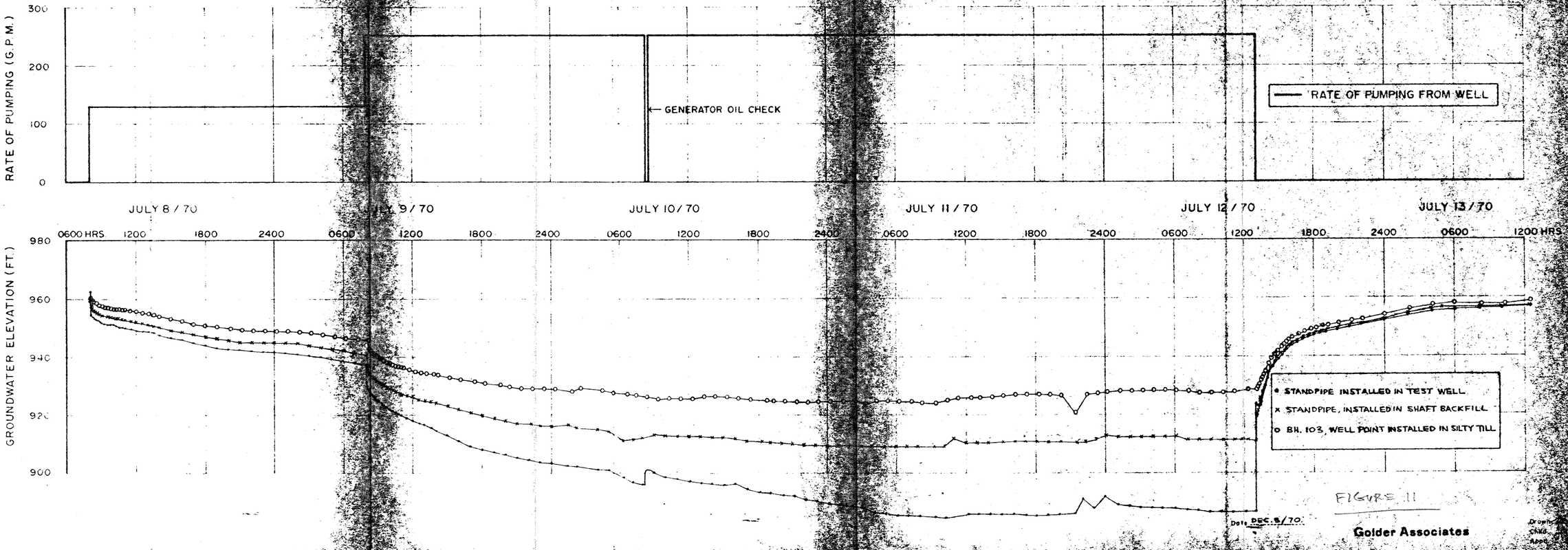
FIGURE 9



PHOTOGRAPH OF WOOD CORE
BOREHOLE 103, SAMPLE 9, DEPTH 143.0 to 144.9FT.

FIGURE 10




RATE OF DRAWDOWN CURVES
RATE OF PUMPING (G.P.M.)
300
200
100
0
RATE OF PUMPING FROM WELL
← GENERATOR OIL CHECK
JULY 8 / 70
JULY 9 / 70
JULY 10 / 70
JULY 11 / 70
JULY 12 / 70
JULY 13 / 70
0600 HRS
1200
1800
2400
0600
1200
1800
2400
0600
1200
1800
2400
0600
1200
1800
2400
0600
1200
1800
2400
0600
1200 HRS
GROUNDWATER ELEVATION (FT.)
980
960
940
920
900
• STANDPIPE INSTALLED IN TEST WELL
x STANDPIPE, INSTALLED IN SHAFT BACKFILL
o BH. 103, WELL POINT INSTALLED IN SILTY TILL
FIGURE 11
Date DEC. 8 / 70
Golder Associates

RESULTS OF PUMPING TEST
RATE OF DRAWDOWN CURVES

FIGURE 12

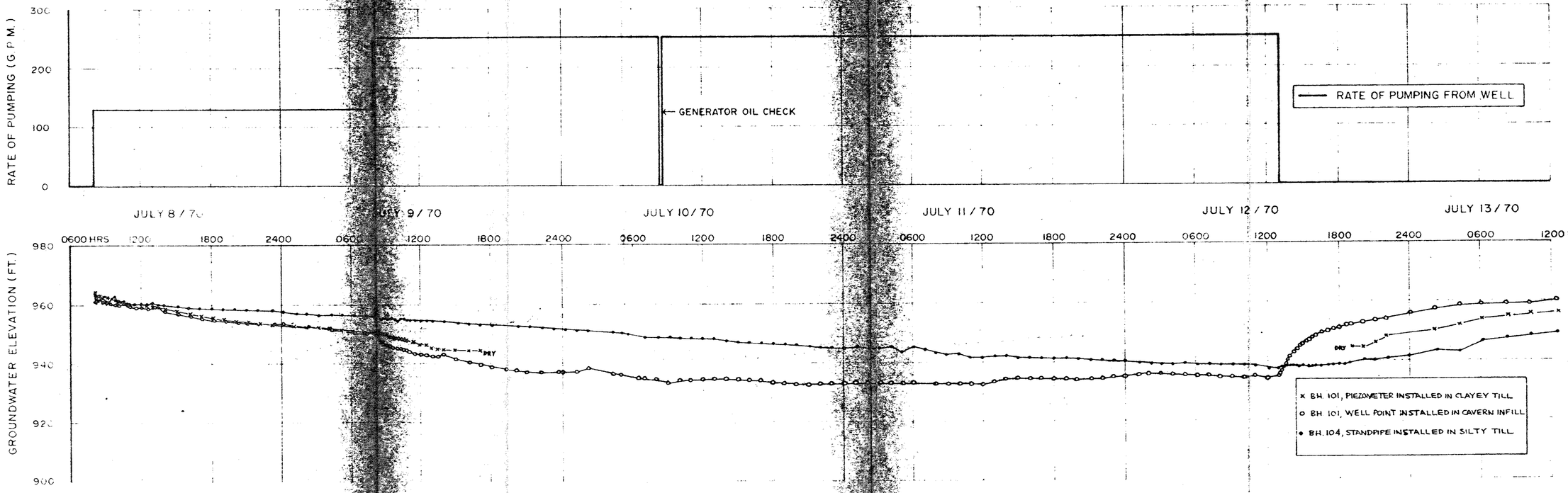


FIGURE 12

Date DEC. 3/70

Golder Associates

Drawn
Chkd.
Appd.

RESULTS OF PUMPING TEST
RATE OF DRAWDOWN CURVES

FIGURE 13

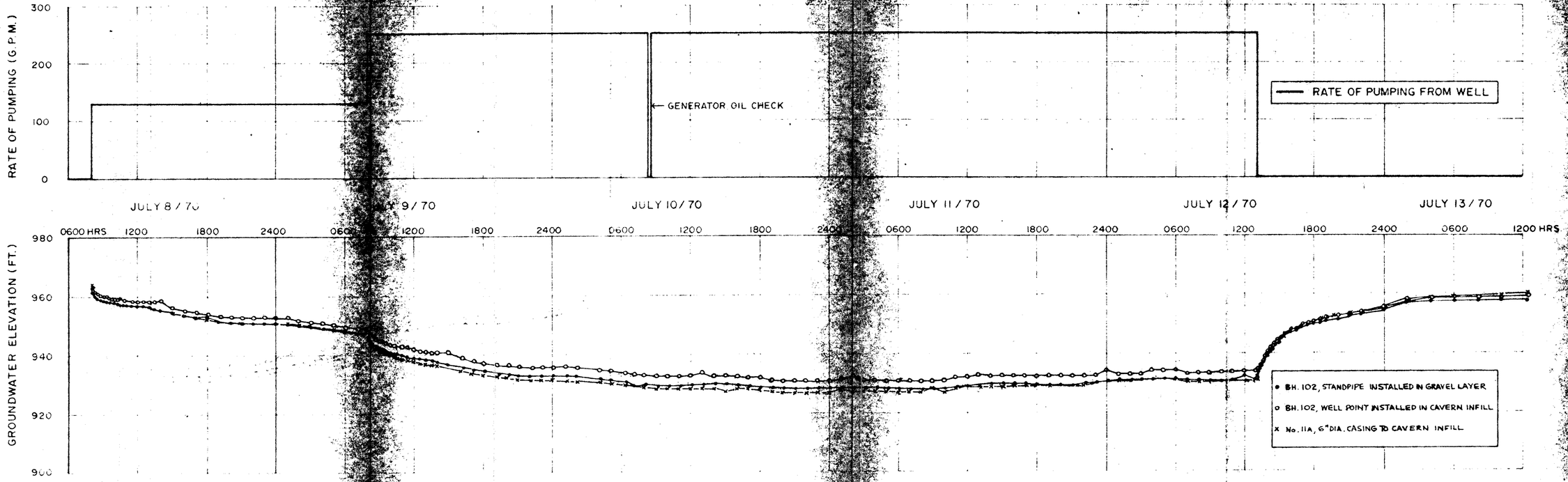


FIGURE 13

Date DEC. 3/70

Golder Associates

Drawn
Chkd.
Appd.

