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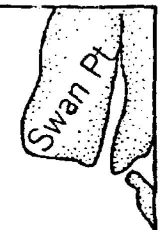
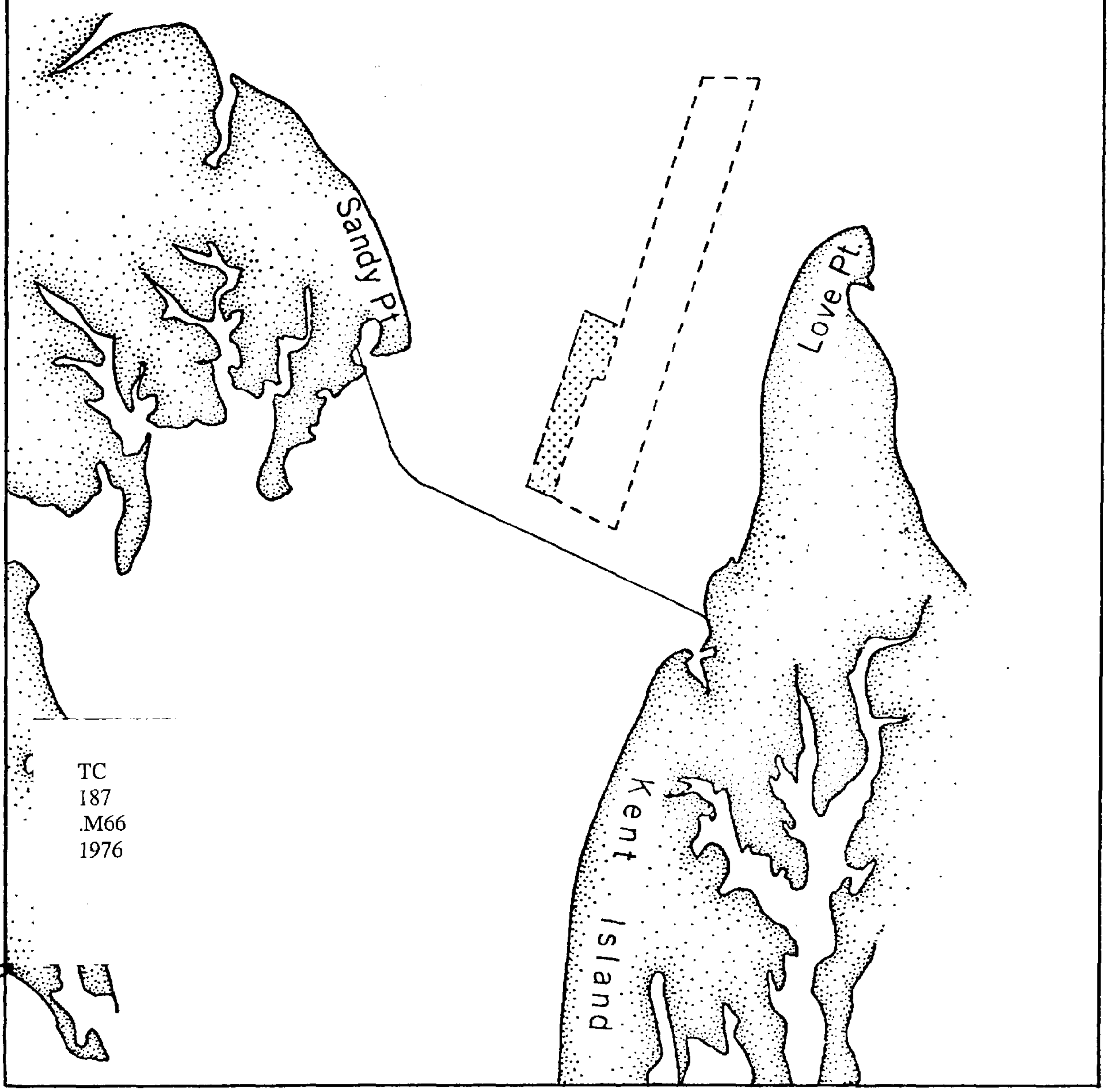


MONITORING OF OPEN WATER DREDGE MATERIAL DISPOSAL OPERATIONS AT KENT ISLAND DISPOSAL SITE AND SURVEY OF ASSOCIATED ENVIRONMENTAL IMPACTS

February, 1976



Maryland Dept. of Natural Resources CZM Prog.

MONITORING OF OPEN WATER DREDGE MATERIAL DISPOSAL OPERATIONS AT KENT ISLAND DISPOSAL SITE AND SURVEY OF ASSOCIATED ENVIRONMENTAL IMPACTS

Final Report To The
Maryland Department of Natural Resources
Water Resources Administration
And
Maryland Department of Transportation
Maryland Port Administration

February, 1976

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Division of General Sanitation

Funding Provided by
The Maryland Department of Transportation
Maryland Port Administration

PREFACE

From February 19 to March 17, 1975, the Baltimore District Army Corps of Engineers conducted maintenance dredging operations in the Baltimore Harbor approach channels. The dredging occurred in the inbound or eastern side of the Brewerton cut-off and Craighill angles, and the material generated was disposed overboard onto the Kent Island Disposal Site.

Public notice of this operation was issued 1 November 1974, and a public hearing was conducted on 3 December 1974 in the City of Baltimore on the western shore of the Chesapeake Bay. In response to requests by the public, the Corps issued a supplemental public notice on 25 November 1974 and conducted an additional session of the public hearing on 5 December 1974 in the Town of Centerville, Queen Annes County, on the eastern shore of the Chesapeake Bay.

Public sentiment towards this project as expressed in the public hearings ranged from support by Baltimore Port and other shipping and boating interests to opposition by Maryland's seafood harvesters and by environmentalists. Opposition to the project focused primarily on the possible environmental consequences of overboard disposal at the Kent Island site. Opposition toward the dredging was seldom voiced.

The position of the State of Maryland as expressed by the Department of Natural Resources towards this maintenance dredging project was based on policy established in 1968. That policy has as its goal the elimination of all unconfined overboard disposal of Baltimore Harbor spoil in Chesapeake Bay. Until that goal is achieved, the State has specified that dredging projects in Baltimore Harbor be limited to those which are critically needed. For those projects considered to be critically needed, State policy allows for the overboard disposal of uncontaminated dredging material provided it is placed in the best available dumpsite in such a manner as to minimize any environmental damage.

