HARRIS
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December 7, 1973

Mr. E. Zell Steever
Director of Water and Related Resources
Connecticut Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115

Reference: Cove Pond and Dam Study
Stamford and Darien, Connecticut

Dear Mr. Steever:

In accordance with the terms of our Agreement dated September 15, 1972, we are pleased to submit our report "Study of Cove Pond and Dam at Stamford and Darien, Connecticut".

The purpose of the report is to study the odor problem at Cove Pond. Our findings show that the problem can be reduced by removing all sources of pollution from the Noroton River and its drainage basin and by increasing the flushing capacity of the pond by making tidal gates operational. Cost of repairs to the dam and gates is estimated at approximately $20,000.

We would like to take this opportunity to express our appreciation for the excellent cooperation and assistance we have received from the Department of Environmental Protection, and the cities of Stamford and Darien during the conduct of this study.

Sincerely yours,

FREDERIC R. HARRIS, INC.

Eugene D. Jones
Senior Vice President

EDJ:ds

STUDY OF COVE POND AND DAM
STAMFORD – DARIEN, CONNECTICUT

May, 1973

HARRIS

Frederic R. Harris, Inc. – Stamford, Connecticut

STUDY OF COVE POND AND DAM

STAMFORD - DARIEN, CONNECTICUT

Frederic R. Harris, Inc.
Stamford, Connecticut
November, 1973
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I INTRODUCTION

This report presents the result of a study of the odor problems at Cove Pond for the Department of Environmental Protection, State of Connecticut. In recent years, Cove Pond has been plagued by the occasional presence of undesirable odors. As a result, Frederic R. Harris, Inc., was commissioned to undertake a study to determine the possible sources of the problem and to recommend possible solutions.

SCOPE OF WORK

Items of work to be completed were as follows:

1. History
Collect all available information pertaining to the odor problem including locating reports, chemical and physical tests on water samples, and interviewing local authorities and residents.

2. Cove Pond Dam Topographic Survey
Take horizontal and vertical measurements for a condition survey of the dam.

3. Dam Inspection
Perform visual inspection of the above water and underwater parts of Cove Pond Dam and the associated gate structure.

4. Required Flushing
Determine the volume of tidal waters required to provide adequate, periodic flushing of the pond.

5. Meteorological and Oceanographic Effects
Examine the effects of tides, currents, winds, and freshwater discharge on Cove Pond.

6. Odor Control
Consider alternate methods for the treatment of the odor problem at Cove Pond.

II RECOMMENDATIONS

On the basis of the following discussion, it seems reasonably apparent that alleviating the odor problem in Cove Pond will require the institution of a series of steps designed to serve a variety of needs.

The first and most obvious step, is to eliminate to as great an extent as possible all pollution sources from the pond, Noroton river, and its drainage basin. This includes the elimination of septic tank leaching as well as the discharge of industrial effluents into the system.

Increasing the flushing capacity of the pond is the second step. In order to facilitate this, it will be necessary to clean and make operational the systems of tidal gates found in the Cove Pond Dam. Additionally, a system should be designed and implemented which will allow the partial or complete opening of the individual gates from a position on shore. Gates should be opened during high slack tide.

The gates should be opened on an experimental basis. Monitoring of flow rates and water quality levels in the pond should be carried out simultaneously. Basically, the level of water depression in the pond should be decided giving due consideration to the area of exposed mudflats as compared to resulting water quality.

On the basis of this study, an initial water level drop of 1 foot below the level of the dam should be instituted on a year round basis. The hope is to maintain a generally higher level of water quality. During the winter months, preferably during times of large fresh water inflow, the gates should be opened sufficiently to decrease the overall level of the pond 2-3 feet over a short period, say one week. In the summer, specifically during periods of extreme temperatures, the gates should be closed and the water level in the pond maintained at the present level of the dam. As soon as temperatures drop, the gates should be reopened and the minimum level of one foot below the elevation of the dam reinstituted.

On the basis of the findings contained herein, it is felt that the depression of water level 1 foot will provide a great deal of necessary flushing, while not exposing an undue area of mudflats. It should be pointed out that this elevation is not axiomatic. A trade-off between water quality and mudflats exposure is necessary. If lesser mudflats are desired, a lesser level of water quality must be tolerated.

It must be noted that the increase in tidal flushing of the system will not halt the eutrophication and overall sedimentation of the pond. The increased flow will probably slow the process, however. In the long term natural processes will fill the pond. The only alternative seems ultimately, to be dredging of the pond. At present a precise estimate of the necessary dredging is not possible. A program of sediment coring would be necessary.

Difficulties with obtaining the appropriate permits, locating acceptable spoil areas, and preparing the necessary Environmental Impact Statement should be anticipated. Costs might prove prohibitive and a decision on the value of the pond will need to be made.

To determine the actual flushing patterns, it is recommended that the following field investigations be undertaken:

1. Tidal Studies
Tidal studies to understand the driving force for the flushing and to more precisely estimate the actual tidal prism.

2. Dye Studies
Dye studies for qualitative understanding of current patterns and a quantitive measure of total residence time.

3. Current Measurements
Current Measurements (by meter or drogue) to understand the current patterns and find areas of poor circulation.

4. Salinity and Temperature Profiling
Salinity and temperature profiling to gain insight into the stratification and vertical mixing of the system.

It is also recommended that repairs be made along the surface of the dam, replacing stones to conform to the original design of the dam. It is estimated that the order of magnitude of cost to make the repairs to the dam and to clean and to make operable the tidal gates is approximately $20,000.

III COVE POND

A. Location and Description

Cove Pond, or Holly Pond, is located on the north shore of Long Island Sound on the coastline of Connecticut approximately 30 miles east of New York City. The pond, which is actually the estuary of the Noroton River, partially delineates the border between the City of Stamford and the Town of Darien. Site Location can be found in Figure 1.

The primary connection of the estuary with the sea is through a natural tidal inlet; a secondary connection is made through a small "gut" on the western side of the pond. The main inlet has been subjected to several man-made modifications. Hurricane protection works in the form of a stone jetty, several small groins in the channel proper, and a large groin used to stabilize an artificial beach have been added. The "gut" is apparently man-made and is presently partially in use as a marina. A more detailed view of the site can be found in Figure 2.

Flow through both passages has been restricted by the addition of dams at the inner end of the inlets which were installed to maintain a minimum water level in the pond. These structures are entirely submerged during periods of high tide. Design elevation of both structures is 6.2 feet above mean low water.

B. History of Cove Pond

The original Cove Pond Dam was constructed in 1796 at a height of 3.5 feet above mean sea level. A mill, located next to the site, probably used the waters of Cove Pond to drive a paddle wheel. This dam existed for one hundred and forty-two years before it was destroyed by a hurricane in 1938.

Examination of old records indicates that prior to the destruction of this dam, an opinion was held by some that a polluted condition of the pond was caused by the presence of the dam. Some felt that the sill prevented adequate tidal flushing of the pond which in turn prevented cleansing the estuary of pollution introduced upstream.

After the dam had been breached by the 1938 hurricane, its impounding effects were lost resulting in the partial exposure of the bottom at low tide. Records indicate that the exposed mudflats were extremely malodorous, particularly in hot, dry weather.

In November 1958, John J. Baffa, Consulting Engineer from New York City, submitted a study entitled: Report to State of Connecticut Water Resources Commission Upon Flood Control For the Noroton River. In Part 1 of this report, 'Cove Pond Area Improvements' it was recommended that the Cove Pond dam be reconstructed to an overflow elevation of 2.5 feet above mean sea level.

As a result, a new dam was constructed by Turner & Bretvogel of Falmouth, Massachusetts in 1960. At that time, it was felt that the dam height was low enough to permit adequate flushing of the pond.

On the basis of soundings made in the pond in 1935 and again in 1958, it was estimated that siltation was progressing at an average rate of one inch per year over the entire surface of the pond. At this rate, the pond would fill up to the elevation of mean high water by the year 1999.

To forestall this eventuality, it was specified that gates be installed to permit periodic quick flush-outs. Adjustable "butterfly" gates were called for, but they proved to be too expensive. "Flap gates" were installed instead. These gates worked fine for a while, but debris accumulating in the sluiceways eventually hindered their proper closure. Ultimately these accumulations caused the gates to rack. Hinges holding the gates in place failed and the gates were washed out to sea.

After the flap gates were washed away, a system was quickly installed to raise the water level to the desired elevation. The present gates are of the "guillotine type" which were designed to be opened or removed by lifting them vertically. They were installed by C.W. Blakslee and Sons in 1966 but it appears that they have not been opened since.

Since the completion of the first dam roughly 177 years ago, the effective total flushing of the estuary has been considerably reduced. The stilling basin effect of the pond has caused a great deal of material to be deposited in the basin. Obviously, the materials which have accumulated were carried into the Noroton River from its drainage basin and ultimately to Cove Pond. Although the quality of the water being poured into the pond at present may be reasonably clean, the effects of years of polluted flow still lie on the bottom of the estuary.

The size and location of this accretion not only affects present water quality, but also circulation patterns and total flushing ability.

In general, the ability of the pond to cleanse itself is related to the geometric and geographic stability of the tidal inlet which provides access to the sea. Since tidal cuts are in a state of dynamic equilibrium, any change in the factors which affect their position and configuration result in an offsetting response by the channel. In the extreme case, an inlet may close entirely, although there are no known cases in Long Island Sound. A variety of situations from the most efficient cross-section to complete closure may occur at a given time, and consequently the volume of sea water available for flushing may vary considerably. (15, 20, 21)

IV SITE INVESTIGATION

A. Introduction

Data concerning Cove Pond were obtained by several means. The three major sources of information are published data, personal interviews, and field measurements.

A review of newspaper clippings, files of interested agencies, and personal interviews revealed two principles of eliminating the malodor problem. One group maintains that the dam should be eliminated, permitting free ingress and egress of clean sea water to relieve a polluted condition. They understand that the drawback here is a drop in the present water level, exposing extensive mudflats. The other group, consisting largely of local homeowners, want to increase the flushing action through the use of tidal gates either seasonally or permanently. In this way, a cleansing effect would be obtained without destroying their property values.

A series of field investigations were undertaken. These included a bathymetric survey of the pond and inlet as well as a detailed survey of the dam. Underwater inspection was made by scuba divers in an attempt to determine the type and condition of the gate systems located at either end of the structure. Four sedimentary samples were collected for use in the determination of inlet stability as well as, to a limited extent, general flow and depositional patterns.

B. Previous Studies

In order to determine the results of any previous work on Cove Pond or similar estuarine systems a literature survey was undertaken. This survey included oceanographic, meteorologic and engineering reports pertinent to the region and problems involved. An attempt was made to locate any thorough technical studies of estuarine systems with similar problems. A large number of editorial and other newspaper articles as well as minutes of various public meetings concerned with Cove Pond were made available by the City of Stamford, the Town of Darien and local residents.

A great deal of opinionated information was available, however, no record of a thorough technical investigation of the system could be located. Technical information which was located is discussed under appropriate sections of this report.

In order to determine if any work had been done on similarly effected estuarine systems, the problem was discussed with personnel of the Coastal Engineering Research Center (CERC), Washington, D.C. This contact revealed that this agency is presently engaged in a study on a similar system on the Alaskan coast. However, no field data has been collected and no immediate assistance on achieving a viable solution to the problem could be offered.

CERC personnel revealed that they had also completed a literature survey in an attempt to locate previous studies of similar phenomenon and had met with no success.

C. Personal Interviews

Interviews with residents of the Cove Pond area substantiated that odor problems have occurred periodically over the years. A combination of several climatic and environmental conditions seem to contribute to the development of the problem. Warm weather, low tidal differentials and limited fresh water inflow are apparent during the incidents.

The worst such incident occurred in July, 1970 and lasted for several days. During this period residents complained of lead house paint turning black, silver tarnishing rapidly and of a generally nauseating odor.

One resident of Cove Pond area maintains that the odor was generated by dying algae, killed by excessively warm water. This dieoff cleaned the pond of growth that year. In the two summers following this odor, he had noticed the algae beginning to appear again. During an inspection of Cove Pond by Frederic R. Harris, Inc. Engineers in March, 1973, extensive amounts of algae were observed on the dam as well as on the rocks at the entrance to the pond.

D. Meteorological Data

According to the U.S. Weather Bureau (27), the prevailing wind direction at Stamford, Conn. is from the Southwest with a mean annual velocity of 12 mph. Atmospheric flow in the region is generally Easterly and a large majority of coastal lows, storms and hurricanes passing over the Northeastern United States pass over or near Connecticut.

Mean annual precipitation as reported by the National Oceanic and Atmospheric Administration is 43.79 inches. Rainfall is generally equally distributed throughout the year.

January is statistically the coldest month of the year with a mean temperature of 30°F. The hottest month is July with a mean temperature of 71°F. The mean annual temperature is 51°F.

According to the U.S. Department of Commerce tide tables (26), tidal fluctuations at Stamford are semi-diurnal and exhibit a mean high tide of +7.2 feet above mean low water. Mean low tide is +0.0 feet above mean low water. Spring range is 8.3 feet.

It should be pointed out in a complex estuarine area, like Cove Pond, tidal phases and ranges cannot be readily extrapolated, with the necessary accuracy, even from nearby stations. The data above is given only to establish an order of magnitude for the local tide range of Long Island Sound.

E. Bathymetry of Pond

On April 9 & 10, 1973, Frederic R. Harris, Inc. personnel utilized an Apelco fathometer mounted in a small boat supplied by the Stamford Parks Department, to conduct a bathymetric survey of Cove Pond. The results of this survey can be seen in Figure 3. All elevations are referenced to Mean Low Water. The survey was conducted during periods of low tide, i.e., when the water level was at the dam elevation. Water level was determined from a temporary tide staff referenced to a known elevation. Therefore, knowing the position of the fathomer head from the bottom as read from a strip chart and the elevation of the water surface, bottom elevations were referenced to Mean Low Water. water surface, bottom elevations were referenced to Mean Low Water. Darien and visually maintained during the survey.

A second contour map was drawn by Harris personnel from data collected by the City of Stamford in August 1935. The results of the 1935 survey can be found in Figure 4. Elevation datum is corrected to Mean Low Water.

The phenomenon of a river filling its estuary with sediment is a common one, and is caused by the estuary acting as a stilling basin for the river discharge. This process generally requires a relatively long period of time, but can be seen quite graphically in Cove Pond by examining the results of the aforementioned surveys.

Comparison of the April 1973 bathymetry with the August 1935 contours yield the following results: with the exception of an area behind the dam on the east side of the pond, the water depth of the estuary has decreased considerably. Accumulations as high as five feet can be seen immediately behind the east side of the dam. The average thickness of the deposition over the entire pond seems to be approximately two - three feet. In general greater accretions are found on the east side than on the west side of the estuary. This implication is twofold:

1. A significant amount of material has been trapped in the estuary.
2. A channeling of the flow on the Stamford side of the pond has occurred. The second conclusion is also supported by the position of the scour hole behind the dam on the Stamford side. The increase in depth at this point amounts to slightly less than one foot.

F. Inlet Bathymetry

In conjunction with the survey of the pond, a bathymetric survey of Cove Pond was undertaken in April 1973. The contour map drawn from this survey can be seen in Figure 5.

A similar procedure to that previously described was used to determine bottom elevations in the inlet. However, the survey was taken at and around high slack tide for obvious reasons of safety.

Examination of this map of the inlet reveals the presence of two main flow channels running from points located approximately in front of the two sets of tidal gates out into the sound. Large shoal areas indicated by the shaded areas in Figure 5 have increased significantly the effective length of the inlet and generally reduced its hydraulic efficiency. The inlet hydraulic efficiency and limits of the dam-weir must be evaluated, when sufficient tidal stage data is developed.

Comparison of the contours constructed from data collected by Harris personnel with a survey conducted by the City of Stamford in 1956 seems to indicate that considerable shoaling of the inlet in general has occurred in the interim. Insufficient data was available from the previous survey to allow construction of 1956 bathymetry.

G. Dam Inspection and Survey

On March 10, 1973, an underwater inspection of Cove Pond Dam was carried out by scuba divers under the auspices of Frederic R. Harris, Inc. The divers' report can be found in Appendix B.

The inspection indicated that the overall condition of the gates and the concrete monoliths used to house the gate systems was generally good. A sketch of the dam, gates, and gate housing may be seen in Figure 6.

A large accumulation of sand, stones and shell was noted in the sluiceways of the individual gates. Evidently, this material is reasonably soft and loose in nature. It was the opinion of the divers that it would not prove difficult to remove.

Due to the extremely poor visibility, the details of the back side of the rubble mound are lacking. In general, however, an extensive amount of material could be seen on the back side of the dam. Apparently, some of this was placed during the construction stages. The exact amount of subsequent sedimentation is difficult to assess without more extensive field work.