RESULTS OF PUMPING TEST.
RATE OF DRAWDOWN CURVES

FIGURE 14

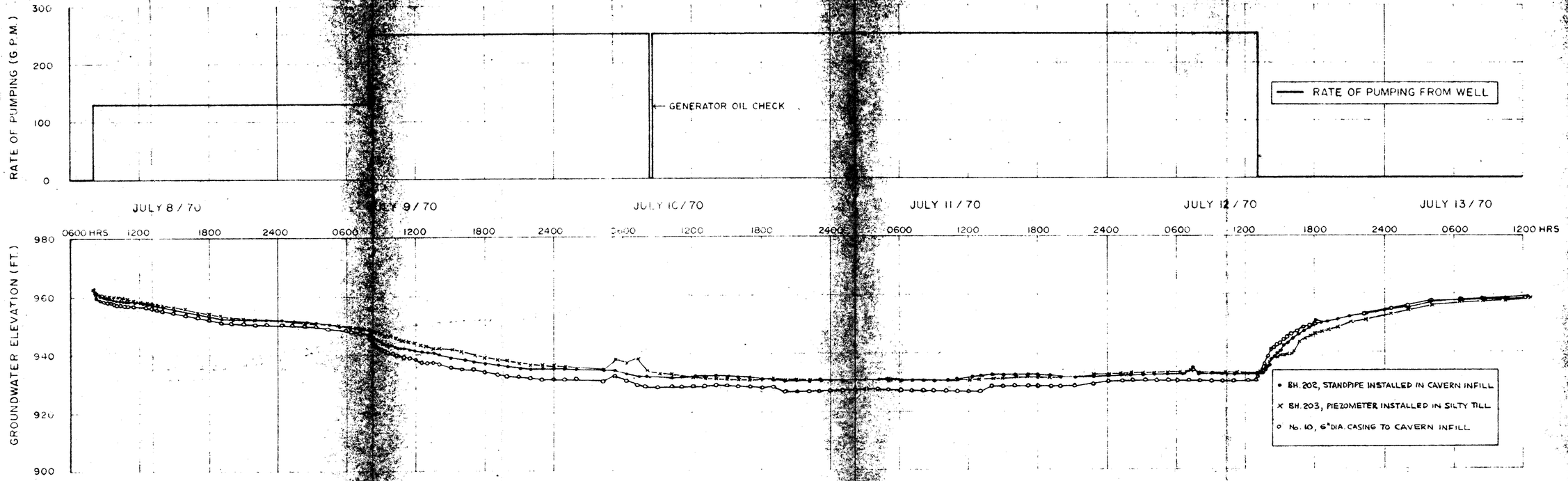


FIGURE 14

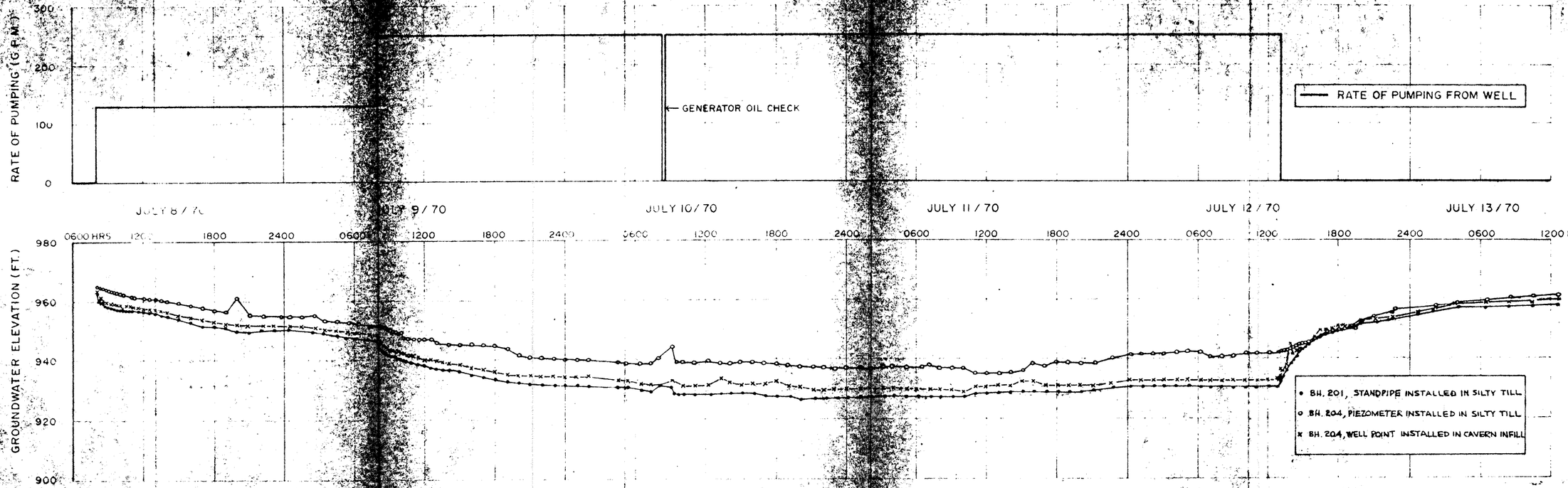
Date DEC. 3/70

Golder Associates

Drawn
Chkd
Appd

RESULTS OF PUMPING TEST
RATE OF DRAWDOWN CURVES

FIGURE 15



Date DEC. 3/70.