On the basis of information provided the State by the Association of Maryland Pilots and confirmed by the Baltimore District, Army Corps of Engineers, shoaling conditions existing in the Baltimore Harbor approach channels in the Fall of 1974 constituted a serious hazard to navigation. Under those circumstances, the maintenance dredging of those shoals was considered to be critically needed.

Analysis and evaluation by appropriate State and Federal agencies of the quality of the sediment to be dredged led to the designation of that sediment as uncontaminated. Evaluation of disposal site alternatives by the State, which has the responsibility of designating which sites may be used by the Corps, led to the conclusion that Kent Island was the only feasible alternative meeting the Corps budgetary constraints within fiscal year 1975. Based on these conclusions, the Kent Island disposal site was designated by the State January 29, 1975, by letter from the Secretary of Natural Resources to the District Engineer, as the site to receive the material generated by the proposed maintenance dredging.

Because of the concern about possible deleterious effects of open water disposal of dredged material at the Kent Island site, an environmental impact monitoring program was initiated by the Water Resources Administration of the Department of Natural Resources. An agreement was made between the Department of Natural Resources

JAMES B. COULTER
SECRETARY

STATE OF MARYLAND

DEPARTMENT OF NATURAL RESOURCES
ENERGY & COASTAL ZONE ADMINISTRATION
TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401

LOUIS N. PHIPPS,
DEPUTY SECRETARY

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April 27, 1976

CZM
Information
JS

Mr. John Sun
NOAA-OCZM
3300 Whitehaven St., N.W.
Page Building 1
Washington, D.C. 20235

Dear ~~Mr.~~ John Sun:

This is to forward six copies of the report on Monitoring of Open Water Dredge Material Disposal Operations at Kent Island Disposal Site and Survey of Associated Environmental Impacts, February 1976.

The study was designed to monitor the environmental impacts of open water disposal of dredged material at the Kent Island site. Specifically, there were four (4) major areas of investigation: (1) accumulation and dispersal of dredged material, (2) biological effects on clams and oysters, (3) impact on existing commercial shellfish populations and predominant benthic organisms, and (4) bacteriological and public health impacts.

The study detected a temporary impact caused by spoil disposal upon benthic organisms within the immediate dumpsite area, but observed no impact upon Natural Resources lying outside the charted dumpsite. The affected area did not involve nearby shellfish beds. Concurrent with an influx of freshwater from the Susquehanna River, potentially adverse impacts to shellfish and other Natural Resources along the Kent Island shore were detected and identified as resulting from that influx.

Additional copies of the report may be obtained from this office.

Sincerely,

Ken

Kenneth E. Perkins, Director
Coastal Zone Management Program, E&CZA

KEP:dls

Enclosures

and the Corps of Engineers that all dredging and disposal activities would immediately cease should any unexpected and deleterious effects be identified by the monitoring activities. No such effects were identified and the dredging and disposal activities proceeded to conclusion. Field efforts were initiated on 14 February 1975 in order to achieve pre-disposal information about existing environmental conditions at the Kent Island site and adjacent areas. The monitoring program was performed from February 14 to October 31, 1975 in order to provide opportunity to detect not only short-term dramatic impacts but longer term impacts which might become apparent only after seasonal changes in the environment.

Sections II, III, IV and V of this report are presented in the format used by the consultants who worked on this project to report their findings to the State of Maryland. The decision to present those findings as individual sections of this final report was a decision of the project manager, and criticisms of any inconsistency of style are accrued thereto.

Frank L. Hamons, Jr.
Project Manager

Brief History of the Kent Island Spoil Disposal Area

The dumping ground for spoil disposal in the Chesapeake Bay off Kent Island was originally established by the Corps of Engineers, U.S. Army in November 1924. This original disposal area extended from a position approximately 3.2 kilometers (1-3/4 miles) northwest of Love Point (approximately 39°, 03.4'N lat.), in a south-southwestward direction along the natural deep channel of the Bay to a position due east of Sandy Point Light. The centerline length of the original disposal area was 5 kilometers (2.70 nautical miles) and the width averaged one kilometer (0.50 nautical miles).

In June 1950, the dumping ground was extended southward to 39°00'N, an extension of just under one nautical mile. Again, in September 1960, the dumping ground was extended southward some 760 meters (2500 feet), to a line running parallel to the Chesapeake Bay Bridge at a distance of 600 meters (2000 feet) from the Bridge. At the same time, the southern 2.0 kilometers (1.1 nautical miles) of the dumping ground were widened toward the west by approximately 300 meters (1000 feet).

Depths along the channel axis in the area covered by the dumping ground, prior to initiation of spoil disposal operations, were 20 to 22 meters (70-73 feet) over the northern three quarters of the area and 26 to 28 meters (86-95 feet) in the southern one quarter of the area. As originally specified, water depths over the dumped material should not be less than 15 meters (50 feet) below MLW. In September 1960, this limit was reduced to 12 meters (40 feet) below MLW.

A map of the disposal area follows. (Figure i-1).