Based on the underwater inspection, no visible signs of deterioration on the back side of the dam or the associated gates and housings were noted. It was concluded that the condition of the gates and concrete monoliths would allow removal of the gates if this was deemed desirable.

In order to further evaluate the condition of the dam and associated gates, a survey of the structure was undertaken on April 12th and 16th, 1973. This data was supplemented by underwater inspections previously described. Comparison of the results of this survey with original engineering drawings prepared by John J. Baffa and Associates in 1960 was undertaken. A section of the original dam, as designed, can be seen in Figure No. 7.

Sections of the structure as it presently appears can be found in tabular form in Figure No. 8. Data was collected using a rod and level with a Coast and Geodetic Survey benchmark supplying the known elevation. Since the elevation varies depending on rod location (i.e. on top of a high stone or in a gap between the rubble) a visual estimate of an average elevation was used to locate the rod.

This data indicates that a settling or, more probably, a slumping of the structure has occurred on the Darien side of the rubble mound. Flow over the structure was also noted at these points. Little or no settling of the concrete monoliths used to house the gates has occurred. Elevations of the gate housings can be seen on Figure 9. The 1960 Cove Pond Dam construction drawing indicated a four inch asphalt topping mix was to be placed on the top of the dam. There was no evidence that this layer was ever placed.

Upwelling, or boiling, occurred at one point on the Darien side inside the gate housing. Another point of minor upwelling was found just off the center of dam nearer the Stamford side. The causes are not known. The locations of these points can be found on Figure 8.

A survey of the dam in the "gut" indicated that it has remained basically intact. The design cross-section can be seen in Figure 10. Mean top elevation of +6.3 feet above MLW was recorded compared to the original design height of +6.2 feet above MLW.

H. Sedimentary Characteristics

In an effort to determine general flow and depositional patterns in the Cove Pond system as well as for use in the determination of the inlet's overall stability, four sedimentary samples were collected. These samples were obtained from the top one to two inches of surface material. One sample of littoral material was taken on each side of the inlet, one sample was taken in the inlet, and a fourth was taken on the Pond side of the dam.

Laboratory analysis of the samples was conducted to obtain grain-size distribution.

Samples were taken from littoral material as well as in the inlet. The littoral material was primarily clean sand while the sediment from the inlet contained a large amount of fragmented shell. The grain-size distribution of these samples is shown in Figure 11. Material removed from the back side of the dam contained large amounts of shell and very fine sediment. The mid range material was conspicuously absent in this sample.

Visual examination of the material in the shoals in front of the dam indicated that the sediment which makes up the majority of these areas is poorly sorted. Material sizes range from coarse sands to silt. Extensive biological overgrowth can be seen on the older areas of the shoals.

I. Water Quality

It is desirable to examine water quality problems in terms of specific constituents or groups of constituents which are discharged either as a result of man's activities or natural phenomena.

Water quality measurements from Cove Pond at the entrance of the Noroton River have been made by the State of Connecticut (30). In addition, coliform measurements have been made by the Stamford Health Department. These records are presented in Appendix C.

V EVALUATION OF FIELD DATA

A. Introduction

The flushing of an estuary such as Cove Pond is determined by the complex interaction of tides, salinity intrusions, geometric shape, fresh-water discharges and winds. The currents which result generate or maintain the motion of sediments and pollutants which find their way into the estuarine system and dictate the time necessary to effect a total interchange of the estuarine waters. Since the hydraulic characteristics of the tidal inlet, which provides access to the sea, in conjunction with geometry of the associated pond dictates the propagation of the tidal flow through the system, the stability and efficiency of the inlet is of considerable interest.

B. Geometric Shape

The geometric shape of an estuary is, in part, responsible for the circulation patterns in the system. Since the propogation of the tide in an estuary is governed by depth of water, bathymetry becomes extremely significant in determining overall circulation patterns. Local current systems can be affected by the presence of coastal land forms such as points or coves. In Cove Pond, for example, a trapping of suspended sediments and pollutants occurs in the arm on the Darien side of the pond.

C. Tides

In very broad terms, currents associated with the rise and fall of the tides are the dominant horizontal motion in an estuary. Tidal fluctuation also, in part, provides the energy necessary to induce turbulent mixing of sea water with fresh water inflow and residual estuarine waters.

Currents induced in the inlet by the tidal variations tend to maintain the hydraulic efficiency of the flow channel. These currents also carry suspended material into and out of the estuary.

D. Salinity Intrusions

The effect of the introduction of saline water to the fresh water discharged into the estuary by the river on estuarine flushing is primarily in the form of the development of salinity gradients. These gradients affect both horizontal and vertical mixing in the pond. These gradients can considerably alter flow patterns in the system. Cove Pond may have such a horizontal salinity gradients and, given the bathymetry, there may very well be vertical gradients. Data on these points is crucial. Salinity measurements should be taken before a detailed analysis of the mixing can be completed.

E. Freshwater Discharges

The introduction of freshwater to an estuarine environment affects discharge through the tidal inlet, flow velocities in the basin, and depending on the quality introduced, circulation patterns and salt water intrusion. The effects of freshwater discharge on Cove Pond are discussed, based on the various water quality parameters.

F. Water Quality Indicators

The dissolved oxygen (D.O.) of a water body is one of the more important water quality indicators. The D.O. reflects the general level and health of a water body and is quality variable that reflects the capacity of the water to support a balanced aquatic habitat. The amount of D.O. in the water is interrelated with such parameters as temperature, light, living organisms, natural occurring decomposable organic matter, and pollution. Temperature directly affects the D.O in the water by deoxygenation and reoxygenation rates which are temperature dependent.

The saturation values of D.O. decrease with salinity, but actual D.O.'s can be expected to be higher in the salt water because of the pollution generally found in freshwater. There is also the effect of temperature on saturated D.O. values. Generally marine waters are cooler than fresh in the summer when odor problems are most acute. The National Technical Advisory Committee on Water Quality Criteria for Fish, other Aquatic Life, and Wildlife has recommended that for a warm water biological system the D.O. level should be above 4 mg/l. D.O. levels measured at Cove Pond at the entrance of the Noroton River have been measured as low as 0 mg/l during the warmer months.

Although qualitiative analytical tests have not been run on the bottom sediments of Cove Pond, some grab samples have been collected. From visual examinations, the organic nature of this sediment would indicate a significant capacity for consuming dissolved oxygen from the overlying waters. Further laboratory tests on more extensive bottom samples should be run to verify this observation.

Phosphorus and nitrogen are the two most important elemental nutrients needed to sustain aquatic life. Various forms of inorganic phosphorus and nitrogen have been the most commonly discussed contributor to algae growth and subsequent eutrophication. Although the concentration of inorganic phosphorus that will produce problems varies with the nature of the aquatic environment, some general criteria are available. When phosphorus levels exceed 0.02 mg/l, a region of potential algae bloom is encountered. When phosphorus levels exceed .1mg/l, an excessively enriched region is encountered. Phosphorus levels in Cove Pond have been measured in the range .04 mg/l to .11 mg/l (Appendix C) indicating that a strong potential for eutrophication does exist. Waters in the United States which support a good fish population generally have a nitrate concentration less than 1 mg/l. Ammonia nitrogen measurements in Cove Pond have averaged 0.3 mg/l and have been recorded as high as 1.1 mg/l.

It is well documented that high levels of nitrogen and phosphorus in aquatic environments are prime causes of excessive botanical growths. (1, 2, 4, 6) In many cases the excessive growth or "bloom" may be characterized by a greenish color of the water (25). One lake under study in Maine had an estimated standing crop of 9.7 Million pounds of algae. Additionally, Barlow's (3) study of Moriches Bay and Jefferies (17) work in Raritan Bay show that even with limited circultation excessive nutrients have an adverse effect on the balance of an ecosystem and soon lead to a partial state of eutrophication.

The presence of coliform organisms in water is regarded as evidence of contamination by excretement of human waste. Fecal coliform measurements in Cove Pond fall with the range of 102 to 104 MPN/100 ml which indicates a dangerous level of waste concentration. In general, the water quality levels in Cove Pond are considered poor and may be hazardous to the public health.

G. Sources of Pollution

It is believed that the major source of pollution of Cove Pond in the past has been the industrial effluent from companies bordering the Stamford side of the Noroton River. The quality of the effluent has been upgraded recently due to increasing surveillance and enforcement by the Stamford Health Department.

Seepage from septic tanks and septic tank drain fields on the Darien side of the pond is believed to be the most significant pollution source at present. Several septic tanks were observed overflowing into storm drains. These storm drains eventually empty into Cove Pond. Future plans call for elimination of the majority of these septic tanks with the installation of a sanitary sewer system.

It is interesting to note that an overloaded primary treatment plant with a flow of 1.6 million gallons per day is discharging effluent in Long Island Sound not far from the Cove Pond Dam. While it is doubtful that this plant is destroying the cleansing ability of the tidal waters, the effect of the effluent should be further evaluated in future studies.

A few of the other point source pollution sources are listed below:

1. Storm drain located on the south side of Post Road at Hollow Tree Ridge Road.
2. Brook at Seagate and Post Road.
3. Storm sewer outfall at Seagate Road.
4. Effluent from three Concord Lane into storm drain.
5. Brook on Wilson Ridge East.
6. Storm drain on Wilson Ridge East.
7. Yard drain on the N.W. corner of Post and Hillside Avenue.

Taking a long range look at the water quality of Cove Pond, it will be necessary to increase the flushing and cleansing effect of the tidal waters on Long Island Sound even if the majority of man-made pollution is eliminated. This will be necessary due to the shallow depth of the pond, which will promote water temperatures in excess of those which will support aquatic vegetation and algae. It is assumed that natural runoff and the existing bottom sediment will promote the growth of algae and aquatic vegetation. In addition to cooling the waters of the pond, increased flushing would hopefully decrease the present rate of sediment deposition.

H. Winds

Wind effects cannot be overlooked. Small (23) found that winds are an important factor in circulating and mixing nutrients in a body of water. Lake Sebasticook in Maine had excessive concentrations which were shown to be directly related to winds. The wind moved algae growths into "dead" areas of the lake, caused discoloration to boats, piers and shorelines and created a pungent pig-pen type odor of decay.

Surface shear generated by wind blowing over the air-sea interface results in a transfer of energy to the body of water. The end result is the generation of horizontal current systems. The combination of friction effects of the wind and the bottom also tends to cause a great deal of vertical mixing in a shallow estuary.

Wind fields also tend to effect current systems already developed or those generated by other means. For example, wind set-up of water in an estuary can cause a decrease in differential across a tidal cut with a resultant decrease in flow velocity.

At Cove Pond the predominent Southwesterly winds tend to reinforce the circulation pattern generated by the incoming tide.

I. Tidal Inlet

The initial restriction to free tidal flow into and out of an estuary is the hydraulic characteristics of the tidal pass which provides access with the sea. From simple continuity considerations, the larger and more efficient the channel, the greater the available flushing system.

Naturally occurring tidal inlets are in a state of dynamic equilibruim. In general the mouths of inlets have a tendency to "migrate" downcoast. The result is an increase in length and, consequently, an increase in hydraulic losses through the cut. Decreases in flow rate result. Ultimately, the length may increase to a point where the inlet is no longer capable of maintaining itself and closure results, (7,8,20,21).

Along with the geographic instability exhibited by tidal cuts, geometric instability is also prevalent, (7,8,20,21). As previously described, an inlet acts as a partial trap for sediment passing down the coast. Shoal areas develop behind the inlet and, while increasing the effective length of the channel, decrease the amount of water available to flush the pass. A decrease in cross-section results. As the shoal areas increase, the inlet may ultimately be completely closed.

Comparison of the bathymetric survey conducted during the course of this study with data collected in 1958 by the City of Stamford indicates that the inlet to Cove Pond is adapting or has adapted to a new flow regime and may be quite stable now.

Examination of the inlet shows that the extensive shoal formations in front of the dam have increased the effective length of the inlet channel. Detailed tidal data is required to fully understand these deposits. Splitting of the channel into two (2) parts is apparent towards the mouth of the inlet and this also contributes to overall hydraulic inefficiency. The consequence is a decrease in flow energy available to flush the pond and the sediment form the inlet.

The inlet to Cove Pond is evidently far from this end. In fact, most naturally occurring inlets pass through cyclic variations in geographic position as well as cross-section. Inlets on Long Island Sound are generally not prone to closure. Since Cove Pond inlet is maintained geographically by the hurricane protection works (See figure 2) found in the area, its only recourse is to change in cross-section. Passage of large storms or particularly rainy seasons undoubtedly clear out the pass.

Of primary concern here is the effect on the inlet of an increase in available tidal prism. That is, if an increased quantity of water is allowed to pass from the sea to the estuary, the inlet will respond. Since, as previously mentioned, the inlet should prove geographically stable, a change in cross-sectional area can be anticipated. The presence of the small jetties on the side of the cut and major groin on the Stamford side should effectively prevent any widening of the inlet and subsequent loss of adjoining property. Apparently, any cross-sectional changes will result in a deepening of the channel and removal of all or part of the shoal areas.

J. Effect of Cove Pond Dam

The effect of the dam on the physiographic unit comprised of Cove Pond and its associated inlet is quite substantial, the most obvious effect being the maintenance of a higher than normal water level in the estuary. of more consequence, however, is the decrease in flushing of the system which results.

In a normal estuarine environment there are only short periods of slack flow when deposition of suspended sediment and pollutants will occur. The presence of the dam in Cove Pond allows only a limited portion of the tidal waters to move in and out of the pond. Once the elevation in the pond reaches the dam, only internal currents continue for some time. The pond becomes an excellent stilling basin.

Effectively the dam acts as a very restricted tidal inlet. The result is a general deposition on both sides of the dam.

Since the stability of the main inlet is directly related to the available tidal prism, the dam has also had an effect on the cross-sectional area of the channel. The dam has effectively reduced the available tide area of the channel. The dam has effectively reduced the available tidal prism and the inlet has responded appropriately.

The dilution of seawater in estuaries provides the density gradients that produce the characteristic estuarine circulation patterns. The basic factors that determine the circulation patterns in estuaries are the fresh water inflow and tidal currents and the geometry of the estuary.

A schematic diagram of the Cove Pond system is shown in Figure 12. The fresh water inflow from the Noroton River has been gauged by the U.S. Geological Survey. Their results are reproduced in Appendix D.

Cove Pond has an estimated surface area of 194 acres at low tide. Based on an average high tide of 7.2 above mean low water, approximately 1.3 feet of tidal water flows over the main dam twice daily. This amounts to an average tidal prism of 2.6 feet per day. This is equivalent to 504 acre-feet or approximately 164 million gallons per day. The low tide volume of the pond is approximately 730 acre feet or 238 million gallons.

If it is assumed that all the water in the pond at low tide is displaced by tidal waters, 69% of the water in the pond would be flushed out each day.

Unfortunately, the tidal water does not completely displace an equal volume of water already in the pond. Consequently, the maximum amount of water replaced in the pond each day is probably closer to 30% of the total volume.

In Cove Pond, the fresh water from the Noroton River has a tendency to flow seaward as a layer of low salinity water overlying the denser salt water from the sea. Because the tidal flow from Long Island Sound is much greater than the flow from the Noroton River, it is suspected that the mixing introduced by the tidal motion overcomes the stability resulting from the fresh water inflow and tends to produce a uniform salinity from surface to bottom. In Cove Pond a natural channel from the entrance of the Noroton River, along the Stamford side to the main dam, is a dominant feature of the flushing pattern.

A tidal stage/discharge relationship for the Cove Pond Dam was calculated and is presented in Figure 13. Using average tidal ranges, a maximum estimated flow of 2,400 cubic feet per second occurs at the main dam with an average velocity of 3.8 feet per second and an approximate maximum of 5.5 fps. The maximum flow over the "gut" dam is 107 cubic feet per second with an average velocity of 2.6 feet per second and an approximate maximum of 3.5 fps. All flows were calculated using the standard weir equation.

It is interesting to note that during the odor occurrence in July, 1970, the tides rose to 6.5 feet, the minimum for that month. At this time, only 0.5 feet of water flowed over the crest of the main dam. This was equivalent to about 194 acre-feet of water per day assuming two tidal cycles. When compared to the average flushing volume of 504 acre-feet per day, only 38% of the average flushing volume was available to cleanse the pond during this period.

The amount of cooling and cleansing water which enters Cove Pond from Long Island Sound can be increased by partially opening one or more of the six "guillotine type" gates in the main dam. On the basis of an underwater inspection, it was determined that the gates can be removed without damaging the structure. The consequence of removing one tide. It is estimated that the water level of the pond could be dropped as much as 1.5 feet during low water without exposing large areas of "mudflats". A drop in elevation of 1.5 feet is equivalent to removing 282 acre-feet of water from Cove Pond. Based on a gate width of 12 feet, it would take almost 12 hours to drop the level of the lake 1.5 feet with one gate open and no tidal inflow. Tidal inflow would occur within 12 hours and the water level would never drop a full 1.5 feet.