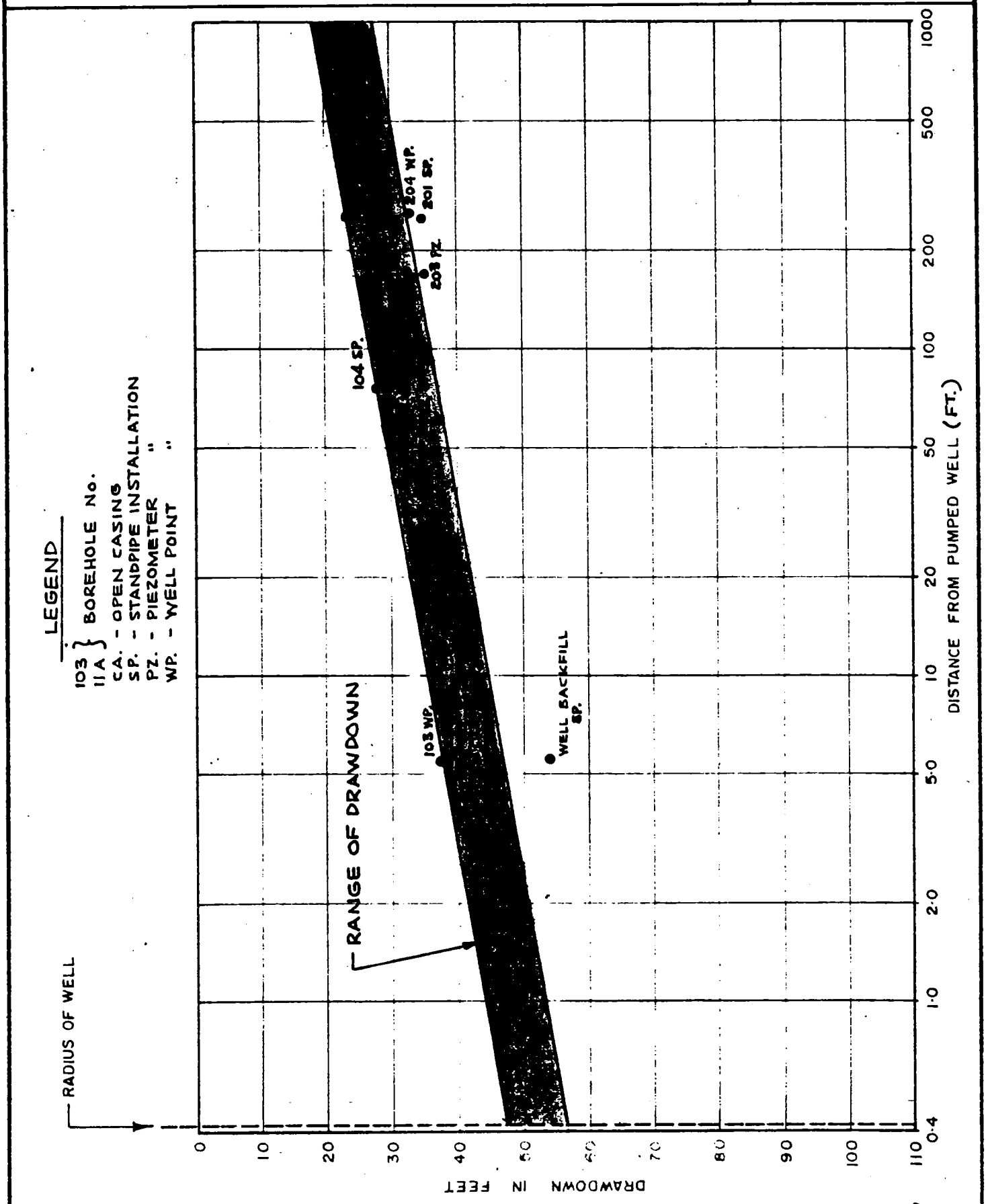
FIGURE 15

Golder Associates

Drawn
Chkd
Appd

DISTANCE DRAWDOWN CURVE FOR AVERAGE CONDITIONS

FIGURE 16



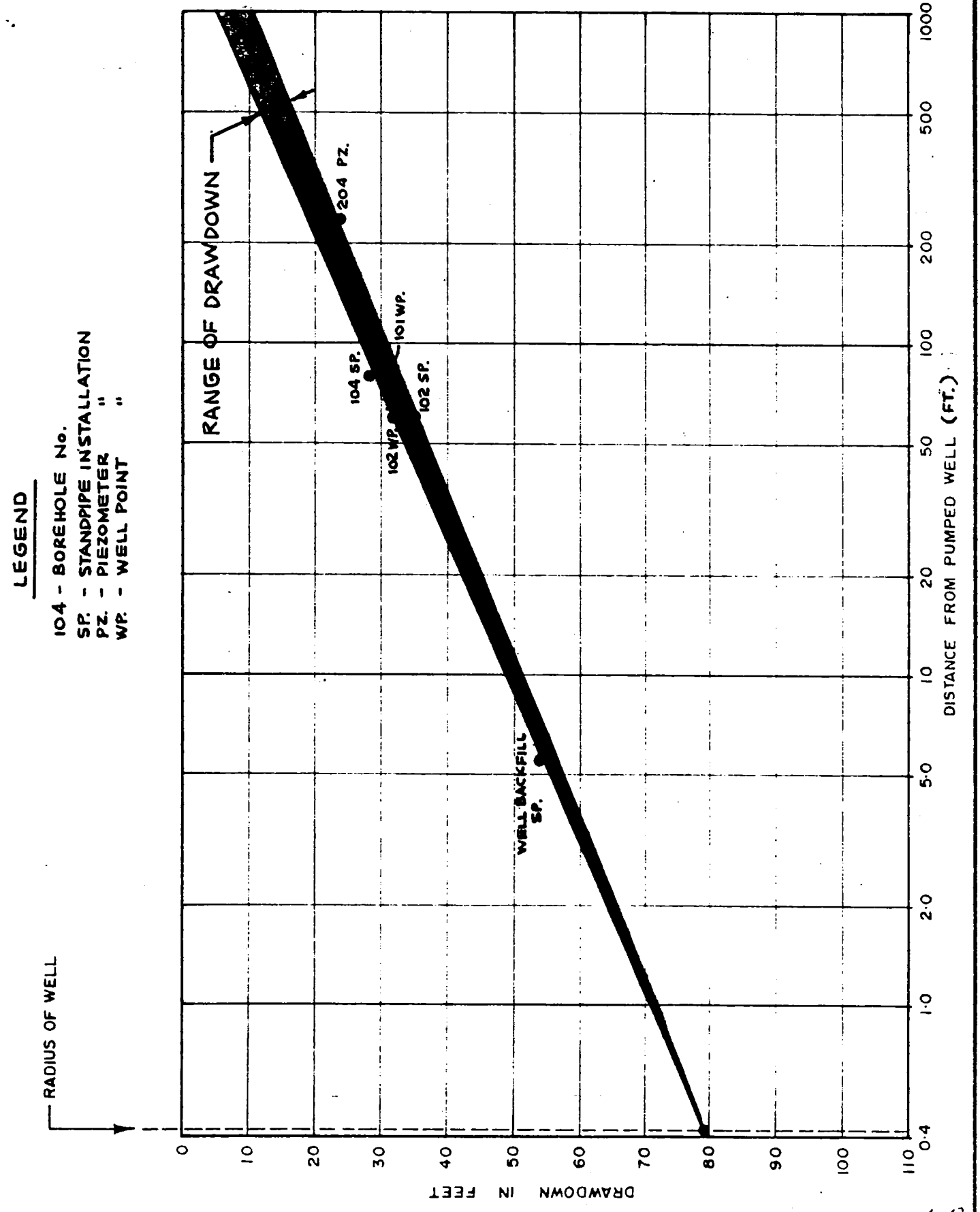
Date DEC. 3, 1970

Golder Associates

Drawn M.Y.B.
Chkd
Appd

DISTANCE DRAWDOWN CURVE OVERBURDEN AND BEDROCK, SOUTH OF WELL

FIGURE 17



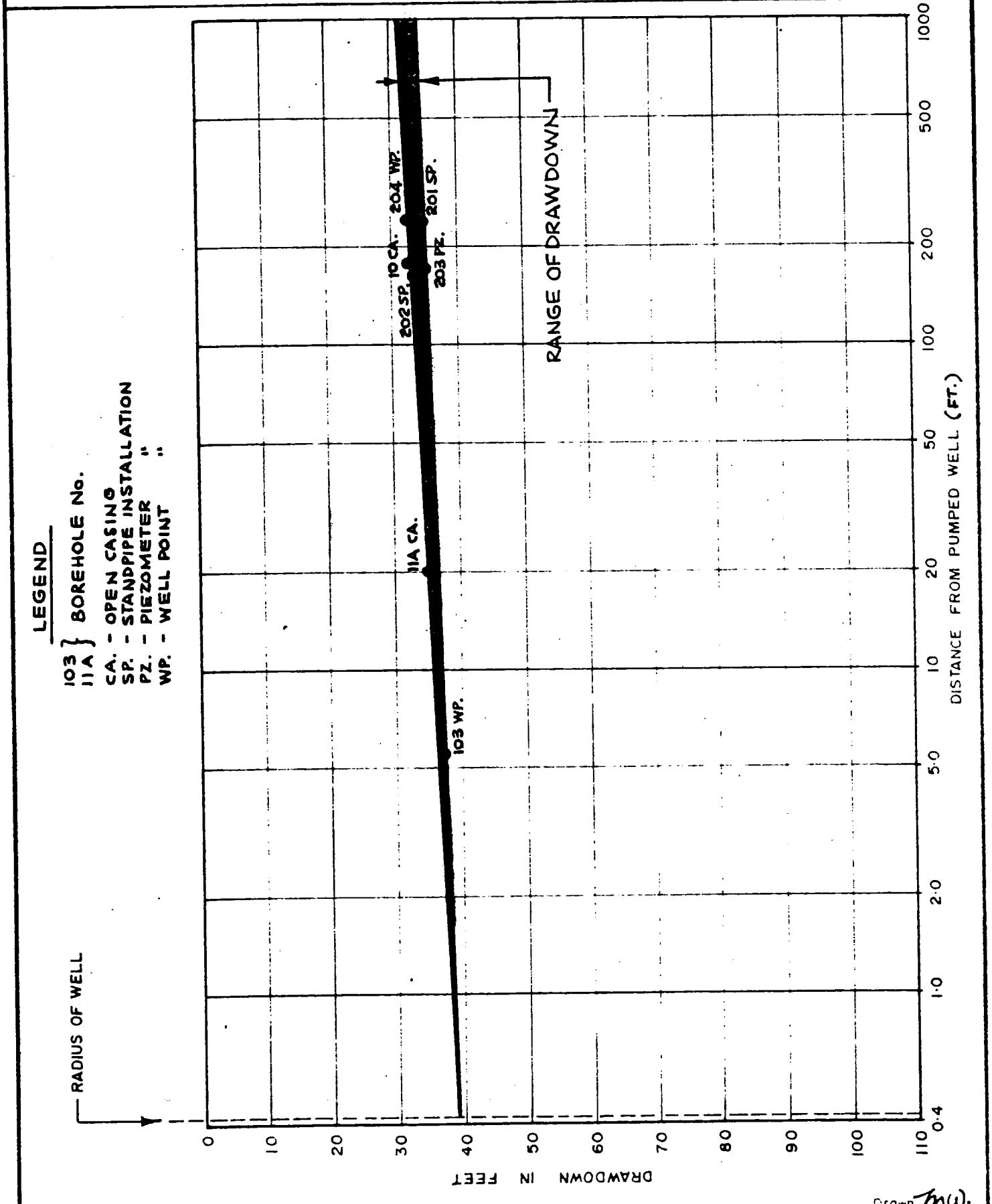
Date DEC. 8, 1970.