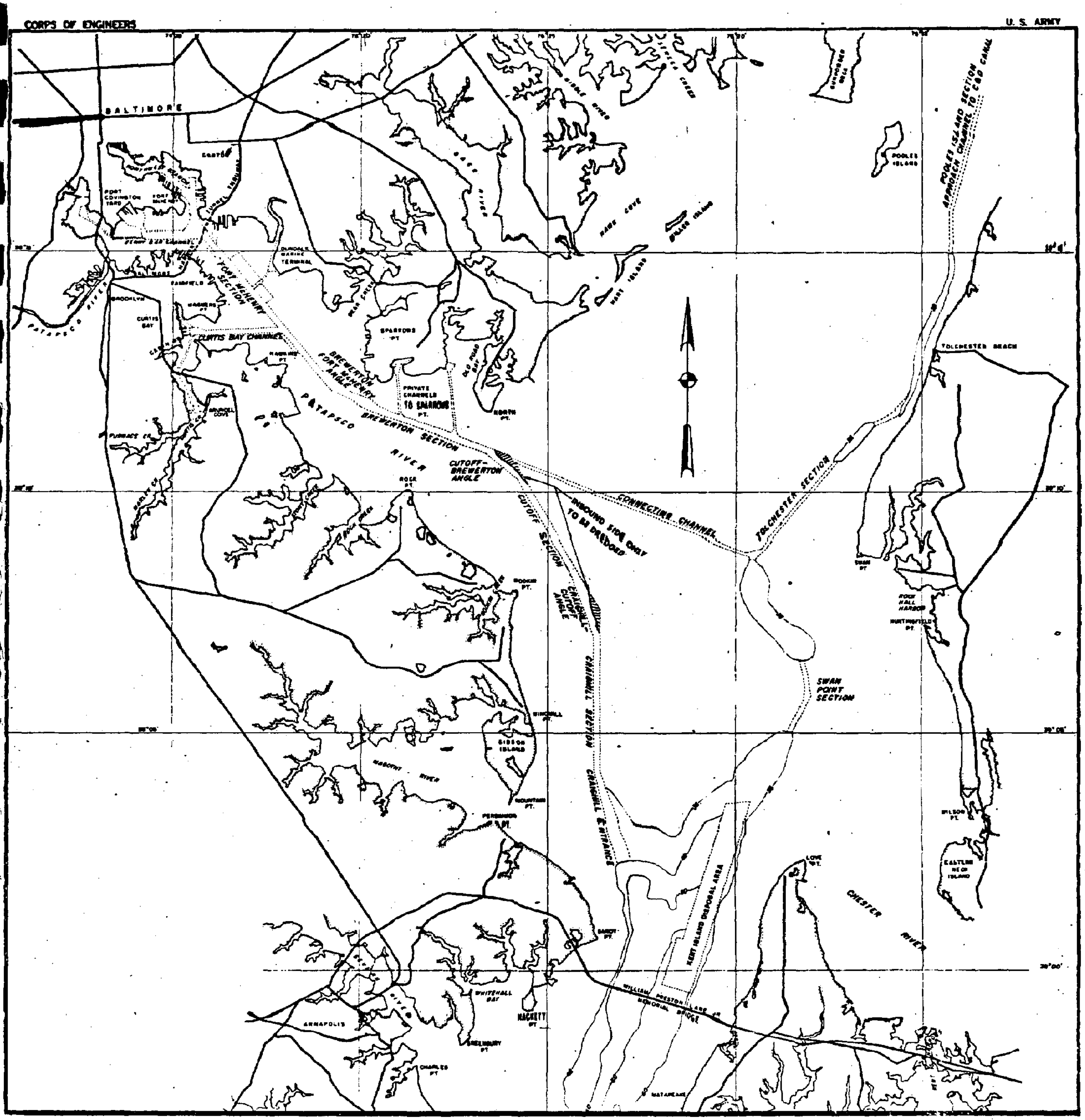

Figure i-1 Map of dredged area and disposal site.

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SECTION ONE:

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Purpose

The purpose of this program was to monitor the Kent Island Disposal Site and contiguous areas for environmental impacts related to the open water disposal of dredged material at that site. Monitoring began February 14, 1975 in order to provide predisposal background information, continued during actual disposal operations (February 19 - March 17, 1975), and concluded October 31, 1975.

Methodology

Specific operations performed for this program are schematically depicted by Figure ES-1, and are defined as follows:

1. The initiating factor; the dumping or release of dredged material onto the Kent Island site by the Corps of Engineers hopper dredge ESSAYONS.
2. The charting of dispersal patterns of dredged material released onto the Kent Island site. The movement of this material was determined through studies of excess turbidity designed to measure the quantities and dispersal patterns of released dredged material being transported by tidal currents. This activity was of primary importance to the study because pollutants such as heavy metals,

FIGURE ES-1

KENT ISLAND MONITORING

SURVEY - FIELD OPERATIONS

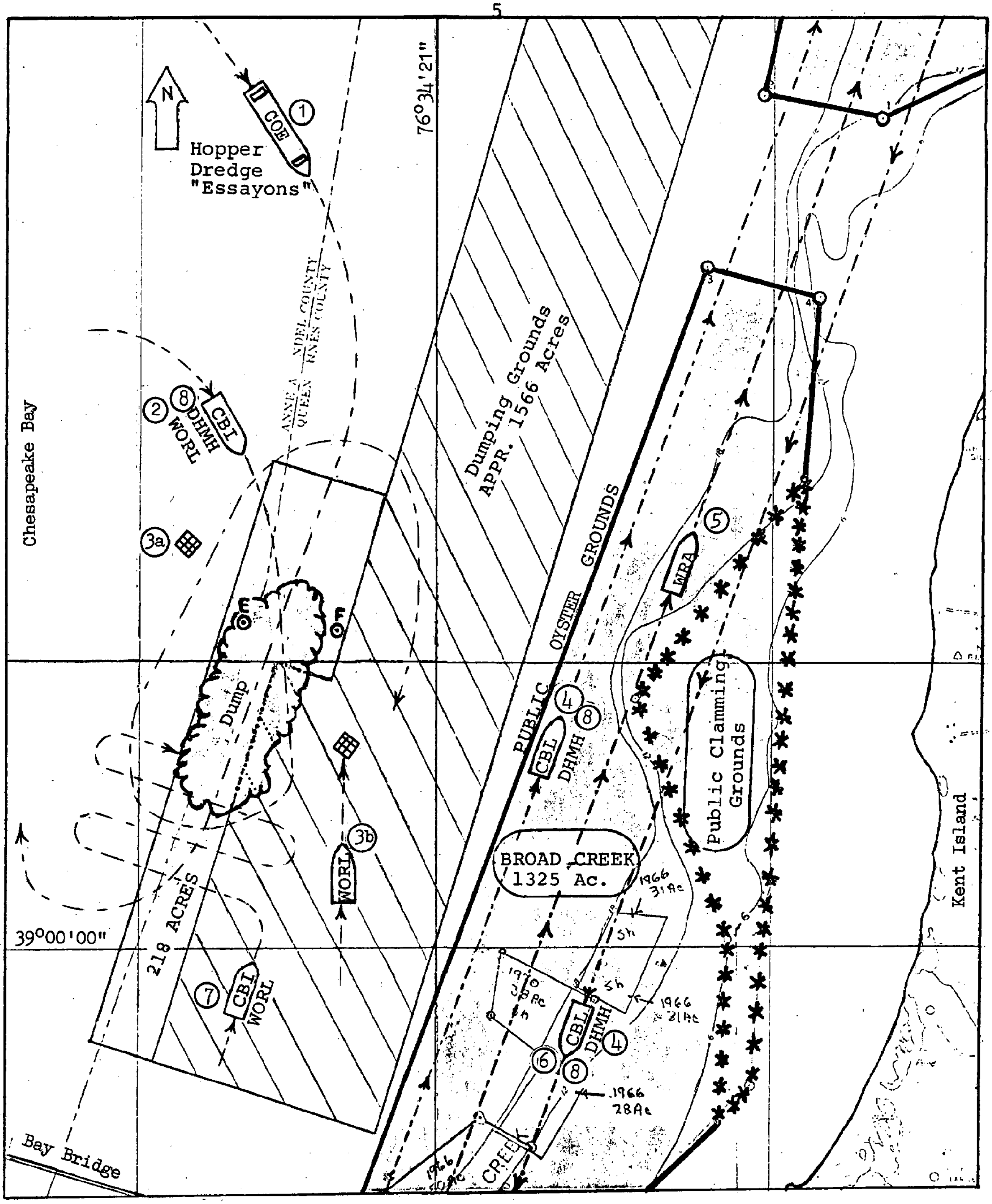
Kent Island Monitoring Survey - Field Operations Key, Figure i-1