Thus, if one gate could not be replaced immediately after it was experimentally removed, there would be no danger of draining the pond. Ideally, the gate should be partially opened on a trial basis to determine the maximum velocity available without "washing out" the foundation of the dam.

By experimenting with one or more gates, a tolerable area of exposed shoreline could be determined while simultaneously insuring the maximum realistic level of flushing action.

VI. EUTROPHICATION

The situation found in Cove Pond is not an uncommon one when one considers the various factors which lead to eutrophication. Industrial effluents introduced to the system, sewage, shallow depths, and reduced flushing all contribute to producing a situation in which eutrohpication occurs.

Shallow depths and limited flushing action are two more factors which must be considered here. Temperature is a critical regulator of biological processes. Jackson, (16), in his study of Lake Pymatuning documented the increased phytoplankton production during the summer months. In a shallow body of water such as Cove Pond maximum water temperatures for any given group of climatic conditions can be sustained. As a result, the system is at maximum production for a given energy input. In a case where excessive nutrients have accumulated and are not removed by adequate flushing the system production is limited only by time and available energy. Brylinsky (9) points out that although excessive nutrients may be present in a system, the energy, i.e. sunlight or solar energy, must be present in order for eutrophication to occur. The literature will support the fact that excessive growths usually take place during the summer months, i.e., when maximum energy is available.

Eutrophication is accelerated as nutrients are added by man through industrial, and municipal sewage, including septic tanks. Human waste, even when treated in a secondary sewage treatment plant still contains phosphorus and nitrogen, both of which are necessary for abundant plant growth.

Many of the consequences of eutrophication are obvious. The water becomes clogged with weeds and boating and fishing become difficult. Other consequences of eutrophication are less obvious. As algae and waterweeds die, the plants settle to the bottom where bacteria and fungi break them down. As the water temperature starts to rise, particularly during the summer months, the bacteria increases its growth rate, thus the biological decomposition of the algae and waterweed is partially temperature dependent. Therefore, only part of the algae and aquatic weeds are converted to plant and animal food. The large amount of decaying vegetation depresses the oxygen level of the water because bacteria and fungi use the water's dissolved oxygen to break down the plants. As the amount of available oxygen decreases, anaerobic bacteria, those not requiring oxygen, begin to predominate. These bacteria breakdown the plants very slowly, producing hydrogen sulfide in the process.

Cove Pond appears to be in an advanced state of eutrophication. The situation was inevitable. As the watershed area of Cove Pond has increased in population, more homes and industrial areas have been built. The industrial and domestic wastes are being dumped into the Noroton River. Due to an apparent lack of flushing ability in Cove Pond, the estuary traps a great deal of the pollution introduced upstream in the Noroton River. Over a number of years these pollutants have accumulated on the bottom of the pond.

As waste loads increase beyond the River and Pond capacity to dispose of them, eutrophication takes place. The flow of the effluent and influent are not controlled or balanced and bottom wastes and sediments act as sludge. The long term natural demise of the estuarine system has been accelerated by the introduction of man-made pollutants. Runoff has deposited an appreciable amount of sediment on the bottom of the pond making the pond shallower each year and raising the water temperature, which aggravates the already unbalanced pond system.

The worst consequence of this eutrophication reported occurred in July, 1970. Cove Pond was simultaneously affected by low tides and a heat wave. The result was that the plant population of the pond was destroyed, producing an obnoxious odor as the vegatation decayed.

At present, the man-made discharges into the Noroton River and later into Cove Pond are becoming increasingly tolerable. The worst offender seems to be the septic tank. On touring the adjacent Darien area numerous sewage overflows from septic tanks were observed. The effluent is eventually carried into the pond by storm drains and natural runoff. Future plans specify that septic tanks will be eliminated and the effluent will be transported to a sewage treatment plant via a sewer system.

Even if all man-made nutrient sources were eliminated, in all probability eutrophication would persist due to natural nutrients, the shallow pond depth, and sediment supplied by the river and through the inlet.

The elimination of man-made nutrient sources then is only part of the solution. A greater degree of flushing will have to be initiated to relieve the oxygen level depression which will continue to occur in the summer months. Increased flushing would hopefully relieve the pond of some of the sediment load which it is now receiving and, depending on grain-size distribution of the bottom sediments, promote an acceptable depth. It is recommended that this acceptable depth be determined by a detailed analysis of the pond bottom, flow quantity, etc.

VII POSSIBLE SOLUTION TO THE ODOR PROBLEM

A. Treatment Procedure

Several alternate methods for the treatment of odor problems at Cove Pond were considered. These included chemical treatment, mechanically induced aeration, and natural flushing with and without dam. Part of the difficulty with choosing an adequate solution, is the relatively limited amount of field data available on flow rate, tidal current phasing, bottom sedimentation and water quality.

Chemical treatment of the waters of Cove Pond had been considered prior to this report. It is felt that the use of chemical additives such as Copper Sulfate and Potassium Permanganate should be discouraged. Although they may provide temporary relief, their effectiveness is, at best, limited. In the long term, they may upset the biological balance of the pond and generally cause an increased accumulation of organic material on the bottom of the basin.

Increasing the dissolved oxygen content of the pond waters by the use of mechanical aerators was also considered. Discussions with several manufacturers of such equipment led to the conclusion that such devices would not be appropriate for Cove Pond. Due to the shallow depth of the estuary, aerators would severly stir up the bottom material and, in general, would not alleviate the problems. In fact, the overall effect might be detrimental.

Removal of the dam at Cove Pond was another measure considered to relieve the situation in the estuary. Elimination of this structure, however, would expose extremely large areas of mudflats. The shaded area in Figure 3 indicates the areas of the bottom which would be visible at mean low water if the dam were not present. The results of this exposure would be disastrous. In all probability, these areas would be extremely malodorous.

In the long term, the assumption that the mudflats would cleanse themselves, may be false. Without more detailed knowledge of the chemical and physical makeup of the bottom sediments it is difficult to make a definitive statement to that effect. However, judging from the limited samples available sediment size distribution appears to be such that movement of this material by the available currents would be unlikely. At the same time, beneficial effects of the dam in terms of flood control and hurricane protection would be lost.

As a result, increasing the level of tidal flushing by one of the two following means seems to be the most feasible alternative.

1. Put check valves in the lower part of the gates. This would selectively remove nutrient rich, low D.O. water, possibly without the need to increase the total tidal volume received by the pond during each tidal cycle. However, check valves have a tendency to jam.
   During the winter months, lower the water level to flush the bottom by experimenting with one or more gates. The gates should be opened during high slack tide to facilitate handling. A trade off technique between a tolerable area of exposed shoreline and maximum level of flushing action could be made to decide the number of gates to be opened.

B <u>Required Flushing</u>

Assuming all man-made wastes are eliminated in the future, an ultimate biochemical oxygen demand will still be exerted by natural run off. Based on a basin area of 870,400 acres, the BOD load of 8,157 lbs. per day will be present in Cove Pond. By applying a simplified Math Model developed by the Environmental Protection Agency (22), the resultant dissolved oxygen level can be calculated for Cove Pond based on its physical characteristics and BOD load.

Using the present estimated dilution flow of 194 acre feet per day, a D.O. level of 3.2 mg/l is projected for low flow conditions. This D.O. level is an indication of poor water quality. To raise the D.O. level to a more acceptable level of 4.5 mg/l a low flow of 356 acre feet per day would be necessary.

In order to obtain the required level of flushing action, it would be necessary to lower the water level in the pond some 2.5 to 3 feet. The result would be the exposure of large areas of mudflats around the periphery of the pond. This water level depression, however, could probably be obtained through judicious use of the six tidal gates located at the ends of the dam. It is felt that an overall water level depression of one foot throughout the year would partially relieve the situation without exposing an excessive area of malodorous mudflats.

C. Conclusions

Several points need be made in reference to the aforementioned recommendations. All are based on limited field data and information.

Increased flushing of the estuary will supply some relief to the pond in terms of alleviating odor problems, however, the above recommendations do not afford a long term solution to the problems at Cove Pond. At best, the eutrophication of the estuary can be decelerated. A far more extensive effort must be made to obtain the data necessary to fully understand the many variables affecting the Cove Pond estuarine system. In all likelihood it will be necessary to consider a major dredging operation to fully restore the pond to a desirable, natural balance.

APPENDIX A

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APPENDIX B.

Report on Visual Inspection of Cove Pond Dam

REPORT ON VISUAL INSPECTION - COVE POND DAM

Stamford-Darien, Connecticut

Personnel Involved: Joseph Bonasia, E. Schmeltz, R.L. Cook

On 10 March 1973 diver examination of Cove Pond Dam was carried out by E. Schmeltz and R.L. Cook. The principal objective was to evaluate the general condition of the overall structure with specific interest in the two sets of three tidal gates located on each end of the rubble mound. A general reconnaisance of the area was also undertaken in the hope of gathering information which might prove useful in subsequent treatments of the overall problem at Cove Pond.

Since the side of the dam facing Long Island Sound is exposed during periods of low tide, visual examination of that face of the structure was carried out during periods of low water. Photographs of this portion of the structure, including points of specific interest, are forthcoming. These will be supplied by Mr. Cook.

During periods of slack low water, considerable quantities of water continue to flow over the dam at several points. The indication is that some settling may have occurred in these areas. These regions are on the easterly end of the dam just inside the concrete monoliths, housing the tidal gates. However, the basic structure appears to be sound.

At several points along the face of the structure upwelling was noted. The source is now known, however, it is probably a valid assumption that this upwelling is a result of flow under or through portions of the dam. Investigations of the back of the dam in the vicinity of these flows yielded no clues as to their probable source.

The entire surface of the structure is covered with an extensive biological overgrowth, primarily in the form of muscles. The thickness of the growth varies considerably.

Flow conditions over the dam have caused a great deal of material to be deposited on the back side of the structure. These accumulations are primarily biogenous in nature consisting in large part of fragments of muscle shells with some coarse sand also present. The exact extent of this sedimentation is difficult to assess without more extensive field work. A small sample of this material was taken for future reference.

The poured concrete structures used to house the gate systems were subjected to an intensive examination and appear to be in generally excellent condition. No visible signs of deterioration could be found.

The gates are of guillotine construction with 8-10" wide wooden planks providing the body of the system. A steel frame fixes all the planks into a unit and is provided with six pull points to facilitate removal. A sketch is attached. Figure No. 6.

The general condition of the gates seemed to be good. Rotting of the wooden parts of the gates or attack by marine organisms was not apparent. Damage to the steel members is limited to surface corrosion. Due to the extremely poor visibility, no photographs were attempted.

Of considerable interest when considering the possible removal of the gates is the extreme amount of material which seems to have accumulated in the sluiceways on either side of the gates. This accretion consists of small stones, muscles, and sand. The extent of these accumulations can be determined by a comparison of the accompanying sketches and any available drawings of the system.

The material piles against the gates are relatively soft and should not prove difficult to remove. With the use of a knife, the divers were able to dig one to one and one-half feet down into the accumulation with little difficulty.

Sediment sample around and in the inlet were obtained for future analysis.

Recommendations:

1. A survey of the top of the dam should be conducted to determine if settling has occurred and, if so, to what extent.
2. One or more of the gates should be dug out and a further inspection conducted with more of the structure visible.
3. The local office of the Army Corps of Engineers should be contacted concerning any objections they may have to opening the gates. An environmental impact statement may be necessary.
4. Locate a sample of the gates or drawings thereof.

Conclusions:

Given the results of this inspection, there seems to be no reason that the gate systems in Cove Pond dam cannot be opened if this is deemed desirable. The accumulations in the sluiceways would necessarily have to be removed, however, this should not pose a major problem.

It appears at present that any damage that might occur would be on the gates themselves and not on the surrounding structures.

At this point in time the dam at Cove Pond seems to be basically sound. The results of a survey would be helpful in assessing the extent of any necessary repairs. However, from a visual standpoint there appear to be no major defects in the system.