Golder Associates

Drawn MW.
Chkd RD
Appd

DISTANCE DRAWDOWN CURVE CAVERN IN BEDROCK, AND AREA NORTH OF WELL

FIGURE 18



LEGEND

103, 11A } BOREHOLE No.

CA. - OPEN CASING
SP. - STANDPIPE INSTALLATION
PZ. - PIEZOMETER "
WP. - WELL POINT

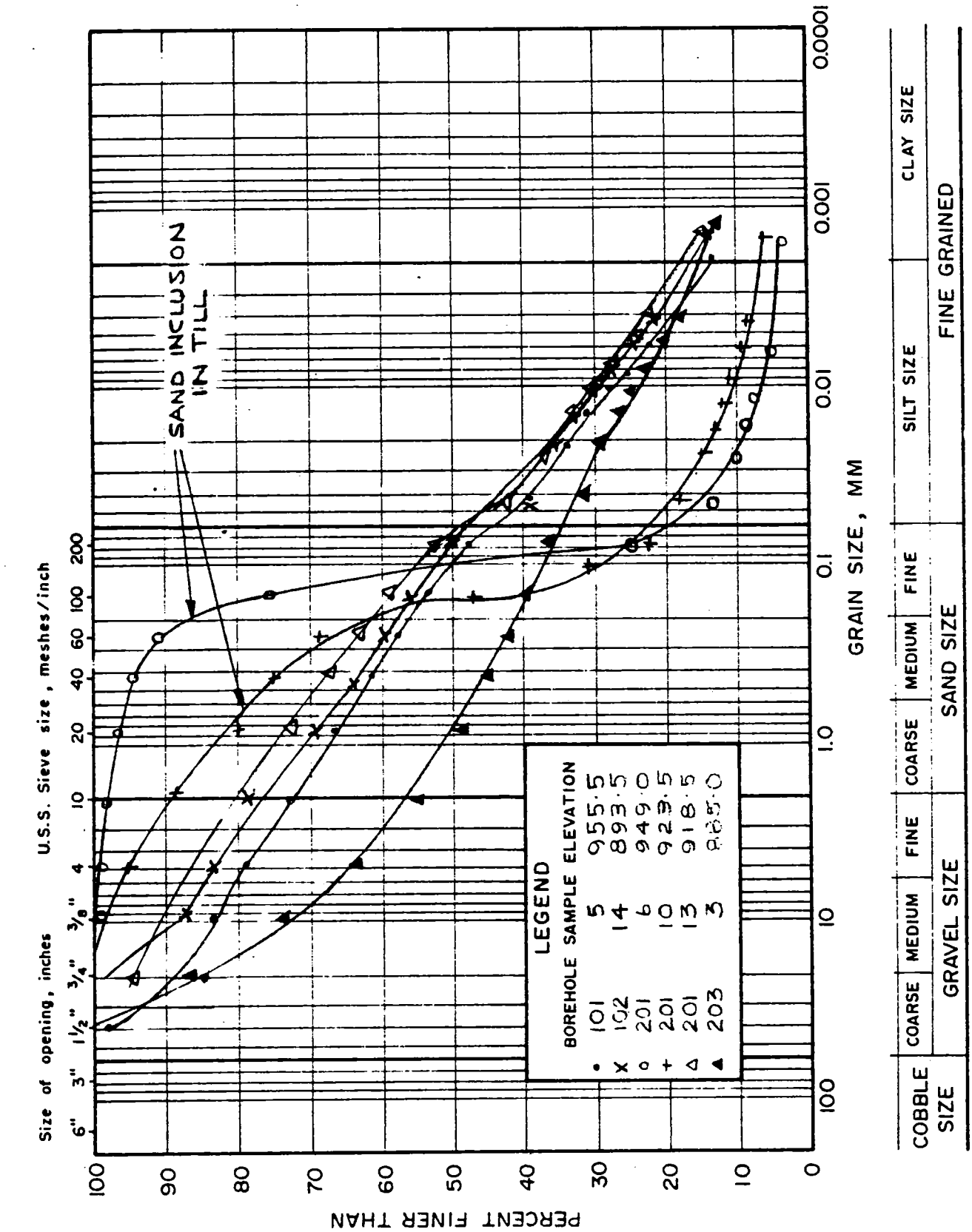
Date DEC. 8, 1970

Golder Associates