Numbers Key

1. The initiating factor, dredged material disposal activity.
2. Charting of suspended dredged material dispersal patterns.
3. Biological experiments, exposure of shellfish to disposal induced turbidity conditions.
4. Near-shore turbidity monitoring.
5. Monitoring for changes in sediment quality on shellfish beds.
6. Monitoring of benthic organisms, eg. oysters, soft shell clams, for changes in biological viability, pollutant buildup.
7. Charting of bottom topography to determine the amounts and possible movements of deposited material.
8. Monitoring of water column and shellfish for Public Health Impacts involving bacteria, trace metals, and chlorinated hydrocarbons.

Abbreviations Key

COE - Corps of Engineers
CBI - Chesapeake Bay Institute, Johns Hopkins University
DHMH - Department of Health and Mental Hygiene
WORL - Westinghouse Ocean Research Laboratories
CBL - Chesapeake Biological Laboratory, University of Maryland, Center for Estuarine and Environmental Studies



KENT ISLAND MONITORING SURVEY
FIELD OPERATIONS
(SCHEMATIC REPRESENTATION - NOT TO SCALE)

chlorinated hydrocarbons and to a considerable extent bacteria are not independently carried by water but are sediment borne, and their dispersal from the point of release is largely dependent upon the movement of released sediment from that point. This operation was conducted by the Chesapeake Bay Institute (CBI) with assistance from the Westinghouse Ocean Research Laboratories (WORL).

3. The exposure of selected stocks of oysters and soft shelled clams to various turbidity conditions created by the disposal of dredged material. This activity determined the impact of such conditions on animal health and pollutant uptake (metals, chlorinated hydrocarbons). Some chlorinated hydrocarbon data is not yet available and will be issued as an addendum to this report. Shellfish used were selected because of approximately equal metabolic rates to facilitate achieving consistent, meaningful results.

For worst possible conditions (maximum exposure), racks of oysters and clams were suspended at normal growth depths near the disposal site in that area where maximum turbidity was expected to occur (3a). However, since such extreme conditions might actually inhibit shellfish respiration and consequently pollutant uptake, and for the purpose of detecting any movement of pollutants toward adjacent shellfish beds, racks of shellfish were placed at normal growth depths about halfway between the disposal site and the nearest shellfish beds (3b). Turbidity conditions at this site were expected to be low to medium.

For comparative purposes, shellfish were stationed at Hacketts bar on the Anne Arundel County shore (not shown on Figure FS - 1). Considerable background information was available for this area, and it is unaffected by disposal activities at the Kent Island site. This operation was conducted by Westinghouse Ocean Research Laboratories (WORL) with analytical assistance provided by the Environmental Protection Agency, Annapolis Field Office.

4. Near-shore turbidity monitoring, determining if water quality in these shallower shellfish growing waters altered significantly during disposal patterns detected by operation #2. This monitoring was conducted by the Chesapeake Biological Laboratory of the Center for Environmental and Estuarine Studies, University of Maryland (CBL).
5. Monitoring of sediment quality on shellfish beds from Swan Point in Kent County to Kentmoor on the Kent Island shore, to detect any change in constituents attributable to the disposal operation. This activity was conducted by the Maryland Water Resources Administration and the Chesapeake Biological Laboratory.
6. The monitoring of benthic organisms, including oysters,

(*Crassostrea virginica*), soft shelled clams (*Mya arenaria*), rangia clams (*Rangia cuneata*), and selected species of worms for any change of biological viability, or metals buildup. Benthic monitoring activities were conducted from Swan Point in Kent County to Kentmoor on the Kent Island shore. Detected changes in these organisms were statistically compared to the sediment dispersal patterns to define any existing correlations. This activity was conducted by the Chesapeake Biological Laboratory.

7. Charting of bottom topography for two reasons: (a) to facilitate measuring the amount of dredged material deposited, and (b) to allow continuing measurements in order to assess whether or not the material stays in place, or is continously eroded away. Estimates of the amount of dredged material deposited in the disposal site were obtained from comparisons of detailed bathymetric and high resolution seismic reflection profiles made in the disposal site prior to and immediately following the disposal operations. Selected studies were made of the sediments and dredged wastes to determine certain physical and chemical parameters that would be useful in identifying waste deposits and in quantifying the volumes of wastes found in the deposits. This activity was conducted by the Chesapeake Bay Institute and the Westinghouse Ocean Research Laboratories.

8. The monitoring of water column and shellfish for Public Health Impacts involving bacteria, trace metals, and chlorinated hydrocarbons by the disposal of dredged material. The chlorinated hydrocarbon data was coordinated with the benthic organisms biological viability investigations as described in operation #6. The water column was sampled in and around the dumpsite, and in adjacent shellfish waters from Swan Point to Kentmoor on the Kent Island shore. Shellfish were sampled from Swan Point to Kentmoor. This activity was conducted by the Environmental Health Administration of the Maryland Department of Health and Mental Hygiene (DHMH).

Administration, coordination and focus for this program was provided by the Water Resources Administration. Funding was provided by the Maryland Port Administration, Maryland Department of Transportation.