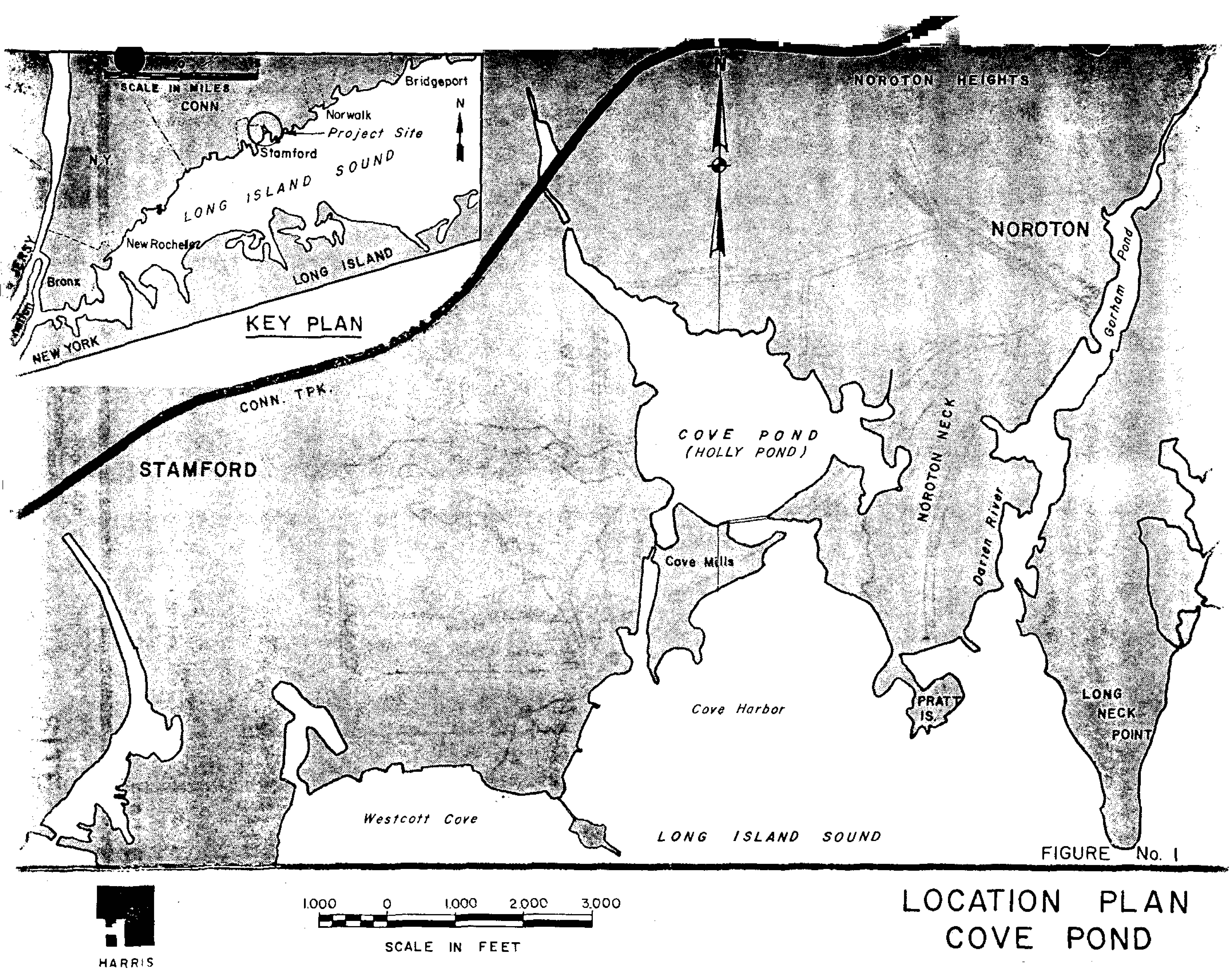


FIGURE No. 1

LOCATION PLAN
COVE POND

HARRIS

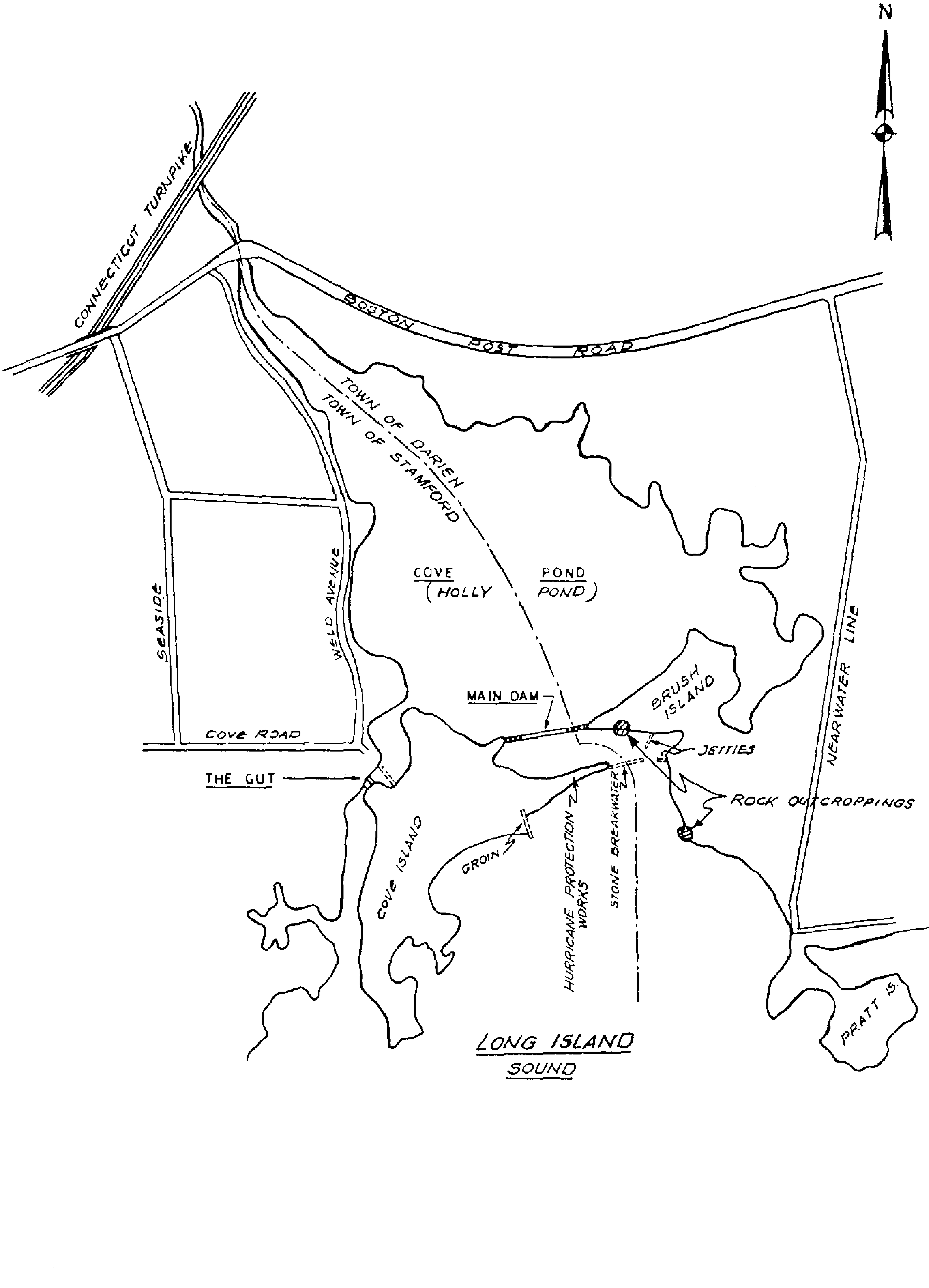
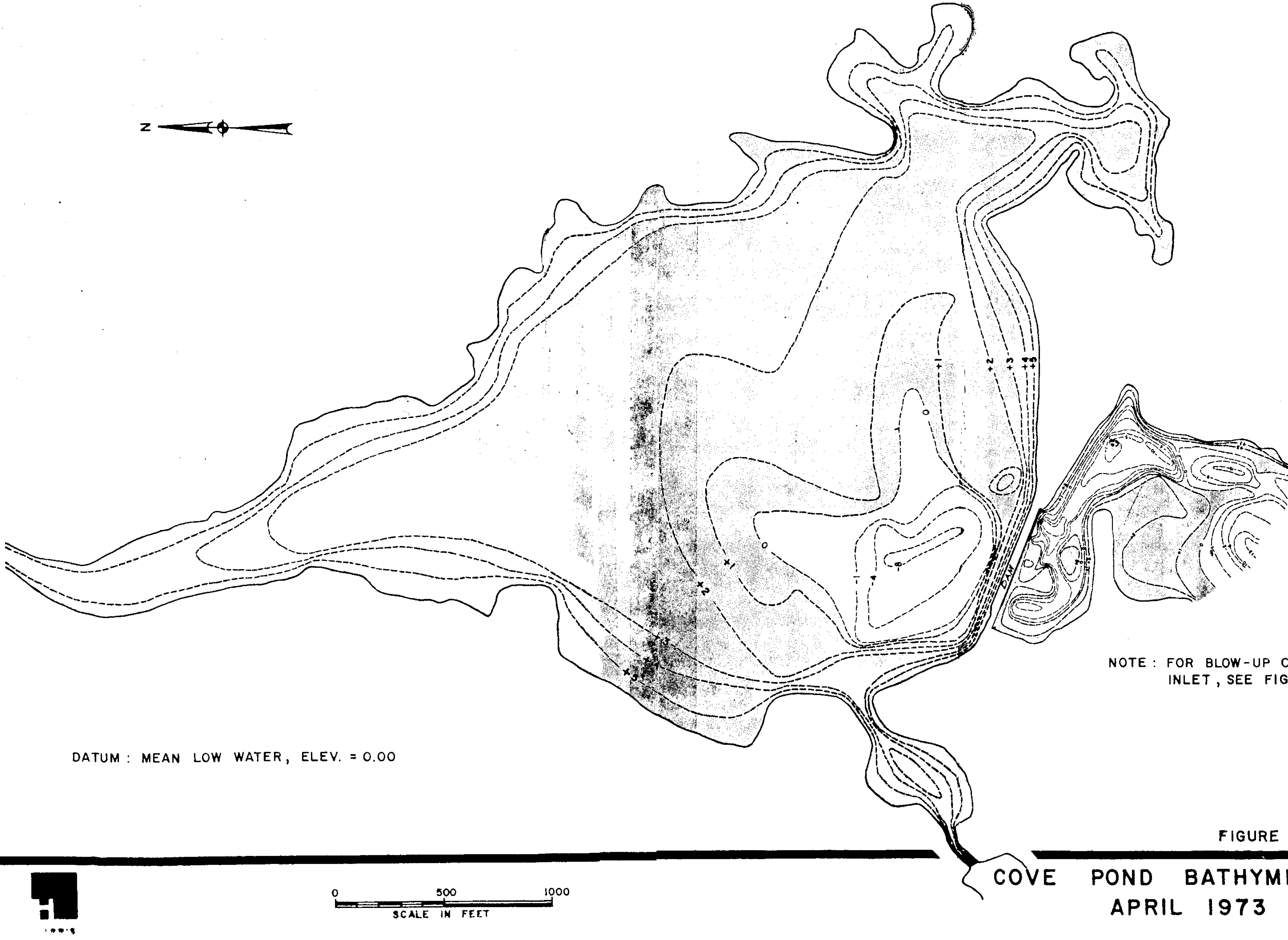