Drawn TMW.
Chkd
Appd

GRAIN SIZE DISTRIBUTION
CLAYEY TILL

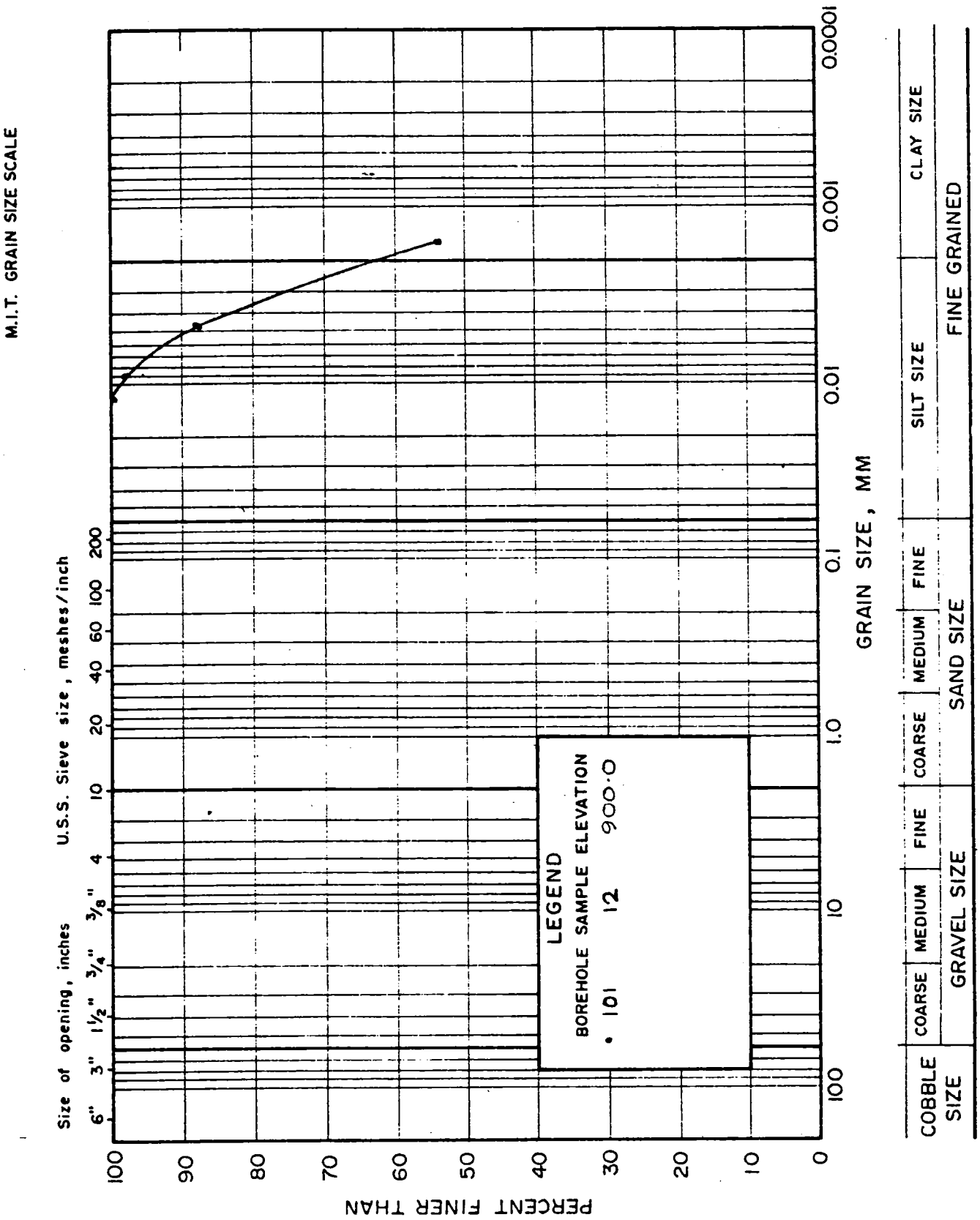
FIGURE 19



Golder Associates

GRAIN SIZE DISTRIBUTION
LAYERED SILTY CLAY

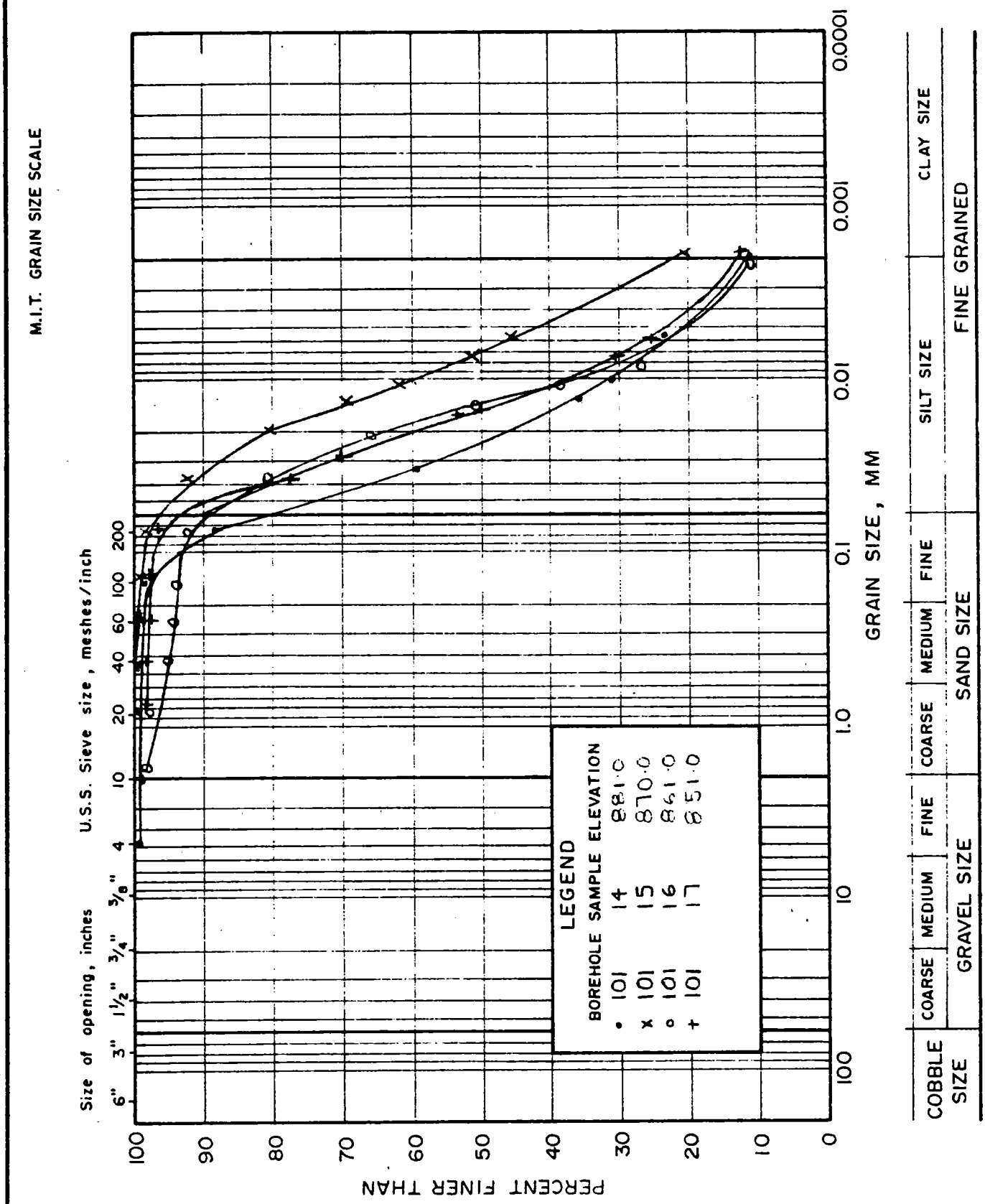
FIGURE 20



Golder Associates

GRAIN SIZE DISTRIBUTION
SILT TO SANDY SILT

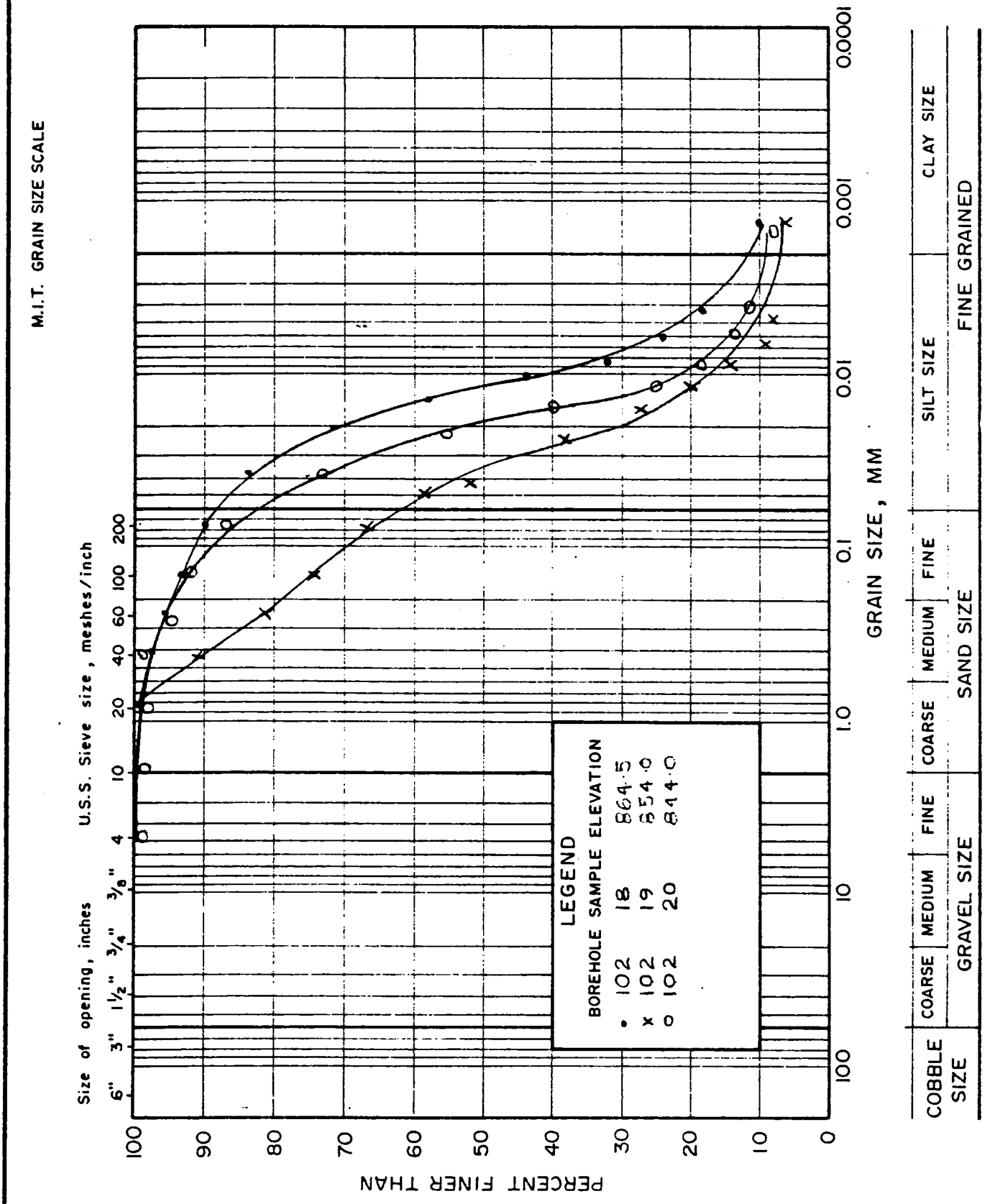