Conclusions

The Kent Island Spoil Disposal Monitoring Survey was designed to monitor the environmental impacts of open water disposal of dredged material at the Kent Island site. Specifically, there were four (4) major areas of investigation: (1) accumulation and dispersal of dredged material, (2) biological effects on clams and oysters, (3) impact on existing commercial shellfish populations and predominant benthic organisms, and (4) bacteriological and public health impacts. The following are conclusions by survey participants in each of those study areas:

<u>Accumulation and Dispersal of Dredged Material - CBI, WORL</u>

1. Within the disposal area, "transmittance measurements were taken approximately 100 yards behind the Essayons while the spoil was released" ... "At D+30 (Dump and 30 Min.), between (buoys) E and F, the transmittance had returned to normal background values", being approximately 80% down to 8m, decreasing to about 20% at 14m, and 0 at 16m."
2. "Excess turbidity from the disposal operations extended to the surface within a few minutes after dumping began ... Although excess turbidity was most noticeable at depths greater than 4m (13 ft.) to 10m (32 ft.)."
3. "At the site near the disposal area, the effects of dumping were detectable at depth greater than 8m (25 ft.) immediately after disposal operations. One hour later at this site, the sediment from the dumping was no longer detectable; indeed the turbidity was slightly clearer then before dumping began. Comparable results were obtained on other days at locations near the disposal operation. These observations suggest that the plume of turbidity from dumping remained primarily at depths greater than 8m (25 ft.) at locations within a few hundred meters of the dumpsite."
4. Investigations indicate that the material being dumped

probably "settled to the bottom as a discrete mass with little or no material reaching the surface. About 15 minutes after release most of the coarse materials had settled out of the water leaving a plume of turbid water a few meters thick that was moved by tidal currents. After about two hours, the plume of turbid water had settled even more leaving only a thin layer of turbid water very near the bottom. This layer of turbid, near bottom water has been ascribed to resuspension of sediment by action of tidal currents."

5. "During the course of this survey, we extended the seismic reflection lines well eastward of the dumpsite extension in order to cover the Broad Creek Oyster Bar. No accumulation of materials were noted in the post-dump survey lines. On the basis of these survey lines, it is clear that no detectable accumulation of new material (spoil) was presented on this bar." "The presence of several mounds south of the marker buoys E and F suggest that (1) dumping of single loads took place in stages; (2) release points varied, or (3) bottom currents redistributed the materials dumped between buoys E and F ..." "We are informed that the dumping routine remained the same throughout the period, and that a single release point was established for all dumping." "The third possibility ... is supported by measurements of strong near-bottom currents flowing about 195°, a trend nearly parallel with the alignment

of the separate mounds."

6. "On the basis of bathymetric change noted in the pre- and post-dump surveys we concluded that approximately 520,000 yds.^{3} of newly deposited material (presumably spoil), can be identified within and slightly to the east of the Kent Island Dumpsite extension on the old dumpsite." Identification of new material accumulations was also attempted by seismic reflection techniques (isopach construction), but imprecision led to abandonment of that method. "The fact that some of the material was apparently deposited slightly east of the boundary is not significant, since our records indicate no significant spoil accumulation has occurred in the Broad Creek Oyster Bar east of the dumpsite. Discrepancies between the amount dredged (as reported by the U.S. Army Corps of Engineers) and that determined by our study indicates that about 338,000 yds.^{3} (256,000m^3) have been deposited elsewhere." "In other words, 60.6% of the material transported by the ESSAYONS could be detected in the designated disposal site."
7. Comparison of the two post-operational surveys shows no compelling evidence for removal" (by normal tidal action) "of dredged materials from the disposal site."

Biological Effects on Clams and Oysters - WORL

8. "There was no compelling evidence of increased metal

uptake of the oysters or clams due to dredging and spoil disposal for cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc ... no obvious increases in heavy metals within exposed shellfish can be attributed to the disposal operations off Kent Island during February - March 1975."

"The health and viability of clams and oysters were affected more by natural physical phenomena during these investigations than by dredge disposal operations."

Impact on Existing Commercial Shellfish Stocks and Predominant Benthic Organisms - CBL, WRA

9. "Spoil disposal operations at Kent Island may have increased turbidity at water depths greater than 40 feet but only in an area immediately adjacent to the disposal site."

10. "Increased levels of turbidity at the disposal site in deeper water (greater than 40 feet) were noted before and two months after spoil disposal operations."

11. "There was no evidence of sediment from spoil disposal operations impinging on commercially important shellfish beds."

12. "There was no detectable mortality or change in health status in oysters, soft shell clams or other benthic organisms on commercially important shellfish beds that could be related to spoil disposal operations."

13. "There was no significant increase in heavy metal concentrations in oysters, soft clams and <u>Rangia</u> clams. Each species seems to concentrate a different metal from the environment."

14. "Documentation of the influx of low salinity, highly turbid, and bacterially contaminated water from the Susquehanna River over commercially important shellfish beds in the Upper Bay provides an explanation of some of the problems of shellfish health and shellfish bacterial quality previously encountered by State agencies."

15. "<u>Rangia</u> clams are experiencing a significant mortality (throughout the Upper Bay) which may be related to their environmental intolerance to northern winter conditions." This phenomenon is not related to the dumping activity.

16. "Changes in the benthic community at the dumpsite were transitory and the spoil was recolonized by benthic forms within thirty to sixty days."

17. "Population levels of oysters in the Upper Bay are extremely low and no recruitment has occurred for years while commercial harvest has continued with maximum effectiveness. Meat quality of oysters above the Chesapeake Bay bridge is very poor, and histopathology suggests extreme stress from a toxic agent complicated by exposure to fresh water."

Bacteriological and Public Health Impacts

18. "Bacteriological water quality, described in terms of organisms of the fecal coliform group, reflected no significant degredation resulting from disposal operations. Runoff occurring after heavy rainfall in late February had an impact upon bacteriological water quality that could have masked the effects of the spoil disposal operation."

19. "Bacterial concentrations in marketable shellfish collected throughout the study indicate that no significant bacteriological uptake occurred."

20. "Levels of trace metals, PCBs and chlorinated hydrocarbons in shellfish collected throughout the study indicate that no significant increase was observed."

Some of the most important results of this survey may result from the coincidental monitoring of a major influx of fresh water from the Susquehanna River. This influx peaked at Conowingo Dam on February 26, 1975 at a discharge rate of 369,200 cfs., and within a three-day period brought with it about 90% of a normal year's sediment discharge. It increased surface turbidity above the Bay Bridge to the extent that the effects of the dumping were indistinguishable. Salinities for a period of weeks were lowered below 5 ppt (parts per thousand) which is considered a critical minimum for most shellfish.