FIGURE No. 2

200 0 400 800

SITE DETAIL

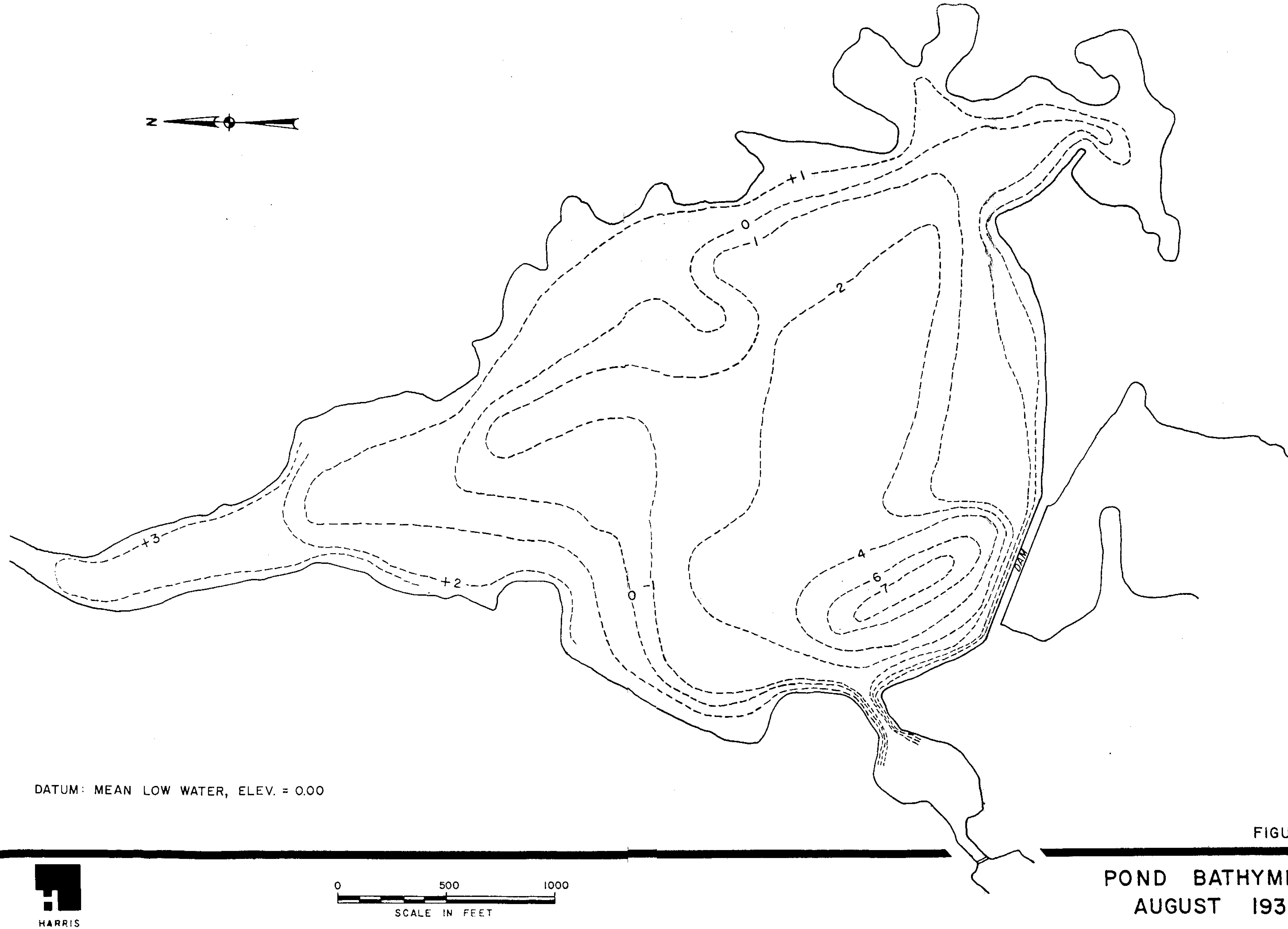


DATUM : MEAN LOW WATER, ELEV. = 0.00

NOTE : FOR BLOW-UP OF INLET, SEE FIG. 5

FIGURE No. 3

COVE POND BATHYMETRY
APRIL 1973

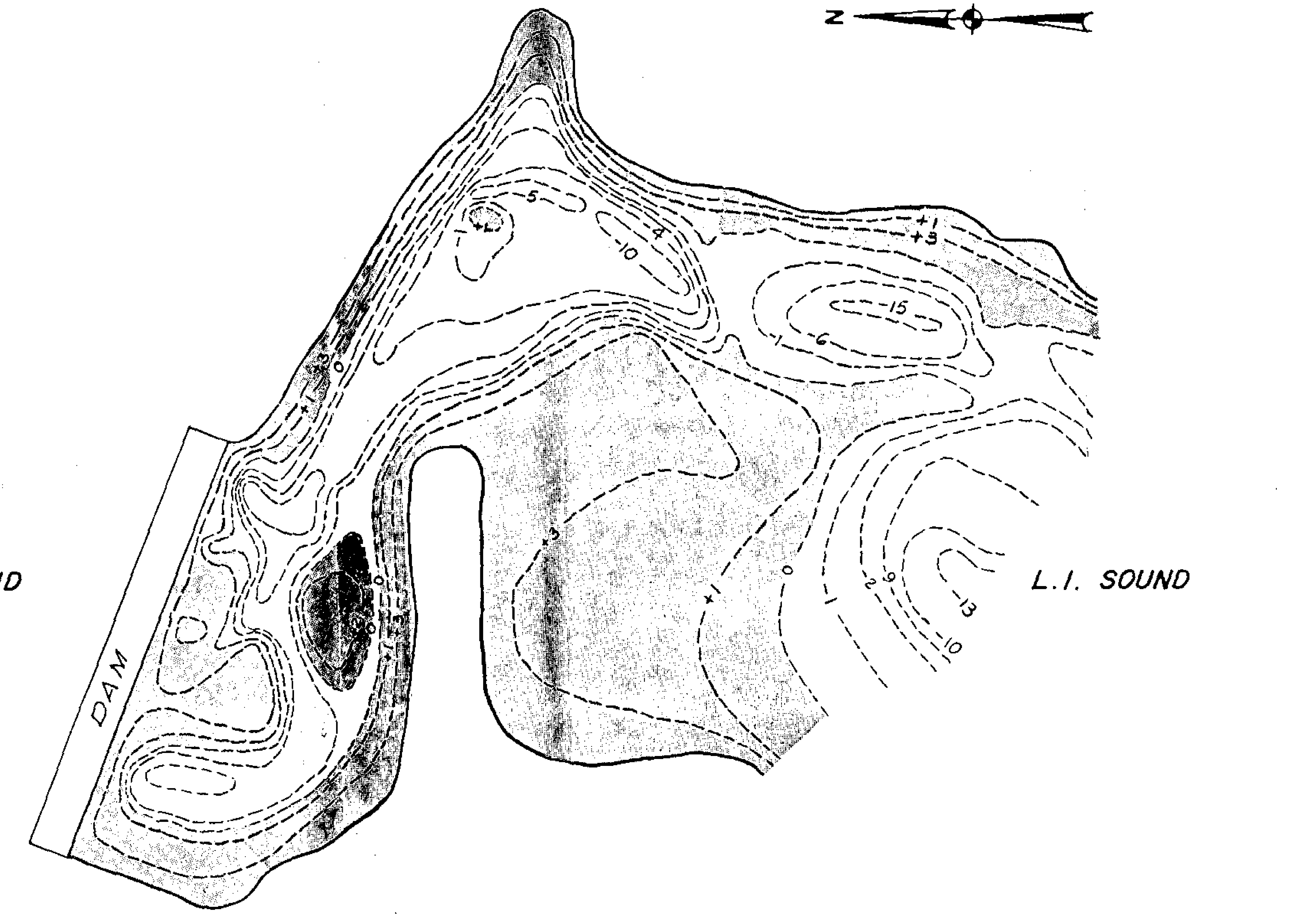


DATUM: MEAN LOW WATER, ELEV. = 0.00

HARRIS

FIGURE No. 4

POND BATHYMETRY
AUGUST 1935

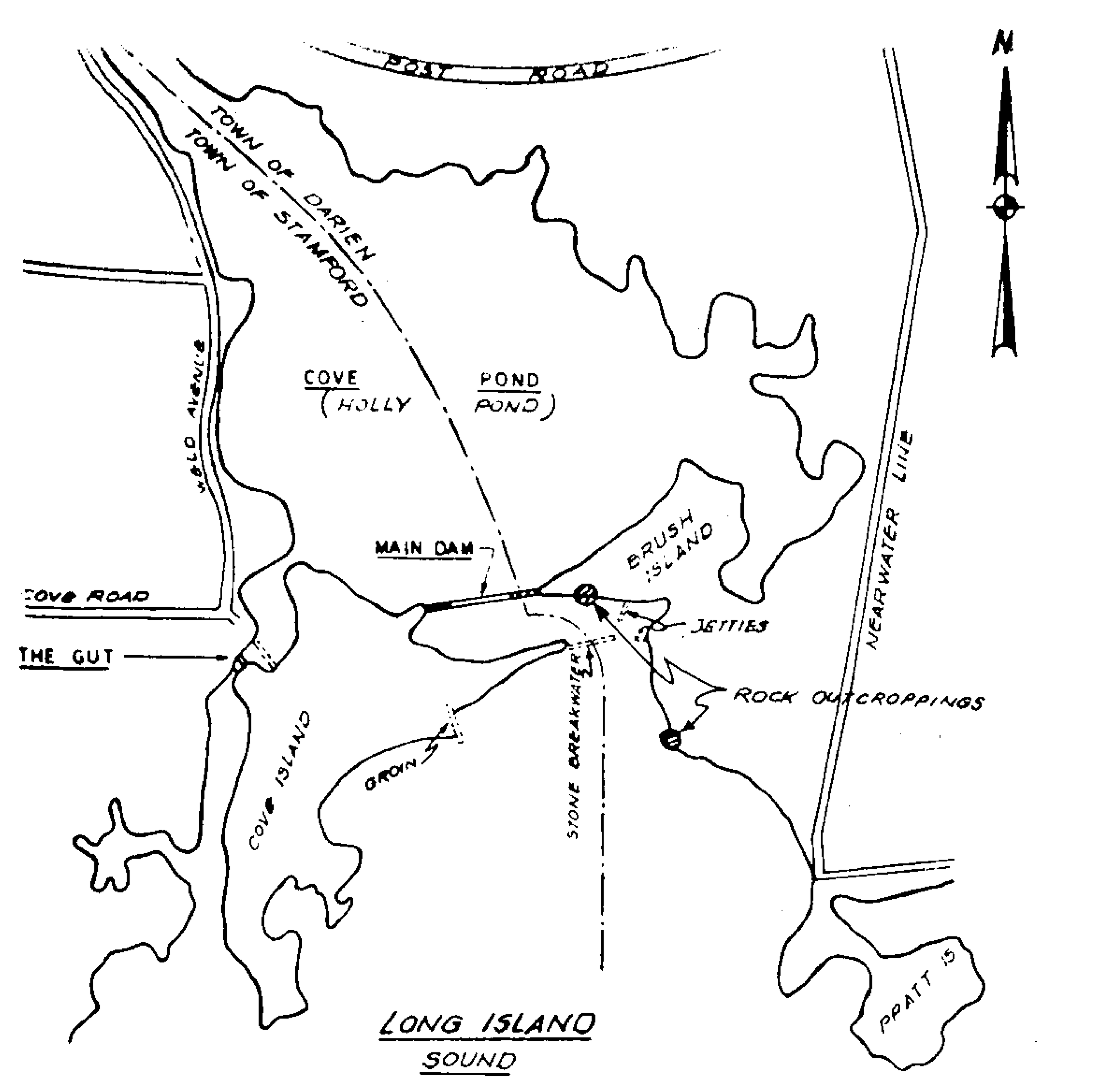


DATUM: MEAN LOW WATER, ELEV. = 0.00

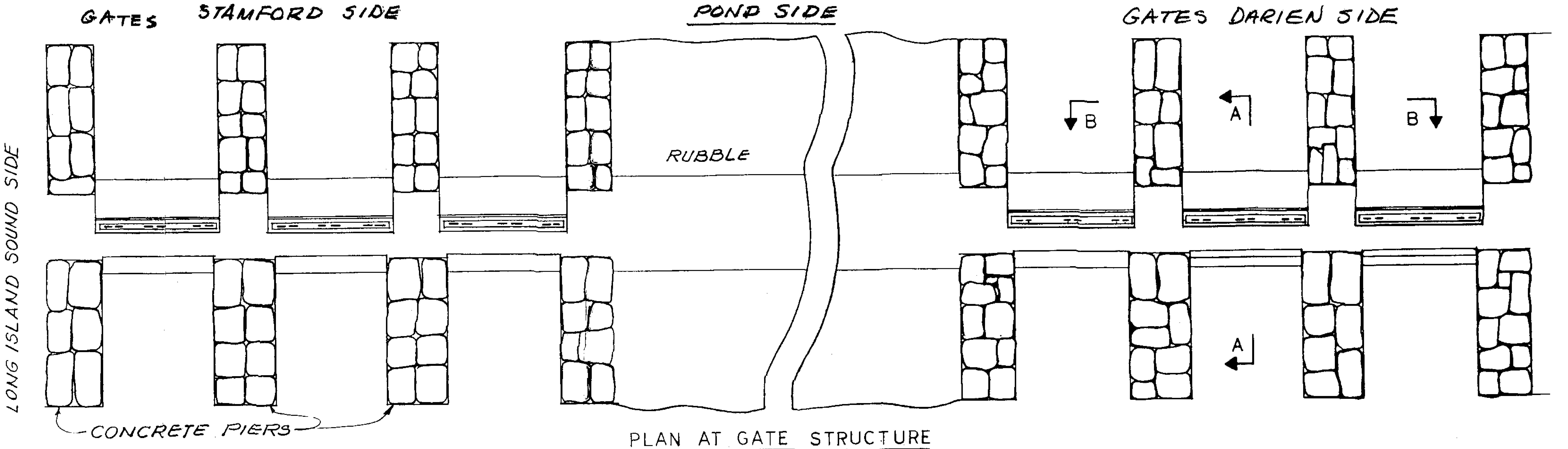
FIGURE. No. 5

INLET BATHYMETRY
APRIL 1973

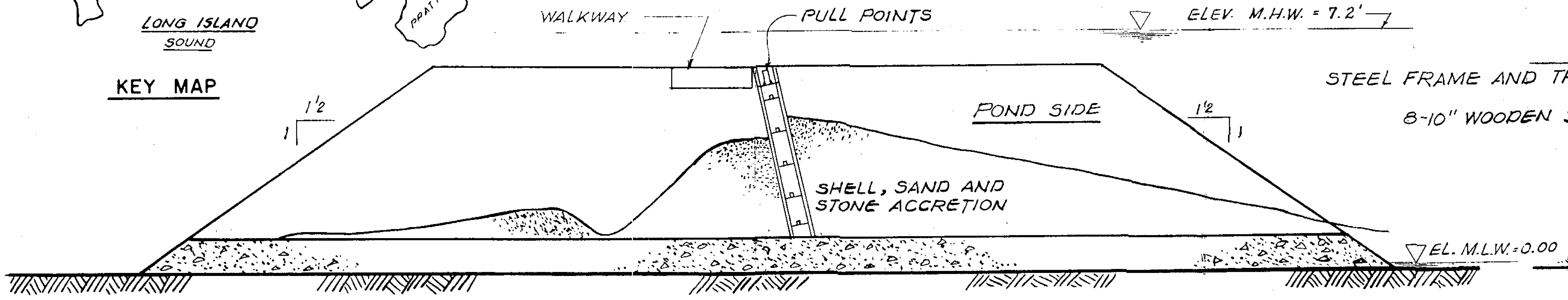
HARRIS



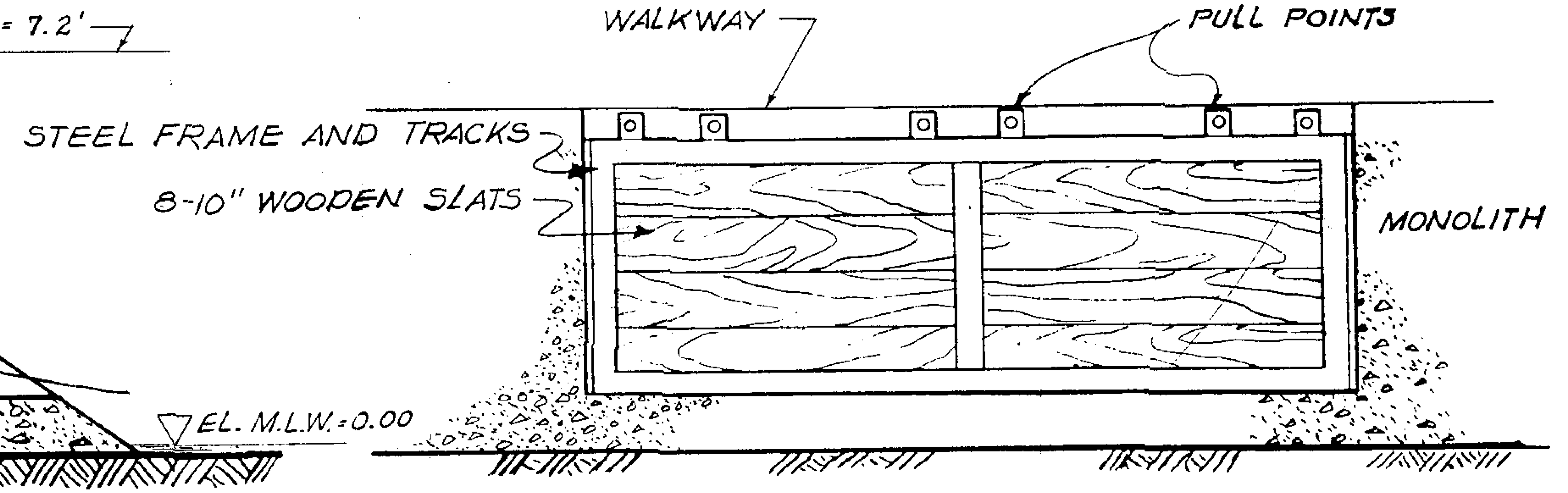
KEY MAP



PLAN AT GATE STRUCTURE
SCALE: 1"= 10'-0"



SECTION THRU GATE A-A
SCALE : 1"= 3'-0"



SECTION B-B
SCALE : 1"= 3'-0"

DATUM: MEAN LOW WATER

FIGURE No. 6

HARRIS

DIVER'S SKETCH – COVE POND DAM AND ASSOCIATED GATES

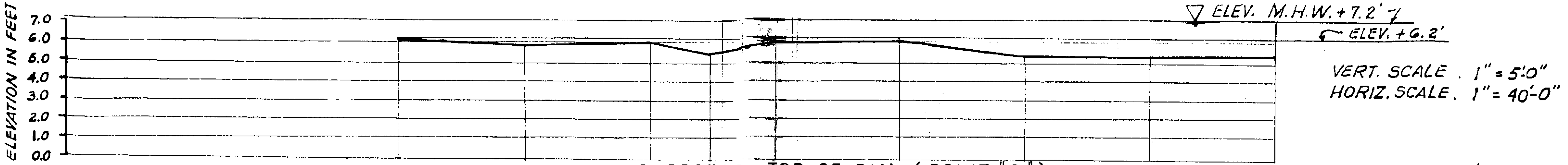
CROSS-SECTION TYPICAL

SCALE: 4" = 1'-0"

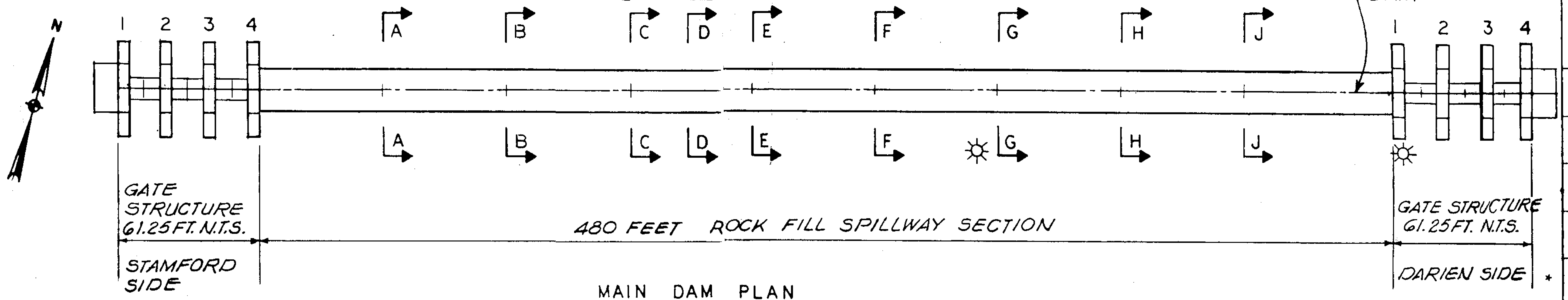
SOURCE: CONSTRUCTION DRAWINGS:
CITY OF STAMFORD
FLOOD & EROSION CONTROL BOARD
COVE POND DAMS
APRIL 1960

FIGURE No. 7

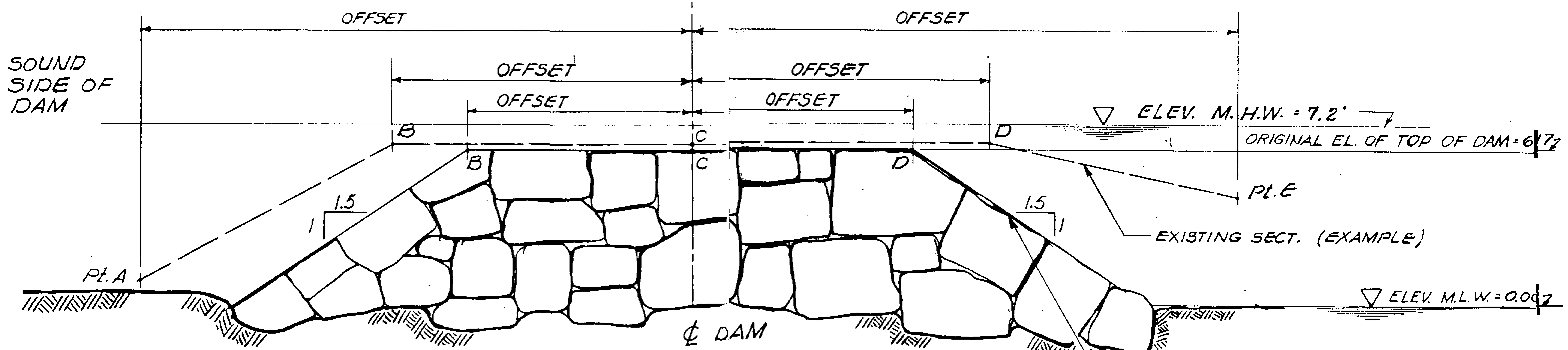
TYPICAL DESIGN CROSS-SECTION
COVE POND DAM



℄ PROFILE TOP OF DAM (POINT "C")



MAIN DAM PLAN
SCALE: 1" = 40'-0"



TYPICAL SPILLWAY SECTION
SCALE: 1" = 4'-0"

TABLE OF DAM ELEVATIONS AND OFFSETS

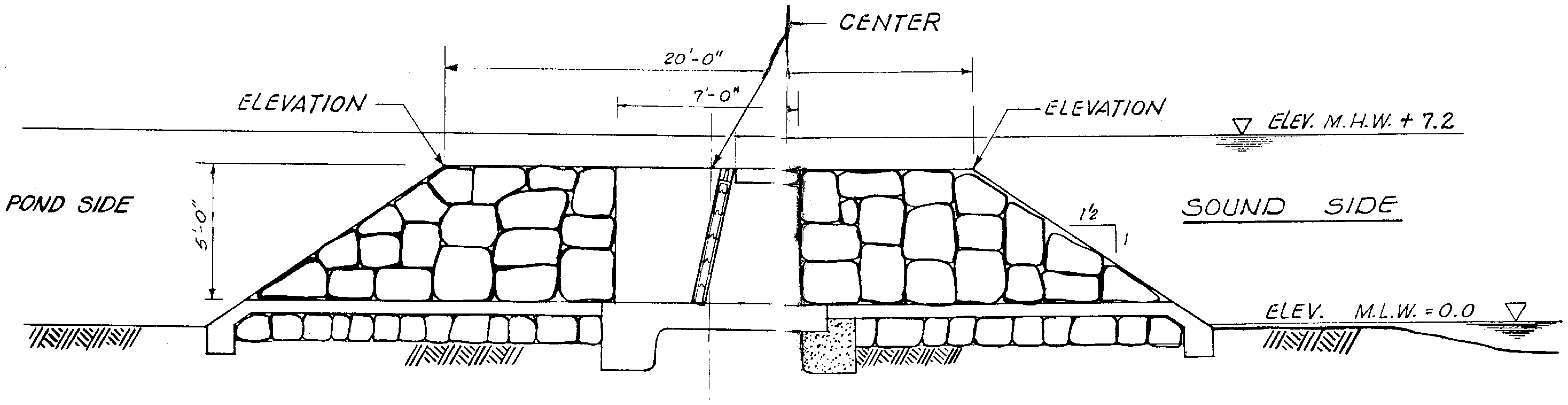
EL. DATUM M.L.W.	Pt. A		Pt. B		Pt. C	OFFSET	Pt. D	Pt. G	Pt. E	Pt. J
	ELEV. FT.	OFFSET FT.	ELEV. FT.	OFFSET FT.	ELEV. FT.		ELEV. FT.	OFFSET FT.	ELEV. FT.	OFFSET FT.
ORIG. SECT.	SEE SLOPE		6.2	9	6.2	0	6.2	9	SEE SLOPE	
SECT. A-A	1.5	23	5.0	12	5.9	0	5.9	12	2.4	22
SECT. B-B	0.8	22	5.9	12	6.2	0	6.1	12	3.6	22
SECT. C-C	1.3	19	5.1	12	6.2	0	6.0	10	3.7	20
* SECT. D-D	1.1	18	5.8	8	5.5	0	5.6	12	3.0	22
* SECT. E-E	2.3	17	5.8	8	6.1	0	6.1	10	4.6	20
* SECT. F-F	2.2	19	5.6	9	6.2	0	6.3	10	3.2	20
* SECT. G-G	N.A. Because of Flow		5.3	10	5.4	0	5.2	10	N.A.	
* SECT. H-H	N.A. Due to Flow		5.2	7	5.4	0	5.7	11	1.0	18
* SECT. J-J	N.A. Due to Flow		5.4	6	5.5	0	5.4	11		