FIGURE 21



Golder Associates

GRAIN SIZE DISTRIBUTION
SILT TO SANDY SILT

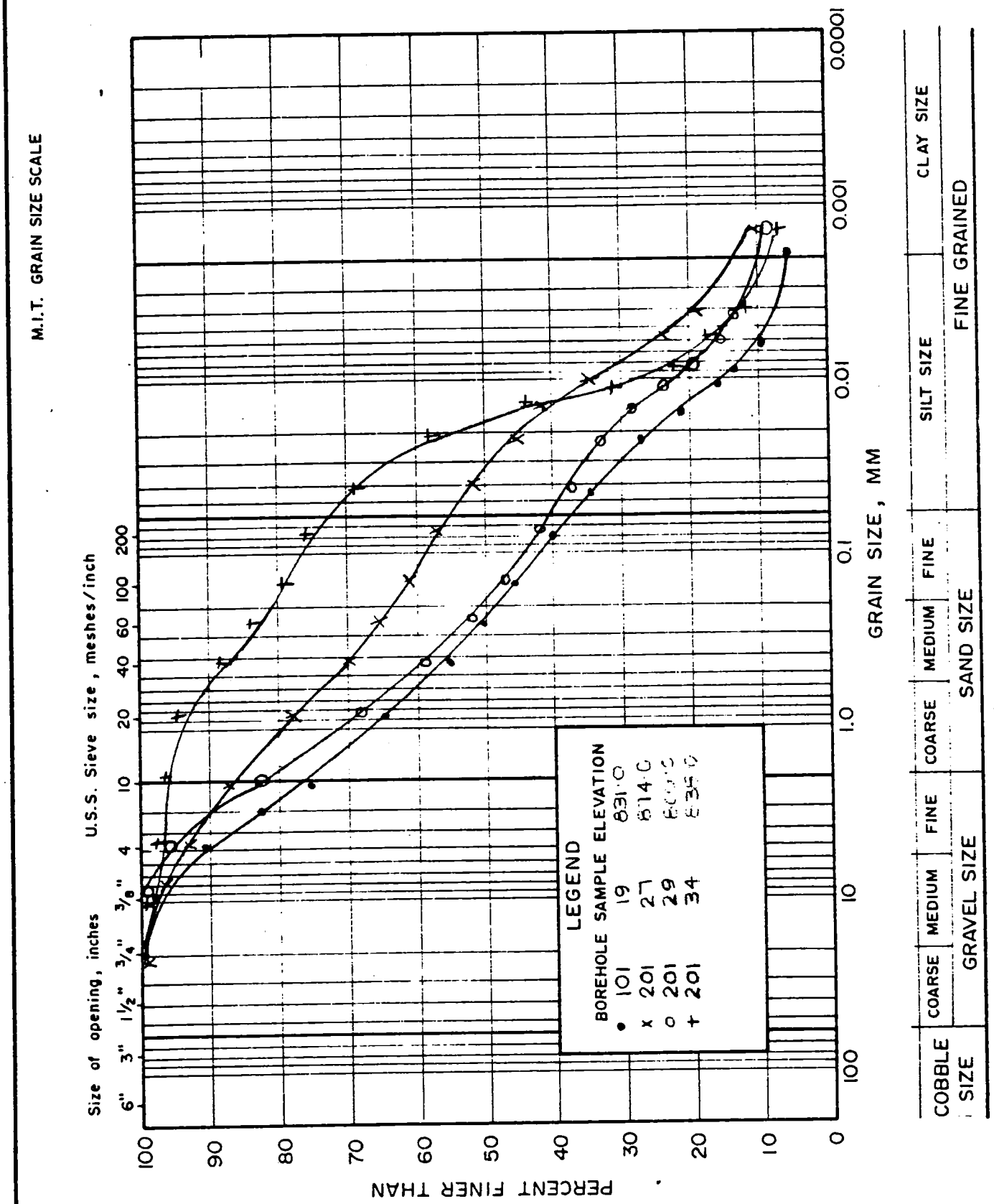
FIGURE 22



Golder Associates

GRAIN SIZE DISTRIBUTION
SILTY TILL

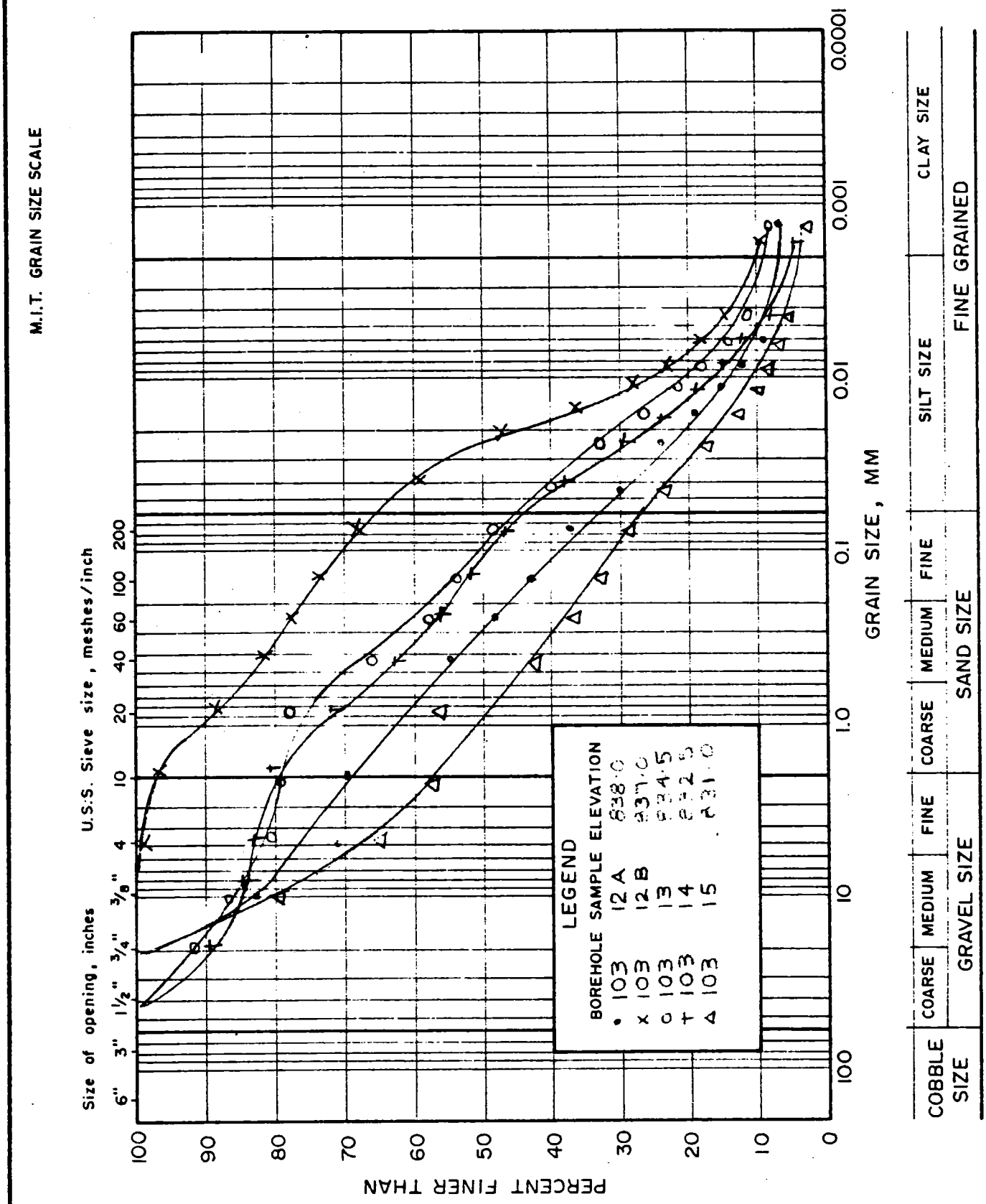
FIGURE 23



Golder Associates

GRAIN SIZE DISTRIBUTION
DISTURBED SILTY TILL