Coinciding with this influx, some increases in concentrations of bacteria and metals in shellfish, and bacteria in the water column were detected. These increases occurred equally at all sample stations, leading survey participants to conclude that these impacts were definitely caused by the fresh water influx. The increases were not significant because of size, but because of their relationship with the Susquehanna input. For example, previous Health Department research has indicated that low salinities (below 7 ppt) seem to precipitate increases of bacteria in shellfish. If a line is drawn down the Kent shore to outline recorded flow patterns of the fresh water, it impacts at Love Point, runs down the shore to about Kentmoor and veers off towards the western shore. This coincides almost exactly with previous late spring, early summer Health Department closures due to high bacterial counts in shellfish. At this time, there is insufficient data on this phenomenon to fully explain it, but further study is considered essential.

In summary, monitoring of Natural Resources by this survey detected a temporary impact caused by spoil disposal to benthic organisms within the immediate dumpsite area, but no impact to Natural Resources lying outside the charted dumpsite was seen. The affected area did not involve nearby shellfish beds. Concurrent with an influx of freshwater from the Susquehanna River, potentially adverse impacts to shellfish and other Natural Resources along the Kent Island shore were detected and identified as resulting from that influx.

SECTION TWO:

ACCUMULATION AND DISPERSAL OF DREDGED MATERIALS KENT ISLAND DISPOSAL SITE, 1975

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8 December 1975

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CHAPTER I: EXCESS TURBIDITY

Excess turbidity was measured by observing optical transmittance (the ratio of light transmitted to the incident light) prior to dumping and comparing the results to observations made at varying times after disposal operations began. Details of the transmissometer used and observing techniques are described in Appendix B. Optical properties of seawater and their determination were discussed by Williams (1970).

Suspended sediment concentrations

Measurements of optical transmittance can be related in the laboratory to suspended sediment concentrations using known concentrations of sediment. Results of these experiments are shown in Figure I-1.

Background observations

Transmissometer observations made between dumping buoys E & F before dumping began showed generally homogeneous, relatively clear water (65 - 85% transmittance) with two exceptions. (Note that high transmittance indicates low sediment concentrations.) During the period of high Susquehanna runoff, the turbidity decreased to 35 - 40% transmittance in the upper 4 meters of water. Suspended sediment brought down from the Susquehanna River in the period of high runoff 25 February - 2 March is the most likely cause. The second unusual occurance was observed from 12m depth to the bottom and was readily apparent on two dates, 25-26 February, again during the period of high runoff.

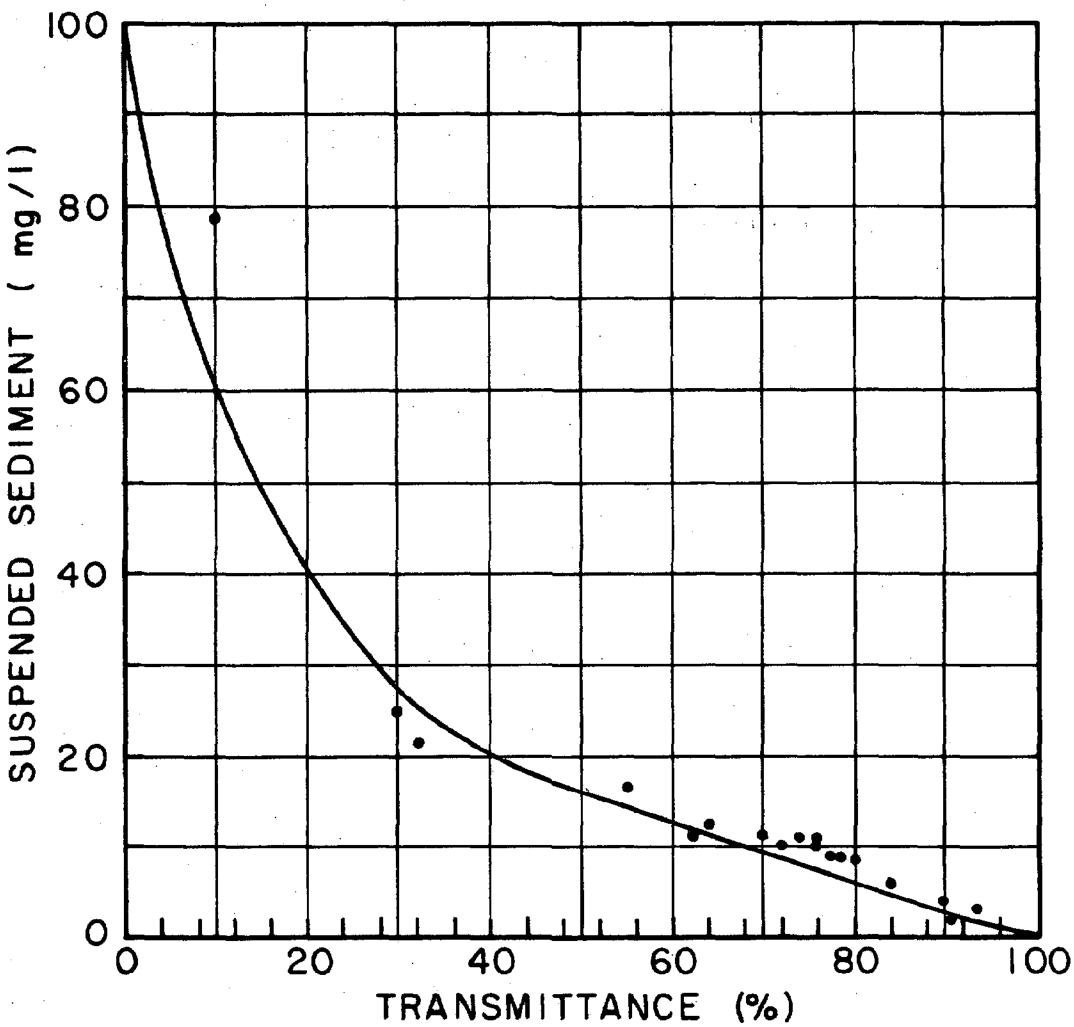

Figure I-1. Suspended sediments (mg/ℓ) vs transmittance (%).

At these times the bottom currents were measured at 1.86 knots (93 cm/sec); this could cause the bottom sediments to be resuspended giving high turbidities. These results are shown in Figure I-2 and in Appendix D.