*INDICATES FLOW OVER THE DAM AT LOW WATER

☼ INDICATES AREAS OF UP WELLING OBSERVED

FIGURE No. 8

ELEVATIONS AND OFFSETS
COVE POND DAM - APRIL 1973



SCALE : 1" = 4'-0"

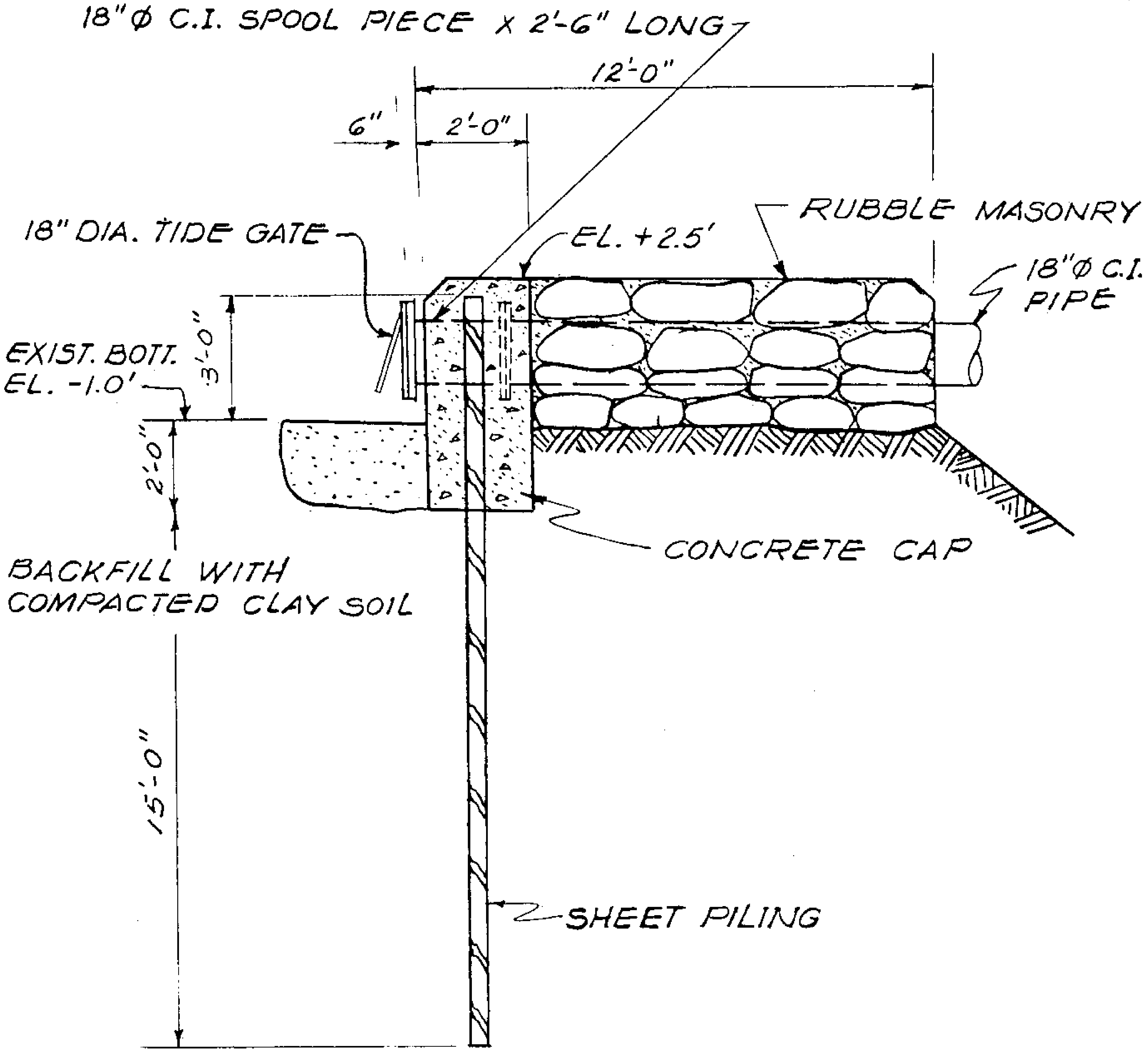
NOTE : FOR FRONT VIEW OF GATE SEE SECTION B-B, FIGURE 6

GATE MONOLITH ELEVATIONS

MONOLITH	STAMFORD			DARIEN		
	SOUND EDGE	CENTER	POND EDGE	SOUND EDGE	CENTER	POND EDGE
1	6.0	6.0	6.0	5.9	5.9	5.9
2	6.0	5.9	6.0	5.9	5.9	5.8
3	6.0	6.0	6.0	5.9	6.0	6.0
4	5.9	6.0	5.9	5.9	6.0	5.9

FIGURE No. 9

GATE HOUSING ELEVATIONS
COVE POND DAM APRIL 1973



THE GUT SECTION

SCALE 1/4" = 1'-0"

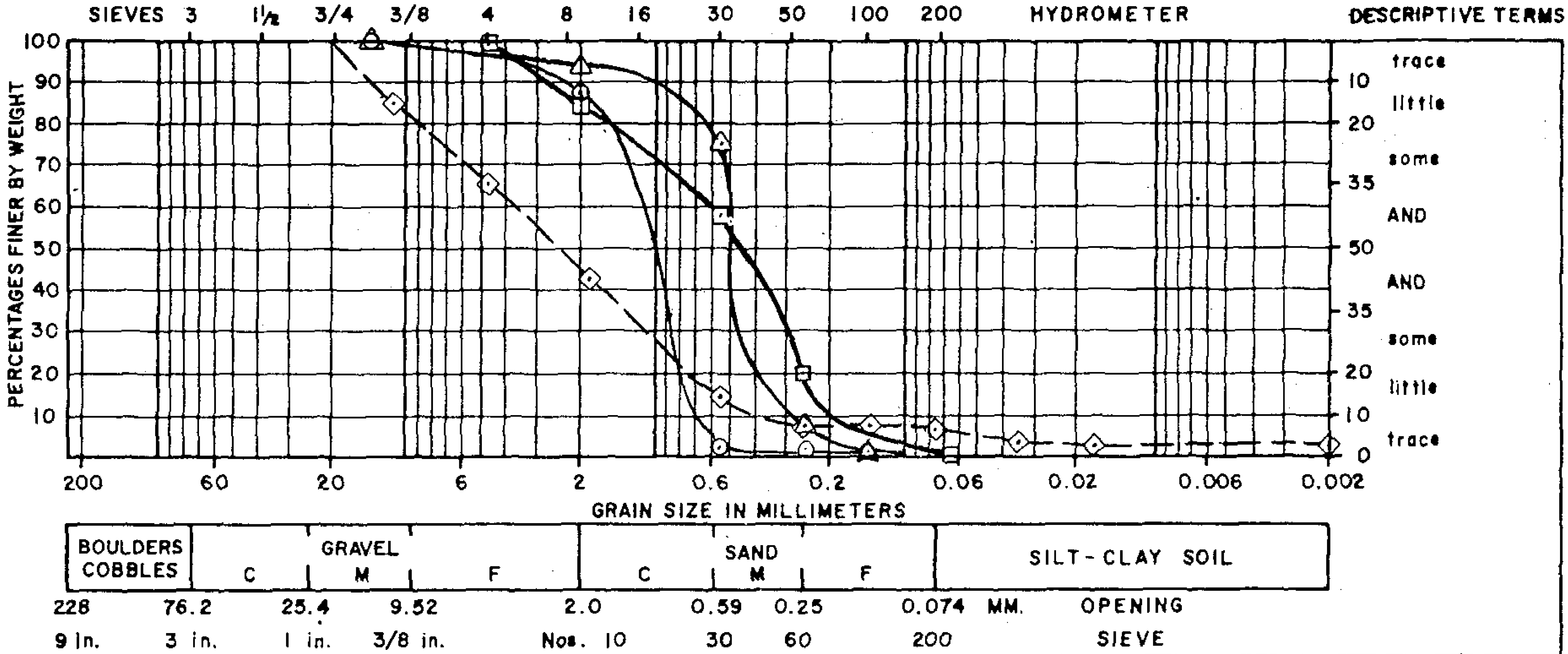
DATUM: MEAN LOW WATER

FIGURE No. 10

TYPICAL SECTION
"GUT" DAM - COVE POND

GRAIN SIZE ANALYSIS

IDENTIFICATION AND DESCRIPTION OF SOILS



SYMBOL	SAMPLE	DESCRIPTION
□	1	Littoral Material - (Stamford)
△	2	Littoral Material - (Darien)
○	3	Inlet Sample
◇	4	Pond Side of Dam

FRH 522

FIGURE No II

SEDIMENT SIZE DISTRIBUTION

HARRIS

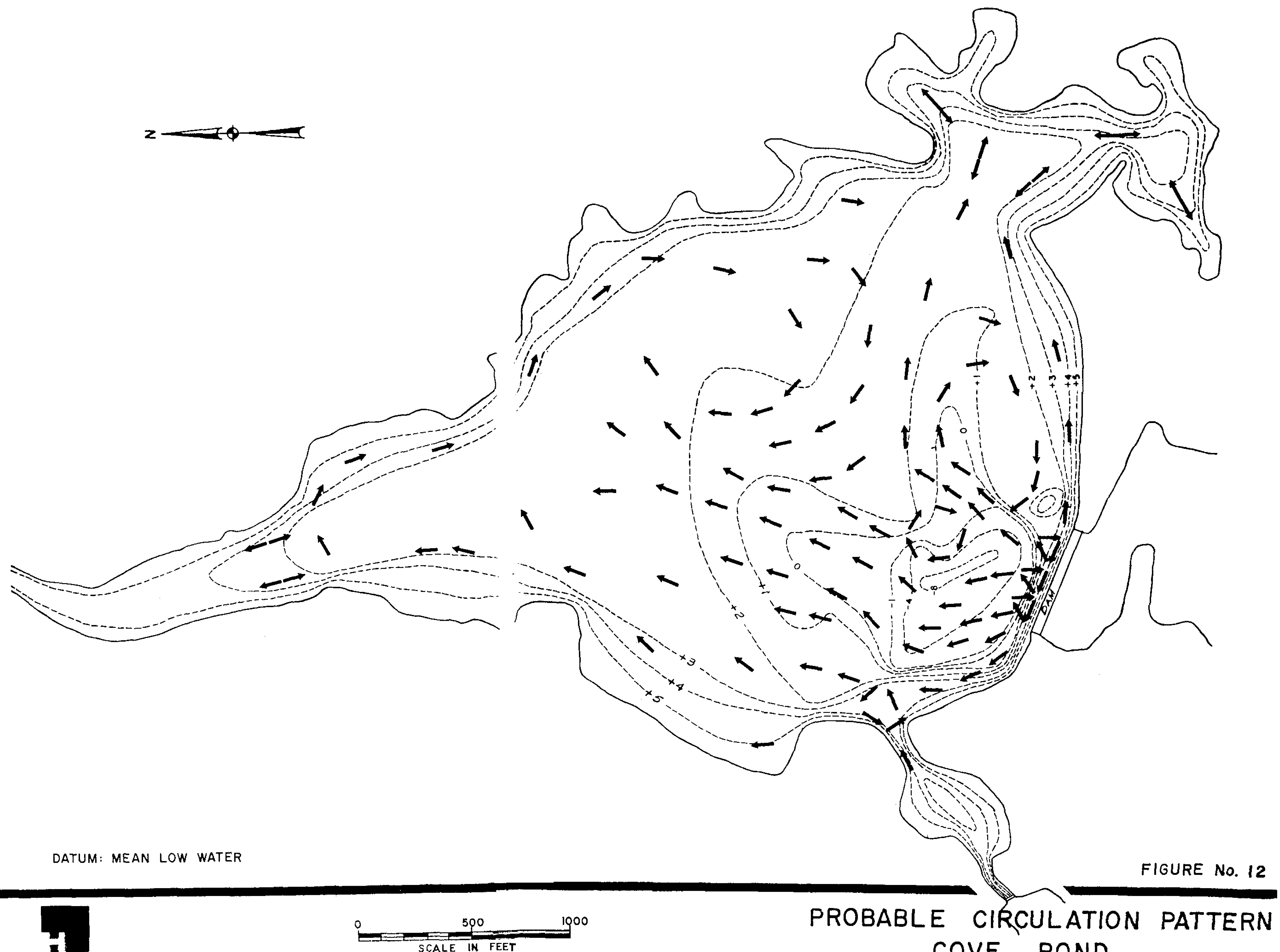


FIGURE No. 12

PROBABLE CIRCULATION PATTERN
COVE POND

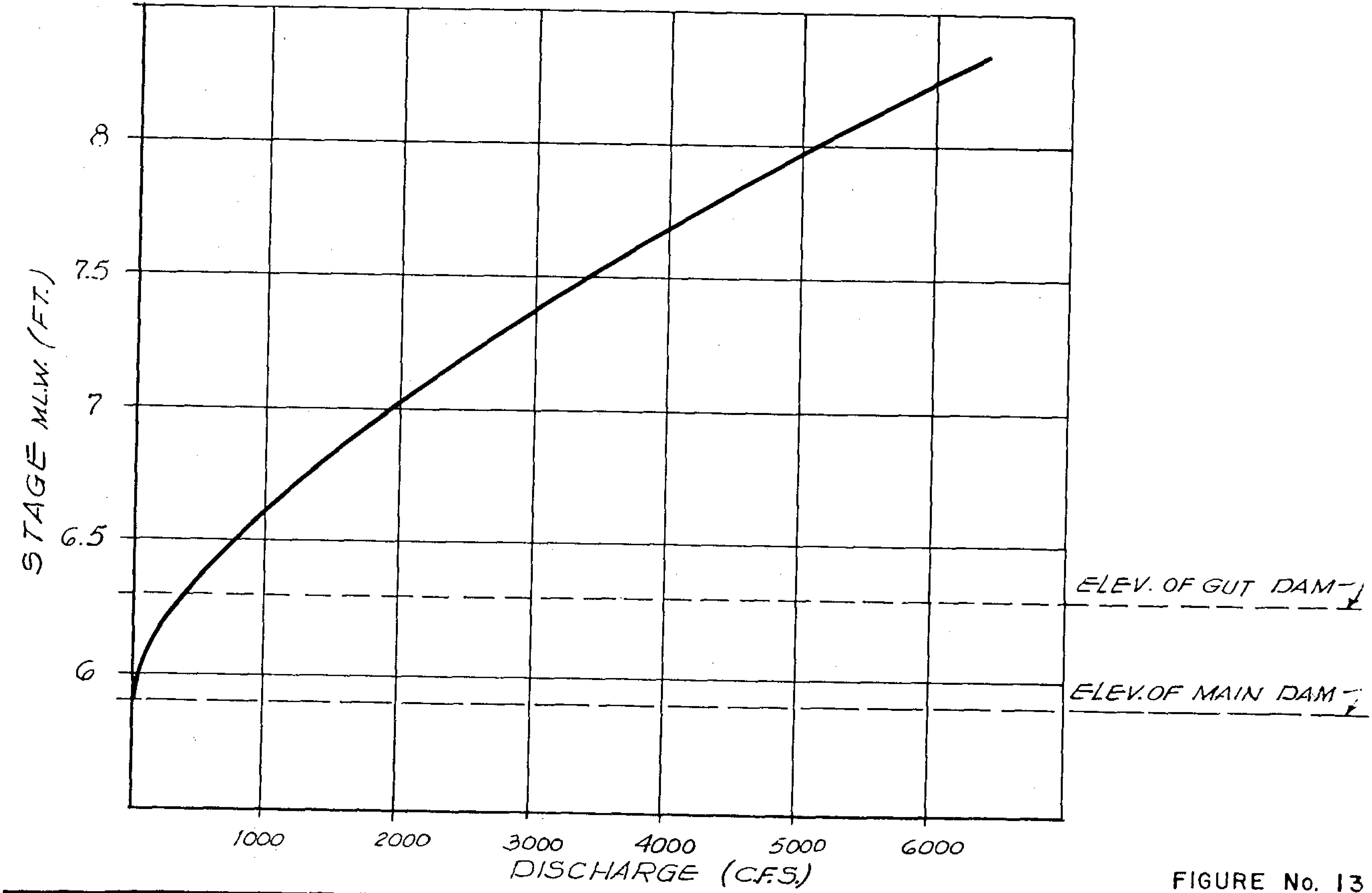


FIGURE No. 13

HARRIS

STAGE DISCHARGE
RELATIONSHIP FOR COVE POND

APPENDIX C.