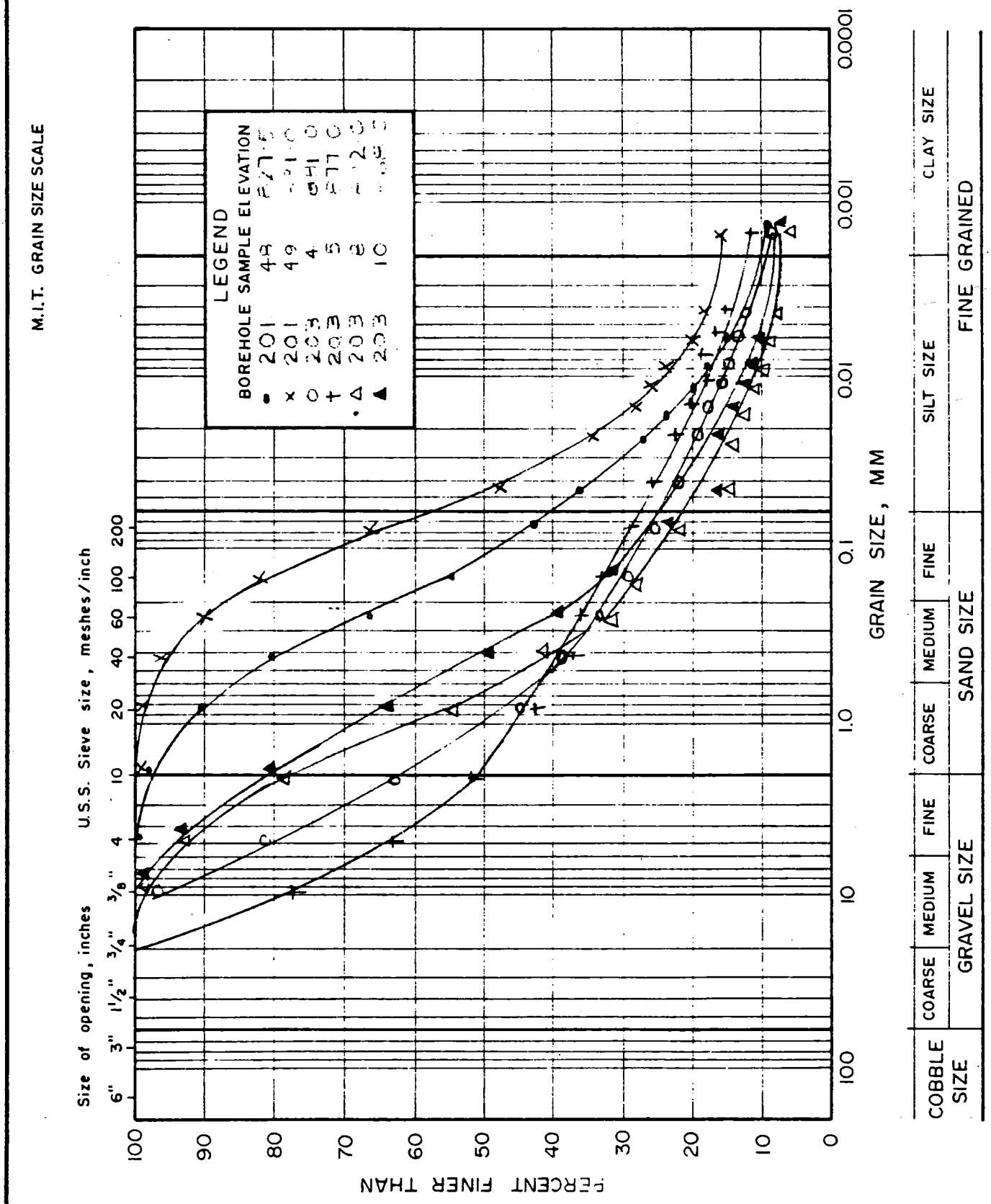
FIGURE 21



Golder Associates

GRAIN SIZE DISTRIBUTION
DISTURBED SILTY TILL

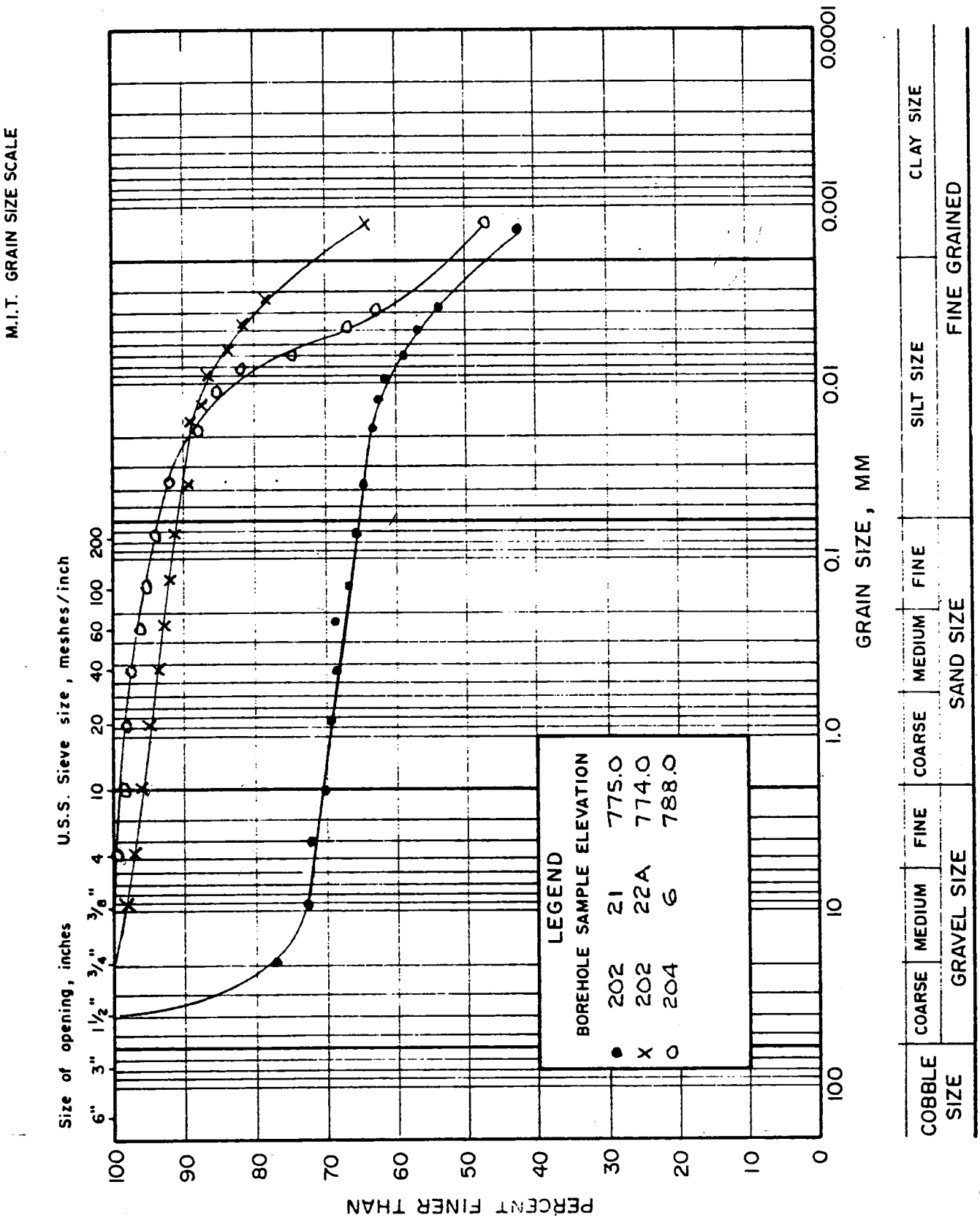
FIGURE 26



Golder Associates

GRAIN SIZE DISTRIBUTION
CLAYEY INFILL MATERIAL

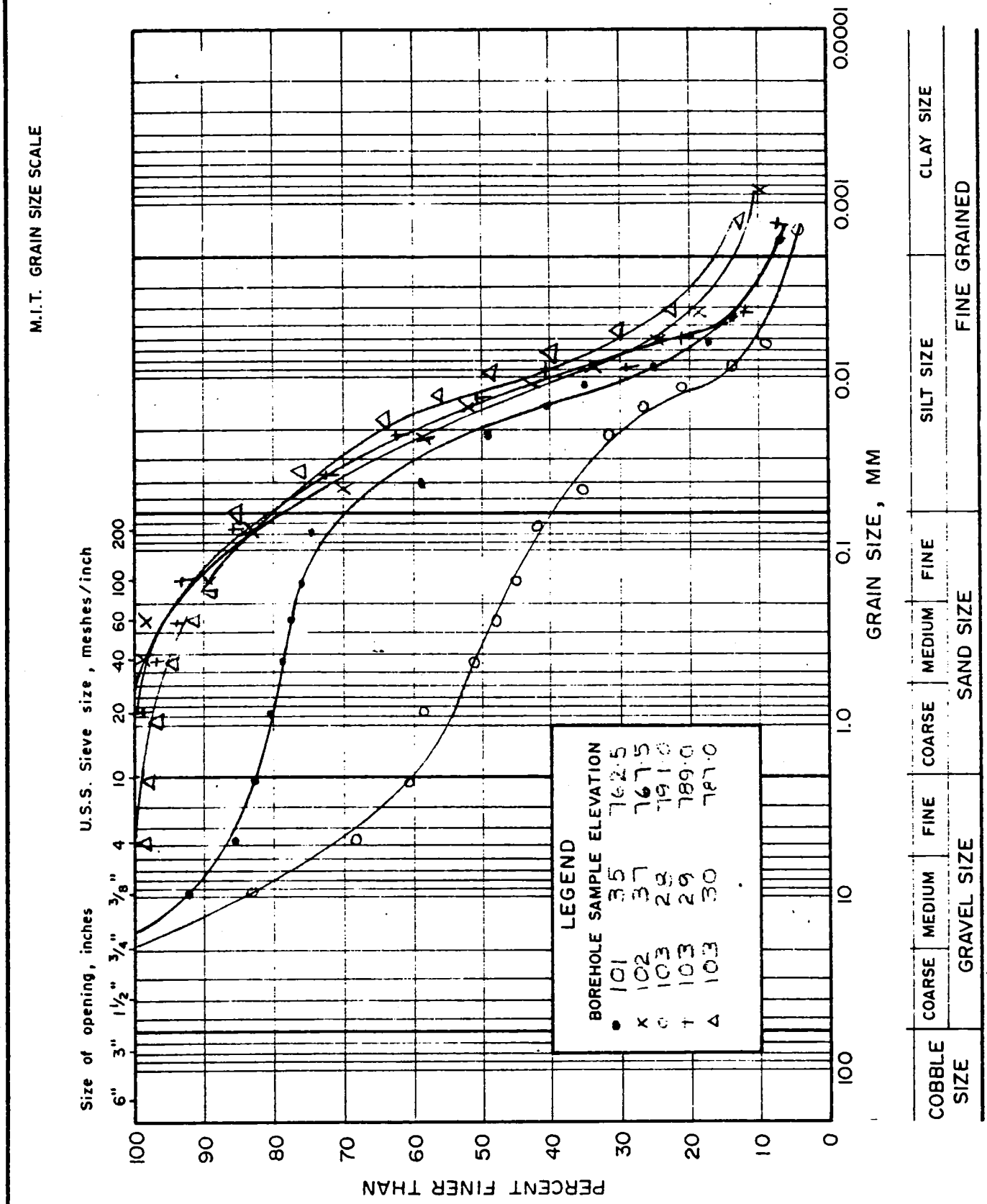
FIGURE 27



Golder Associates

GRAIN SIZE DISTRIBUTION