A typical background observation, taken on 17 March 1975, shows no effect either from runoff or spoil disposal. At that time transmittance ranged from a mimimum of 74.3% to a maximum of 91.5%, averaging 81.8% for eleven stations both in and south of the disposal area. Figure I-3 shows the tabular and graphical transmission percentages and Figure I-4, the station locations. Observations made on the ebbing tide gave no indication of resuspension of bottom sediments.

Excess turbidity during disposal operations

Transmittance during disposal operations was measured by three methods: (1) observations were made behind the ESSAYONS while dumping was taking place and comparing with transmission before and after the dump, see 25 February 75, Figure I-5 and I-6; (2) measurements were made before, during and after dump from a fixed station 100m east and slightly south of the buoys E & F which marked the dump site boundary, see 11 March 1975, Figure I-7 and I-8; and (3) the ship followed a current drogue which was set at 12m behind the ESSAYONS during the dump, see 11 March 1975, Figures I-9 and I-10.

Turbidity following the ESSAYONS

Following the ESSAYONS (see Figure I-5), transmittance

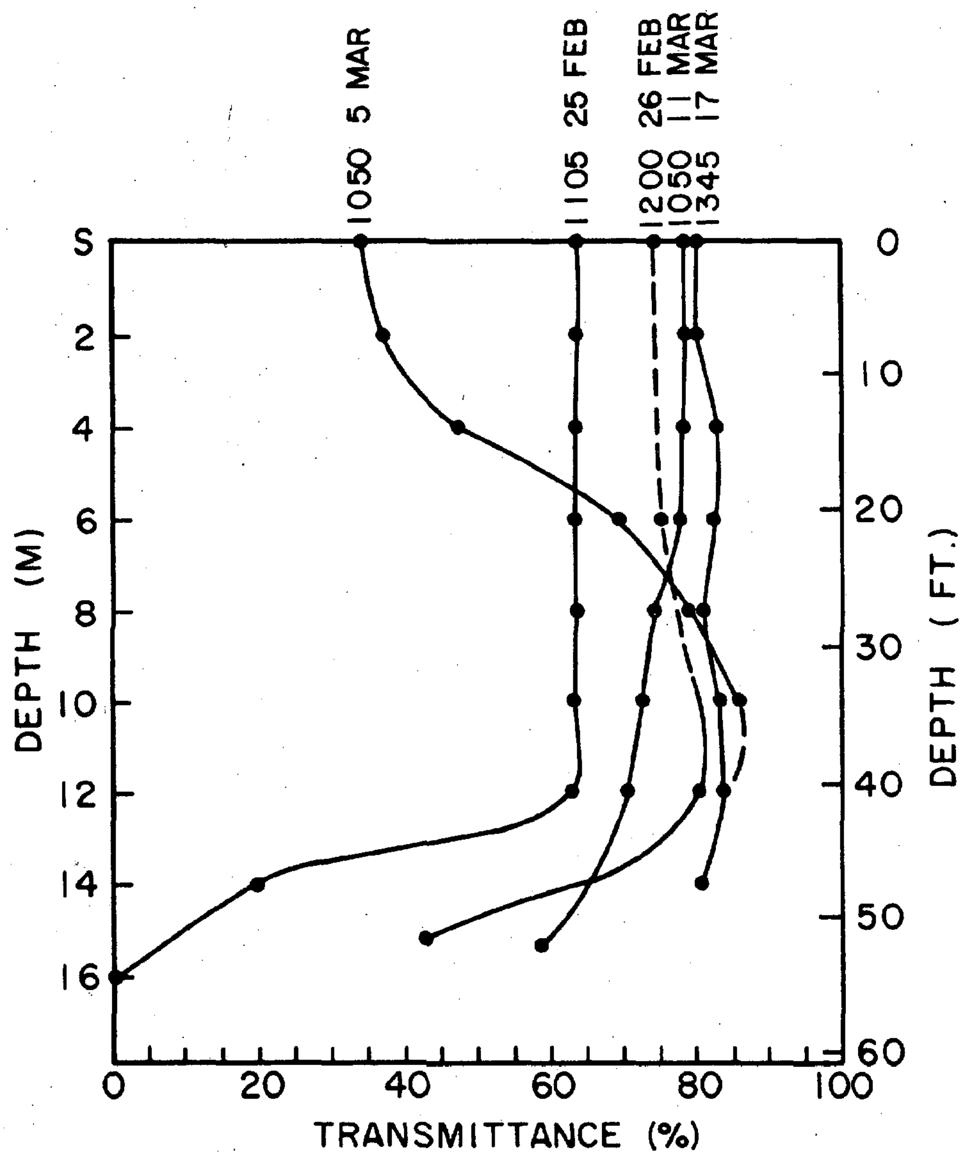

Figure I-2. Background transmissivity between E and F dumping buoys 39°00'54"N 76°21'31"W.

Depth (m)	Sta	Min	Av	Max	Sta
S	9	80.2	81.6	84.1	1
2	7	79.1	80.6	81.5	3
4	1	80.9	86.0	90.0	9
6	1	80.4	88.4	91.5	9
8	1	74.3	81.7	91.5	11
10	1	77.5	82.6	88.9	11
12	1	80.3	83.6	88.4	10
14	4	80.6	81.8	83.3	8
16	5	78.2	80.5	82.6	9
18	4	77.4	79.2	82.7	9
Sta 7&8 only {20	7	76.6	77.4	78.0	8
Sta 9-11 only { 22	11	77.6	81.3	83.7	10
24	11	75.4	79.1	81.4	9