Water Quality Sampling Program, Noroton River Stamford

WATER QUALITY SAMPLING PROGRAM

STATION NO LWS-4 LOCATION NOROTON RIVER - STAMFORD

DATE	TIME	TEMP °C	DO	COLIFORM MPN PER 100 ML	COLIFORM MF PER 100 ML	E. COLI MPN PER 100 ML	E. COLI MF PER 100 ML
7-10-67	9:30	–	6.3				
	12:30	26	4.9				
	3:30	–	14.0		3400		
	7:30	28	13.2		3200		
9-13-67	8:45	19	4.6				
	12:15	19.	11.4		100		
	1:45	20	12.5				
	5:45	20	11.7		50		
5-8-68	9:00	15	10.1		2100		
	11:00	15	7.1		2500		
	1:00	15	11.9		2100		
	3:00	14	13.0		1200		
7-8-68	8:50	22	11.9	4600	2400	2400	700
	10:50	23	13.0	240	2600	240	90
	1:10	24	12.9	2400	12000	2400	2900
	2:50	25	13.2	4600	1400	460	200
8-28-68	9:15	22	(8.0)	1500	1400	1100	300
	11:15	22	5.2	1500	600	750	400
	1:15	24	7.3	11000	29000	11000	700
	3:15	24	13.7	2400	700	240	6100
5-7-69	9:30	15	10.2		760		
	11:30	16	11.0		190		
	1:30	16	11.6		170		
	3:40	16	11.8		90		
6-30-69	8:15	22	6.8				
	10:15	23	8.7				
	12:15	25	10.4				
	2:15	26	11.4				
8-6-69	9:20	23	7.6	930	1600	230	
	11:20	23	8.5	24000	2200	930	
	1:20	25	9.0	4600	1100	230	
	3:20	26	9.2	2100	1000	430	
4-27-70	9:20	15	11.6	24000	20000	11000	
	11:25	16	11.6	24000 "	19000	24000	
	1:25	18	11.8	2400	2700	93	
	3:20	19	12.3	2400	3000	150	
6-24-70	9:20	21	10.3	2400	560	240	
	11:20	22	11.9	1100.	900	460	
	1:20	24	13.0	2400	780	240	
	3:20	27	13.3	2400	1000	2400	
8-5-70	9:15	23	(0.0	2100	3700	240	
	11:15	22	0.0)	2400	2400	460	
	1:15	23	[illegible]	4600	7100	2400	
	3:15	23	0.0	2400	620	2400	

WATER QUALITY SAMPLING PROGRAM

STATION NO. LWS #4 LOCATION NOROTON RIVER STAMFORD

DATE	pH	ALKALINITY: HYDROXIDE	ALKALINITY: CARBONATE	ALKALINITY: BICARBONATE	DISSOLVED SOLIDS: TOTAL	DISSOLVED SOLIDS: FIXED	DISSOLVED SOLIDS: VOLATILE	TEMPERATURE °C	D.O.	BOD	TOC	TOTAL CARBON	CHLORIDE	TOTAL HARDNESS	SULFATE	SPECIFIC COND.	AMMONIA N	PHOSPHATE – P	ABS	IRON	COPPER	ZINC	COLOR	TURBIDITY
4/19/72	6.8	0	0	32	332			12 13	11.4 11.7	1.8	3	10	86	96	46	510	0.1	0.04	< 0.05	0.4	< 0.1	< 0.1	20	1
	6.9	0	0	31	247			15 16	11.8 11.8	2.8	4	10	57	86	49	380	0.1	0.04	< 0.05	0.4	< 0.1	< 0.1	20	1
6/14/72	7.1	0	0	38	403			18 18	8.7 9.2	1.4	5	13	129	107	40	620	0.3	0.05	< 0.05	0.4	< 0.1	< 0.1	31	0
	7.1	0	0	38	239			19 19	9.6 9.6	1.6	5	13	58	83	40	360	0.3	0.05	< 0.05	0.4	< 0.1	< 0.1	28	0
8-14-72	7.0	0	0	63	[illegible]			14 14	[illegible] 7.5	4.2	14	[illegible]	[illegible]	1310	420	1000	1.1	0.11	0.05	.25	<0.1	<0.1	20	2
	7.2	0	0	61	[illegible]			15 18	10.6 14.3	4.2	13	[illegible]	[illegible]	1220	420	[illegible]	0.3	0.08	0.05	0.5	<0.1	<0.1	2.0	2

CHANGE SODIUM CHLORIDE TO CHLORIDES (Cl)

WATER QUALITY SAMPLING PROGRAM

STATION NO Lws-4 LOCATION NOROTON RIVER - STAMFORD -

DATE	TIME	TEMP °C	DO	COLIFORM MPN PER 100 ML	COLIFORM MF PER 100 ML	E. COLI MPN PER 100 ML	E. COLI MF PER 100 ML
4-19-71	9:20 A	14	12.0	460	420	93	
	11:20 A	15	13.4	1500	830	140	
	1:20 P	17	13.3	240	290	93	
	3:20 P	18	12.7	460	230	93	
6-7-71	9:20	17	11.2	1100	490	75	
	11:20	23	9.3	11,000	6,400	93	
	1:20	23	13.8	2,400	320	430	
	3:20	23	13.4	2,400	2,200	93	
7/21/71	9:15	23	8.3	4600	3900	430	
	11:15	24	8.3	1100	290	240	
	1:15	24	9.7	4600	1600	240	
	3:15	24	10.0	11600	4700	240	
4/17/72	9:25	12	11.9	2100	790	93	
	11:25	13	11.7	24300	2100	1500	
	1:25	15	11.8	1100	360	23	
	3:25	16	11.8	1100	420	23	
6/14/72	9:20	18	8.7	750	260	72	
	11:20	18	9.2	4600	1300	460	
	1:20	18	9.6	240	380	93	
	3:20	19	9.6	11000	550	2.00	
8-14-72	9:20	14	2.3	4600	2100	930	
	11:20	14	7.5	2400	1500	150	
	1:20	15	10.6	930	430	230	
	3:20	18	10.3	7 24000	2700	11,000	

WATER QUALITY SAMPLING PROGRAM

STATION NO. LWS-4 LOCATION NOROTON RIVER STAMFORD

DATE	pH	ALKALINITY: HYDROXIDE	ALKALINITY: CARBONATE	ALKALINITY: BICARBONATE	DISSOLVED SOLIDS: TOTAL	DISSOLVED SOLIDS: FIXED	DISSOLVED SOLIDS: VOLATILE	TEMPERATURE °C	D.O.	BOD	TOC	TOTAL CARBON	SODIUM CHLORIDE	TOTAL HARDNESS	SULFATE	SPECIFIC COND.	AMMONIA N.	PHOSPHATE	A B S	IRON	COPPER	ZINC	COLOR	TURBIDITY
7-10-67	8.0	0	0	70	10,219	7627	2592	— / 26	6.3 / 4.9	<5			9405	1780	400		0.3	0.8	0.08	1.1	0.4	0.7		
	8.1	0	0	57	6524	5,209	1315	— / 28	14.0 / 13.2	<5			5445	1040	350		0.2	0.8	0.07	0.6	0.4	0.1		
9-13-67	7.5	0	0	76	14,613	14,350	2263	19 / 19	4.6 / 11.4	1.1			14,500	2920	1600		0.2	1.4	0.11	0.5	0.5	1.0	22	4
	7.2	0	0	42	493	382	111	20 / 20	12.5 / 11.7	4.1			227	132	80		0.2	1.4	0.1	1.4	1.2	2.1	45	13
5-8-68	7.3	0	0	48	6498	5338	1160	15 / 15	10.1 / 7.1	3.1			5100	1100	460	11,100	0.2	2.4	.05	0.6	0.1	<.1	23	5
	7.4	0	0	37	1348	1114	234	15 / 19	11.9 / 12.2	2.9			1200	360	120	2580	0.2	2.8	0.07	0.6	0.1	<.1	30	8
7-8-68	8.0	0	0	61	9310	8064	1246	22 / 23	11.9 / 12.0	2.9			7900	1580	660	15,300	0.1	0.2	<.05	0.4	<.1	<.1	32	4
	7.4	0	0	47	2006	1714	292	24 / 25	12.9 / 12.2	2.8			1700	390	150	4050	0.2	0.2	<.05	0.3	<.1	<.1	40	5
8-20-68	7.8	0	0	86	22,160	18,944	3216	22 / 23	2.0 / 3.2	7.1			19,000	4100	1880	23,000	<.1	1.1	0.11	0.5	0.1	0.3	32	6
	7.7	0	0	67	15,262	13,184	2078	24 / 24	7.3 / 13.7	7.4			12,300	2600	1160	14,000	<.1	2.0	0.08	0.5	0.2	0.5	45	8
5-7-69	7.0	0	0	32	454	341	113	15 / 16	10.2 / 11.0	1.8			304	120	72	630	0.2	0.5	0.08	0.5	0.2	0.6	26	2
	7.0	0	0	28	213	138	75	16 / 16	11.6 / 11.8	2.3			76	83	52	255	0.3	0.5	0.09	0.4	0.2	0.4	27	2
6-30-69	7.1	0	0	42	290	229	61	22 / 23	6.8 / 8.7	1.8			137	101	51	510	0.1	0.4	0.07	0.6	0.2	0.8		
	7.3	0	0	40	285	217	58	25 / 26	10.4 / 11.4	2.7			122	93	53	510	0.1	0.4	0.07	0.6	0.2	0.7		
8-6-69	7.1	0	0	41	221	161	60	23 / 23	7.6 / 8.5	2.2			86	81	114	360	0.7	0.5	0.06	0.6	<.1	0.3	44	3
	7.3	0	0	39	206	157	49	25 / 26	9.0 / 9.2	2.3			70	79	55	360	0.5	0.5	0.06	0.5	<.1	0.5	34	2

WATER QUALITY SAMPLING PROGRAM

STATION NO. LWS-4 LOCATION NOROTON RIVER - STAMFORD - DARIEN T.L.

DATE	pH	ALKALINITY: HYDROXIDE	ALKALINITY: CARBONATE	ALKALINITY: BICARBONATE	DISSOLVED SOLIDS: TOTAL	DISSOLVED SOLIDS: FIXED	DISSOLVED SOLIDS: VOLATILE	TEMPERATURE °C	D.O.	BOD	TOC	TOTAL CARBON	SODIUM CHLORIDE As of 1972??	TOTAL HARDNESS	SULFATE	SPECIFIC COND.	AMMONIA N.	PHOSPHATE	ABS	IRON	COPPER	ZINC	COLOR	TURBIDITY
4-27-70	7.8	0	0	34	245	194	51	15 16	11.6 11.6	2.2	8	14	99	80	49	370	0.4	0.5	<.05	0.6	<.1	0.1	28	5
	7.9	0	0	35	237	149	88	18 19	11.8 12.3	4.1	10	15	92	81	50	370	0.5	0.1	<.05	0.5	<.1	0.1	28	3
6-24-70	7.4	0	0	42	457	341	116	21 22	10.3 11.9	2.0	11	18	332	130	60	880	0.2	0.2	<0.05	0.4	<0.1	<0.1	31	6
	7.8	0	0	44	492	365	127	24 27	13.0 13.3	2.0	13	19	296	132	62	880	0.2	0.3	<0.05	0.4	<0.1	<0.1	32	4
8-5-70	8.1	0	0	80	10916	8996	1920	23 22	0.0 0.0	3.6	15	32	8600	1300	310	10000	0.6	0.5	0.09	0.5	<0.1	<0.1	40	7
	8.2	0	0	70	5125	4212	916	25 23	2.9 0.0	4.0	12	28	4100	870	400	10000	0.3	0.4	0.07	0.5	<0.1	<0.1	40	5
4-9-71	7.5	0	0	37	519	434	85	14 15	13.0 13.4	2.1	7	14	332	152	66	1000	0.3	0.1	<.05	0.4	<.1	<.1	20	1
	8.2	0	0	37	362	296	66	17 18	13.3 12.7	2.5	6	12	184	120	62	625	0.3	0.1	<.05	0.4	<.1	<.1	21	2
6-7-71	6.9	0	0	46	2085	1704	381	19 23	8.2 9.3	2.4	7	16	1680	410	178	3800	0.4	0.3	0.07	0.5	<.1	<.1	30	1
	7.4	0	0	56	8484	7080	1404	23 23	13.4 10.4	1.9	6	18	7000	1400	620	13000	0.2	0.3	<.05	0.5	<.1	<.1	25	2
7/21/71	7.0	0	0	45	748	560	188	23 24	8.3 8.3	3.5	11	22	440	140	84	1500	0.9	0.4	<.05	0.3	<0.1	<0.1	39	1
	7.0	0	0	48	1461	1207	254	24 24	9.7 10.0	2.8	11	22	960	264	140	3000	1.0	0.3	.06	0.3	<0.1	<0.1	39	1
4-19-72																							20	1
																							20	1

APPENDIX D.

Noroton River Basin Discharges

NOROTON RIVER BASIN

1-2097.85 Noroton River near Stamford, Conn.

Location.--Lat 41°05'39", long 73°30'56", on left bank, 350 ft south of Camp Avenue, and just downstream from Springdale Brook, at Springdale, Fairfield County.

Drainage area.--7.84 sq mi.

Records available.--July 1964 to September 1964 (occasional low-flow measurements). October 1964 to September 1965.

Gage.--Wire-weight gage and crest-stage indicator; gage read twice daily. Altitude of gage is 60 ft (from topographic map).

Extremes.--Maximum discharge during year, 248 cfs Feb. 8 (gage height, 2.79 ft); minimum observed, 0.28 cfs Aug. 14-25, Sept. 1, 6-8; minimum gage height observed, 0.72 ft July 1.

Remarks.--Records good except those for periods of ice effect, which are fair.

Rating tables, except periods of ice effect (gage height, in feet, and discharge, in cubic feet per second)

Oct 1 to Dec. 28		Dec. 29 to Sept. 30			
0.78	0.85	0.60	0.20	1.0	7.8
.85	1.55	.65	.40	1.1	13
.90	2.75	.70	.68	1.3	27
.95	4.1	.75	1.10	1.6	54
1.0	7.0	.80	1.95	2.0	105
1.2	20	.85	2.85	2.4	170
1.4	35	.90	4.2		

Discharge in cubic feet per second, water year October 1964 to September 1965

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.40	1.28	0.9	5.1	5.5	16	*11	13	14	*0.92	0.68	0.28
2	3.8	1.28	1.0	5.4	5	*16	11	13	12	1.01	5.4	1.40
3	1.55	1.40	1.28	5	5	14	9.9	21	11	1.10	7.8	.68
4	1.40	1.40	3.0	4.5	4.5	13	11	20	8.8	4.5	5.4	.45
5	1.28	1.40	19	*4.2	4.5	13	13	17	6.9	1.01	3.1	.45
6	1.28	1.40	18	4.5	4.5	20	12	14	4.8	1.10	2.15	.28
7	1.28	1.00	9.4	3.6	7.5	19	12	23	3.6	1.01	1.55	.28
8	1.40	1.00	3.8	2.65	160	17	13	25	2.65	1.95	1.01	.28
9	1.00	1.00	2.75	4.2	*71	16	14	19	*2.25	1.01	1.01	.45
10	.85	1.40	2.0	16	42	15	13	19	1.95	1.01	*1.75	.68
11	.85	1.40	1.55	12	40	14	13	19	1.95	1.40	1.55	2.15
12	1.00	1.40	11	8.8	*39	14	21	17	1.55	1.25	.68	1.55
13	1.28	1.40	10	8.3	27	14	17	17	1.55	1.25	.45	3.1
14	1.40	1.18	4.5	5.7	24	13	11	16	1.55	1.25	.28	3.9
15	1.40	1.18	4.1	5.5	26	13	8.8	16	1.55	1.25	.28	3.1
16	1.28	1.55	3.25	5.4	24	13	21	14	1.25	1.01	.28	*1.75
17	1.75	1.40	2.5	5.3	20	12	23	13	1.25	1.01	.28	2.65
18	1.40	1.40	2.25	5.2	19	12	20	12	1.25	19	.28	3.1
19	1.00	1.75	2	5	17	13	17	12	1.25	23	.28	2.65
20	*1.00	1.75	1.5	4.5	16	18	17	11	1.25	5.4	.28	1.01
21	1.75	.85	1.5	4.2	14	19	16	9.9	1.55	2.45	.28	1.01
22	1.18	.85	1.40	5.1	14	13	14	9.9	1.55	1.55	.28	.68
23	1.00	.85	1.75	5.4	12	13	13	8.8	1.95	1.55	.28	.68
24	.85	.85	2.5	6.5	11	13	12	7.8	1.95	1.01	.28	.68
25	1.00	*.85	3.5	7.8	46	12	12	6.9	1.55	1.01	.28	2.65
26	1.00	1.75	5.6	9.9	21	13	26	6.9	1.25	1.01	1.01	1.01
27	1.00	.92	33	11	19	13	26	7.8	1.01	1.01	2.15	.68
28	1.40	.92	29	9.9	17	13	20	8.8	.92	1.55	1.01	.68
29	1.28	1.55	13	7.8		13	17	13	.92	1.01	.68	.45
30	1.28	1.08	9.3	6.9	---------	12	14	20	.92	1.01	.45	.45
31	1.28	---------	6.1	6.5	---------	11	---------	17	---------	.68	.45	---------
Total	40.62	37.44	210.43	201.85	715.5	440	458.7	447.9	95.92	84.28	41.64	39.16
Mean	1.31	1.25	6.79	6.51	25.6	14.2	15.3	[illegible]	3.20	2.72	1.34	1.31
Cfsm	0.167	0.159	0.866	0.830	3.27	1.81	1.95	1.84	0.408	0.347	0.171	0.167
In.	0.19	0.18	1.00	0.96	3.39	2.09	2.18	2.12	0.46	0.40	0.20	0.19

Calendar year 1964: Max --- Min ---- Mean ---- Cfsm ----- In. -----

Water year 1964-65: Max 160 Min 0.28 Mean 7.71 Cfsm [illegible] In. 13.36

Peak discharge (base, 150 cfs).--Feb. 8 (1600) 248 cfs (2.79 ft).