SANDY TO SILTY INFILL MATERIAL

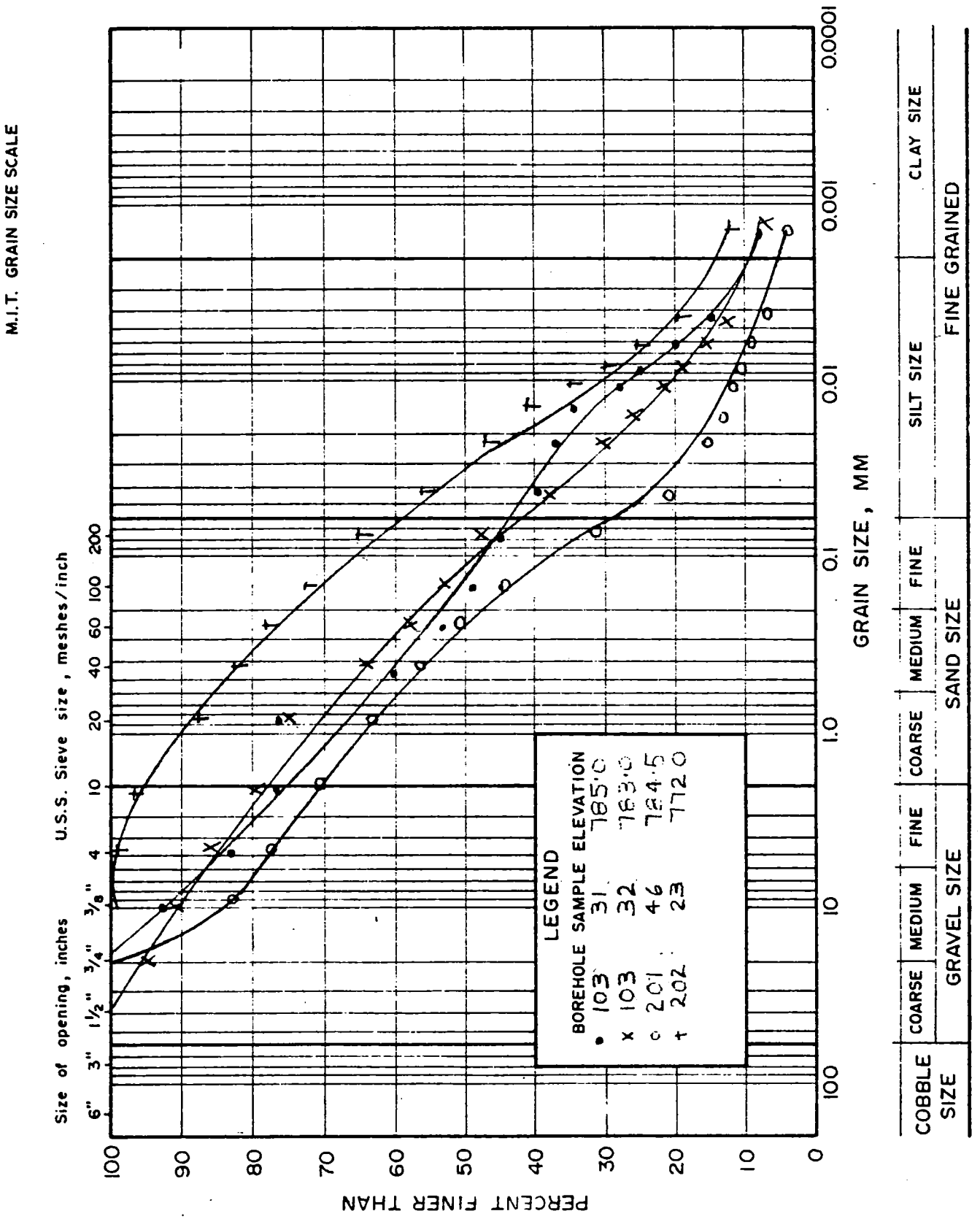
FIGURE 28



Golder Associates

GRAIN SIZE DISTRIBUTION
SANDY TO SILTY INFILL MATERIAL

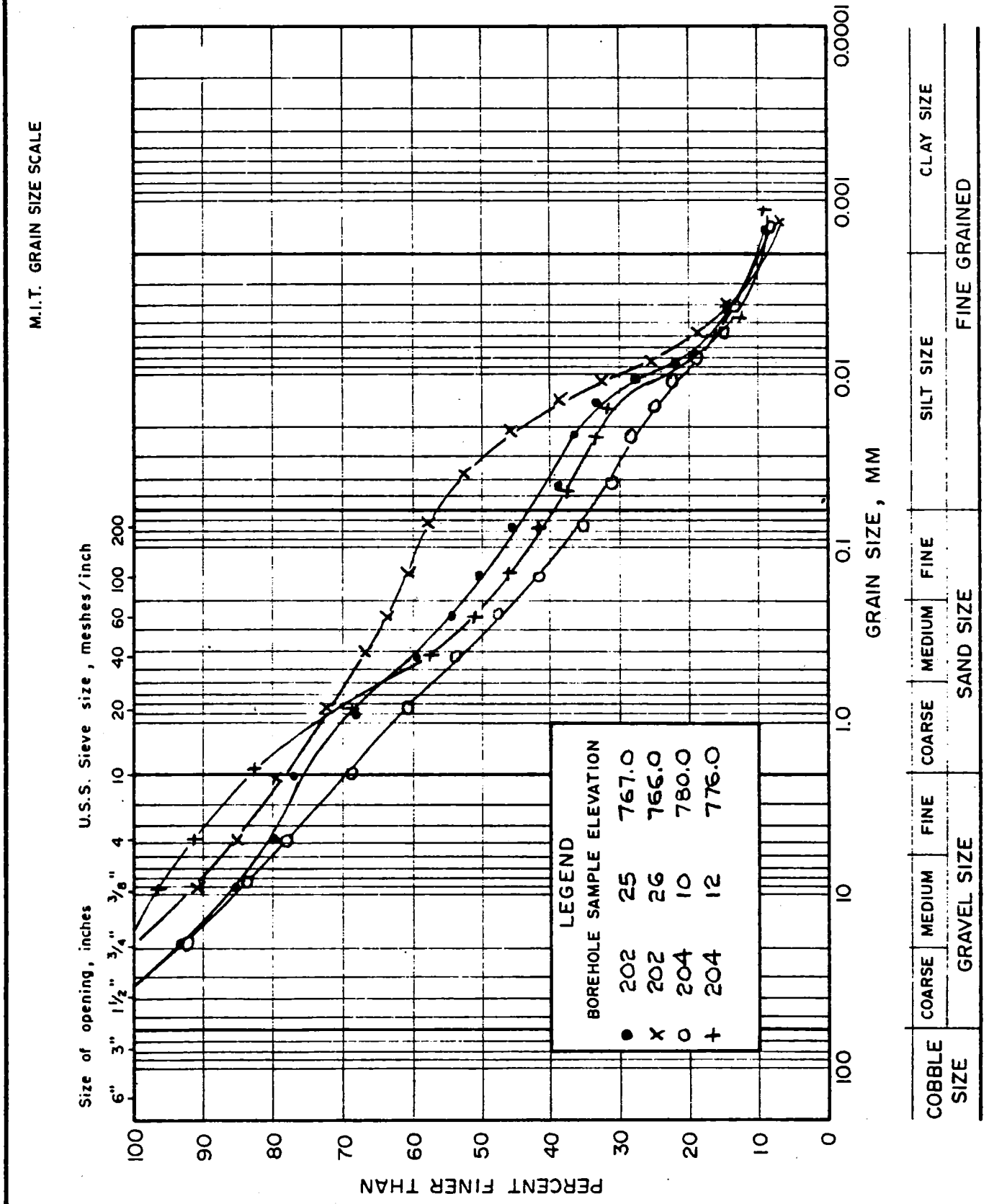
FIGURE 29



Golder Associates

GRAIN SIZE DISTRIBUTION
SANDY TO SILTY INFILL MATERIAL

FIGURE 30



Golder Associates