* Discharge measurement made on this day

Note.--Stage-discharge relation affected by ice Dec. 1, 2, 17, 19-21, Jan. 3, [illegible] Feb. 6.

NOROTON RIVER BASIN

1-2097.85 Noroton River near Stamford, Conn.

Location.--Lat 41°05'39", long 73°30'56", on left bank, 350 ft south of Camp Avenue, and just downstream from Springdale Brook, at Springdale, Fairfield County.

Drainage area.--7.84 sq mi.

Records available.--Water year 1964 (occasional low-flow measurements). October 1964 to September 1966.

Gage.--Staff gage and crest-stage indicator; gage read twice daily. Datum of gage is 61.12 ft above mean sea level, datum of 1929.

Extremes.--Maximum discharge during year, 241 cfs May 19 (gage height, 2.75 ft); minimum observed, 0.27 cfs Sept. 9, 10 (gage height, 0.11 ft).
1964-66: Maximum discharge, 248 cfs Feb. 8, 1965 (gage height, 2.79 ft); minimum observed 0.27 cfs Sept. 9, 10, 1966 (gage height, 0.11 ft).

Remarks.--Records fair.

Discharge, in cubic feet per second, water year October 1965 to September 1966

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.95	1.10	1.10	3.2	2.8	68	11	30	11	1.5	2.0	0.50
2	1.75	1.10	.92	3.2	2.8	40	11	16	9	1.6	1.9	.4
3	1.55	1.10	.75	7.8	2.8	25	11	12	8	1.5	2.2	.3
4	1.25	.92	.75	6.5	2.8	21	14	8	7	1.3	2.5	.5
5	1.25	.75	.75	6.2	2.8	22	15	7.4	6.2	1.2	2.6	1.0
6	.83	.75	.75	6.2	2.8	23	12	7.4	5.5	1.3	2.15	.7
7	.68	.92	.75	7.8	2.8	16	11	7.4	6.2	1.6	2.2	.4
8	3.6	.92	.75	7.0	2.8	16	11	7.4	6.6	1.4	2.15	.31
9	2.45	.75	.75	5.2	2.8	16	11	7.4	6.6	1.3	2.15	.25
10	1.25	.75	.75	3.5	2.8	16	11	7.4	14	2.6	2.15	.25
11	1.01	.75	1.95	2.2	2.8	17	11	7.4	15	2.2	2.15	.70
12	42	.75	3.1	1.5	2.8	20	11	7.4	10	1.91	2.0	1.91
13	2.15	1.40	5.7	1.2	12	19	11	7.4	7.1	1.6	1.9	1.0
14	1.55	1.40	3.6	1.2	58	16	11	7.4	5.8	1.41	2.1	2.0
15	1.25	1.10	3.1	1.2	29	15	11	7.4	5.3	1.3	3.3	3.6
16	1.01	.92	2.65	1.2	17	13	11	9.9	5.3	2.0	2.2	2.15
17	2.15	1.55	2.25	1.2	17	12	11	7.3	4.9	2.8	2.9	1.81
18	1.95	1.40	1.95	1.2	16	15	11	7.3	4.4	2.5	2.2	1.71
19	1.95	1.10	1.7	1.2	13	13	14	102	3.2	2.2	2.0	1.51
20	1.55	1.10	1.7	1.2	14	13	20	35	2.5	2.0	1.8	1.61
21	1.10	1.10	1.7	1.2	15	12	18	18	2.4	2.0	1.6	26
22	.83	1.55	2.0	1.6	13	11	16	15	2.4	1.8	1.41	29
23	2.15	1.40	2.6	2.0	13	11	17	12	2.2	1.9	1.32	7.5
24	1.95	1.10	4.2	3.0	12	11	12	9	1.8	1.9	1.23	3.8
25	1.95	1.10	5.7	3.2	13	11	10	6.5	1.7	2.0	1.41	3.7
26	1.55	1.10	6.5	3.1	13	11	8.3	8	1.8	2.2	1.14	3.5
27	1.25	1.55	4.8	3.0	13	11	8.5	12	1.9	2.2	.90	3.3
28	1.01	1.40	3.5	3.0	12	11	14	30	1.9	2.4	.73	2.25
29	1.01	1.10	3.2	3.0		11	14	18	1.7	2.2	.5	2.15
30	1.01	1.10	3.2	2.9	----------	11	13	15	1.5	2.0	.45	2.5
31	1.01	----------	3.2	2.8	----------	11	----------	12	----------	2.0	.58	----------
Total	50.15	33.03	76.32	97.8	313.6	538	370.8	466.4	162.9	57.82	55.92	106.41
Mean	1.62	1.10	2.46	3.15	11.2	17.4	12.4	15.0	5.43	1.87	1.80	3.55
Cfsm	0.207	0.140	0.314	0.402	1.43	2.22	1.58	1.91	0.693	0.239	0.230	0.453
In.	0.24	0.16	0.36	0.46	1.49	2.55	1.76	2.21	0.77	0.27	0.27	0.50

Calendar year : Max 160 Min 0.28 Mean 7.35 Cfsm 0.937 In. 12.73
Water year : Max 102 Min 0.27 Mean 6.38 Cfsm 0.814 In. 11.05

Peak discharge (base, 150 cfs) May 19 (1330) 241 cfs (2.75 ft).

APPENDIX E.

Water Quality Data, Stamford Health Department

WATER QUALITY DATA

STAMFORD HEALTH DEPARTMENT

1/6/70 - 8/30/72

NOTES:

+ designates "greater than"

- designates "less than"

FC-Fecal Coliform

TC-Total Coliform

FS-Fecal Streptococci

Date	Location	Tc/100	Fc/100	Fs/100
1-6-70	Holly Pond	700	100	220
	East Beach	1,480	220	260
	Horseshoe	940	180	90
1-20-70	Horseshoe	130	50	40
	East	50	10	30
2-3-70	Holly Pond	TNTC	1,400	3,360
	East	850	410	470
	Horseshoe	1,140	430	410
2-17-70	Holly Pond	430	110	30
	East	160	40	10
	Horseshoe	460	130	30
3-3-70	Holly Pond	110	20	50
	Horseshoe	260	20	10
	East	180	- 10	80
3-17-70	East	10	10	10
	Holly Pond	10	10	10
	Horseshoe	10	- 10	10
3-30-70	East	700	360	70
	Horseshoe	1,400	670	150
	Holly Pond	9,200	160	40
4-14-70	East Beach	30	- 10	40
	Horseshoe	30	- 10	60
	Holly Pond	1,120	100	30
4-28-70	East	210	20	10
	Horseshoe	130	20	10
	Holly Pond	2,640	280	40
5-12-70	Holly Pond	1,700	1,160	70
	Cove (East)	1,230	390	100
	Horseshoe	1,470	380	110
5-26-70	East	30	10	± 10
	Horseshoe	20	10	± 10
	Holly	± 3,000	1,940	130
6-2-70	East	- 10	- 10	- 10
	Horseshoe	20	- 10	- 10
	Holly Pond	3,000	100	70
6-9-70	East	30	- 10	10
	Horseshoe	60	50	20
6-16-70	Holly Pond	± 3,000	680	
	East	60	10	
	Horseshoe	60	10	
6-23-70	East	30	0	
	Horseshoe	40	10	
	Holly Pond	400	50	
6-30-70	Horseshoe	50	10	
	East	30	10	
	Holly Pond	2,100	120	
7-7-70	East	60	20	30
	Horseshoe	360	30	10
	Holly Pond	± 3,000	20	40

Date	Location	Tc/100	Fc/100	Fs/100
7-14-70	East	70	0	
	Horseshoe	190	0	
	Holly Pond	± 3,000	560	
7-21-70	East	40	- 10	
	Horseshoe	50	20	
	Holly Pond	1,600	320	
7-28-70	East	70	0	
	Horseshoe	100	0	
	Holly Pond	6,900	630	
8-3-70	East	130	120	
	Horseshoe	20	20	
	Holly Pond	TNTC	400	
8-4-70	East	20	- 10	
	Horseshoe	20	10	
	Holly Pond	16,000	700	
8-11-70	East	50	50	
	Horseshoe	10	10	
	Holly Pond	2,100	1,800	
8-18-70	East	20	0	
	Horseshoe	40	10	
	Holly Pond	700	100	
8-25-70	East	10	10	
	Horseshoe	10	- 10	
	Holly Pond	4,500	770	
9-1-70	East	0	0	
	Horseshoe	10	0	
	Holly Pond	300	100	
9-15-70	East	60	0	
	Horseshoe	70	40	
	Holly Pond	600	110	
9-28-70	East	990	70	
	Horseshoe	± 3,000	20	
	Holly Pond	TNTC	± 3,000	
10-13-70	East	200	- 10	
	Horseshoe	600	30	
	Holly Pond	6,200	1,220	
10-27-70	East	1,870	520	
	Horseshoe	710	70	
11-9-70	East	430	20	
	Horseshoe	240	- 10	
	Holly Pond	1,180	70	
12-3-70	East	10	- 10	
	Horseshoe	100	10	
	Holly Pond	1,100	300	
12-22-70	East	220	160	
	Horseshoe	130	30	
	Holly Pond	TNTC	980	

Date	Location	Tc/100	Fc/100	Fs/100
1-4-71	East	220	60	
	Horseshoe	610	220	
	Holly Pond	TNTC	+ 3,000	
1-19-71	East	- 10	- 10	
	Horseshoe	- 10	- 10	
	Cove (Holly Pd.)	± 3,000	2,200	2,700
2-24-71	East	220	90	
	Horseshoe	140	40	
	Holly Pond (Outfall)	15,000	4,400	
	Holly Pond (Landing)	1,100	210	
3-10-71	East	- 10	- 10	
	Horseshoe	- 10	- 10	
	Holly Pd. (Outfall)	1,500	440	
	Holly Pond (Landing)	140	20	
3-24-71	East	30	20	
	Horseshoe	80	10	
	Holly Pond (Outfall)	30,000	3,000	
	Holly Pond (Landing)	980	150	
4-13-71	East	20	- 10	
	Horseshoe	- 10	- 10	
	Holly Pond (Landing)	70	10	
	Holly Pond (Outfall)	200	100	
4-27-71	East	20	10	
	Horseshoe	50	- 10	
	Holly (Landing)	930	280	
	Holly (Outfall)	2,000	180	
5-11-71	East	70	- 10	
	Horseshoe	- 10	- 10	
	Holly (Landing)	TNTC	400	
	Holly (Outfall)	TNTC	200	
5-25-71	East	10	- 10	
	Horseshoe	30	- 10	
	Holly (Landing)	2,400	440	
	Holly (Outfall)	TNTC	- 10	
6-1-71	East	30	0	
	Horseshoe	20	0	
	Holly (Landing)	2,000	20	
	Holly (outfall)	TNTC	10	
6-8-71	East	100	0	
	Horseshoe	100	0	
	Holly Pd. (Landing)	4,800	25	
	Holly (Outfall)	800	20	
6-15-71	East	100	0	
	Horseshoe	0	0	
	Holly (Landing)	1,500	400	
	Holly (Outfall)	3,300	1,000	
6-22-71	East	200	0	
	Horseshoe	300	10	
	Holly Pd. (Landing)	TNTC	150,000	
	Holly Pd. (Outfall)	TNTC	240,000	
6-23-71	Holly Pd. (Landing)	7,500	800	
	Holly Pd. (Outfall)	2,900	900	

Date	Location	Tc/100	Fc/100	Fs/100
6-29-71	East	200	0	
	Horseshoe	250	0	
	Holly (Outfall)	TNTC	4,000	
	Holly (Landing)	34,000	3,300	
7-7-71	East	200	100	
	Horseshoe	100	0	
	Holly (Landing)	1,800	200	
	Holly (Outfall)	TNTC	2,400	
7-13-71	East	300	0	
	Horseshoe	400	100	
	Holly (Landing)	600	200	
	Holly (Outfall)	1,800	500	
7-20-71	East	200	0	
	Horseshoe	400	200	
	Holly (Landing)	5,300	2,600	
	Holly (Outfall)	TNTC	13,000	
7-28-71	East	200	0	
	Horseshoe	300	100	
	Holly (Landing)	7,600	3,500	
	Holly (Outfall)	5,800	4,700	
8-3-71	East	100	0	
	Horseshoe	200	0	
	Holly Pd. (Landing)	8,100	3,500	
	Holly Pd. (Outfall)	TNTC	3,000	
8-9-71	East	200	0	
	Horseshoe	200	0	
	Holly (Landing)	5,600	1,200	
	Holly (Outfall)	12,000	2,800	
8-17-71	East	100	0	
	Horseshoe	200	0	
	Holly Pd. (Landing)	1,600	400	
	Holly Pd. (Outfall)	12,000	3,100	
8-24-71	East	200	0	
	Horseshoe	100	0	
	Holly (Landing)	400	100	
	Holly (Outfall)	TNTC	4,700	
8-31-71	East	100	0	
	Horseshoe	100	0	
	Holly (Landing)	3,800	1,600	
	Holly (Outfall)	15,000	4,000	

Date	Location	Tc/100	Fc/100	Fs/100
9-3-71	East	200	0	
	Horseshoe	200	0	
	Holly (Landing)	1,500	400	
9-22-71	East	0	0	
	Horseshoe	3,200	1,000	
	Holly (Landing)	2,000	900	
10-5-71	East	0	0	
	Horseshoe	100	0	
	Holly Pd. (Landing)	3,800	0	
10-19-71	East	300	100	
	Horseshoe	300	0	
	Holly (Landing)	3,000	1,900	
11-9-71	East	100	0	
	Horseshoe	100	0	
	Holly (Landing)	1,800	300	
12-28-71	East	200	0	
	Horseshoe	100	400	
	Holly (Landing)	2,000	400	
1-4-72	Horseshoe	200	0	
	East	100	0	
	Holly (landing)	890	200	
1-24-72	Horseshoe	500	0	
	East	100	0	
	Holly (Landing)	1,200	200	
2-15-72	Holly (Landing)	900	300	
	Horseshoe	200	0	
	East	200	100	
2-29-72	East	100	0	
	Horseshoe	100	0	
	Holly (Landing)	900	200	
3-15-72	East	0	0	
	Horseshoe	100	0	
	Holly (Landing)	900	200	
4-11-72	East	0	0	
	Horseshoe	100	0	
	Holly (Landing)	800	200	

Date	Location	Tc/100	Fc/100	Fs/100
4-28-72	East	0	0	
	Horseshoe	0	0	
	Holly (Landing)	1,000	400	
5-22-72	East	0	0	
	Horseshoe	0	0	
5-29-72	East	0	0	
	Horseshoe	100	0	
6-13-72	East	0	0	
	Horseshoe	300	0	
	Holly (Landing)	2,800	300	
	Holly (Outfall)	TNTC	3,900	
6-20-72	East	100	0	
	Horseshoe	200	0	
	Holly (Landing)	8,000	1,900	
6-28-72	East	100	0	
	Horseshoe	100	0	
	Holly (Landing)	2,300	800	
7-3-72	East	100	0	
	Horseshoe	100	0	
7-11-72	East	100	0	
	Horseshoe	100	0	
7-19-72	East	0	0	
	Horseshoe	100	0	
7-25-72	East	200	0	
	Horseshoe	200	0	
8-1-72	East	0	0	
	Horseshoe	100	0	
8-8-72	East	100	0	
	Horseshoe	0	0	
8-16-72	East	300	0	
	Horseshoe	400	100	
8-23-72	East	0	0	
	Horseshoe	100	0	
8-30-72	East	100	0	
	Horseshoe	100	0	