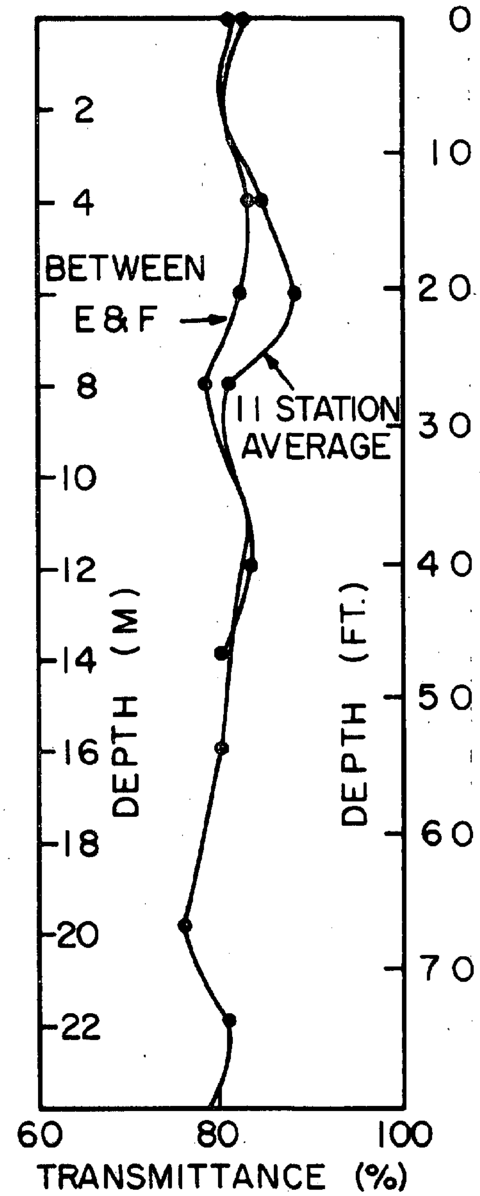

Figure I-3. Tabular and graphic transmittance (%T) between E & F and at 11 stations (17 March 1975).

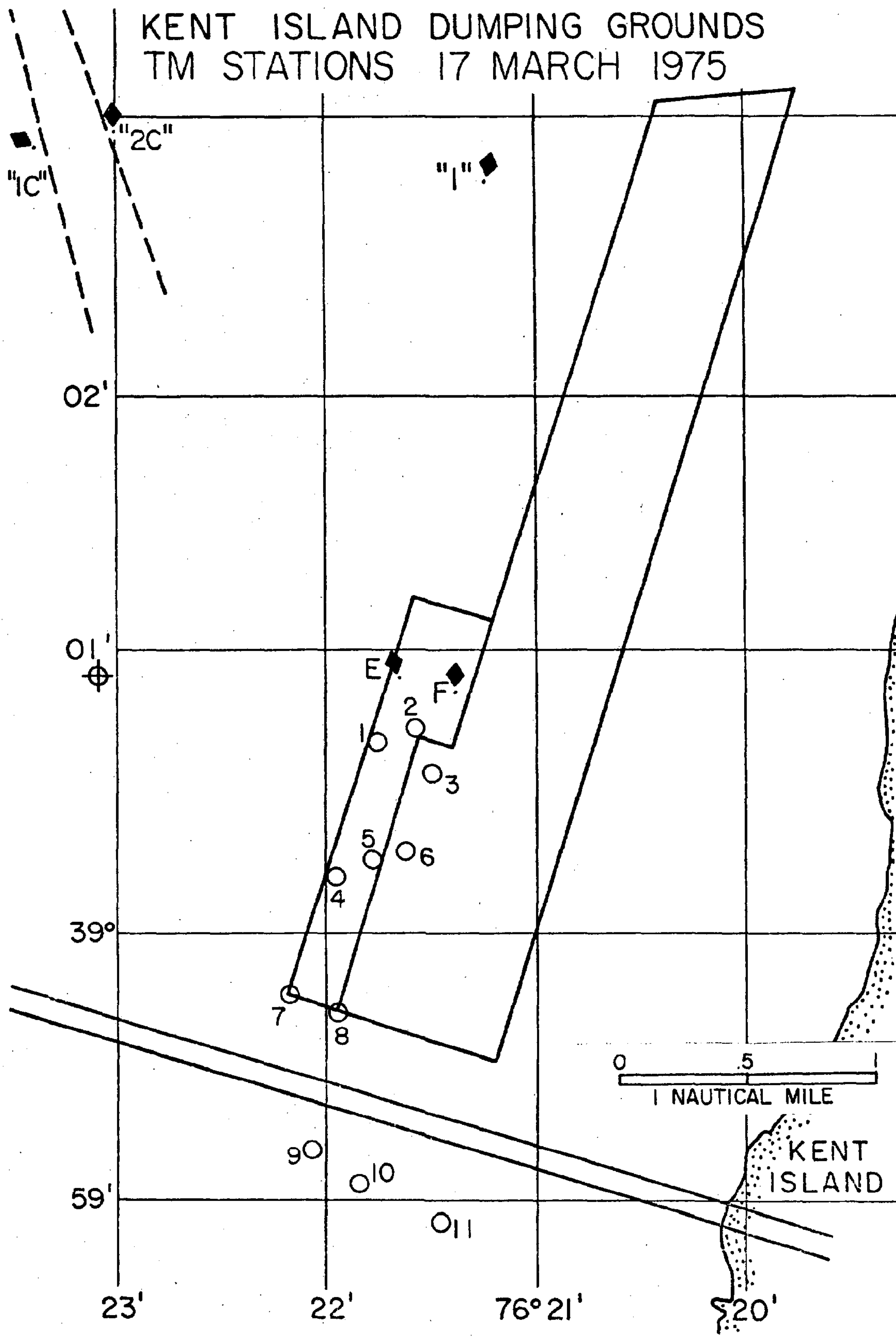

Figure I-4. Station locations for background transmissivity, 17 Mar 1975.

measurements were taken approximately one hundred yards behind the ESSAYONS while the spoil was released. Curve D - 40 was taken between buoys E & F forty minutes prior to the dump and D - 0 shows how the transmittance decreased to 0 - 30% at 4m (extremely variable) and to 0% at 8m. Five minutes later at the same location, the turbidity had reached almost a constant 35% transmittance from the surface to 8m with most of the mixing due to the passage of the ship. Below 8m the transmittance sharply decreased to 7% at 12m, 3% at 14m, and 0% at 16m. At D + 15, between E & F, the surface to 4m transmittance had cleared to normal and thereafter slowly decreasing to 0% at 16m. At D + 30, between E & F, the transmittance had returned to normal background values. Values higher than the original background at D - 40 are attributed to replacement of the water by the ebbing tide (tidal stage--just before slack flood).

As Figure I-5 indicates, excess turbidity from the disposal operations extended to the surface within a few minutes after dumping began (D + 5) although excess turbidity was most noticeable at depths greater than 4m (13 ft.) to 10m (30 ft.).

<u>Turbidity at a location near the disposal site</u>

Percent transmittance between E and F prior (D - 120 minutes) at start (D - 0) and post (D + 60) (26 February 75) is shown in Figure I-6. This figure shows a transmittance of 75 - 80% down to 10m, decreasing to 30% at 14m prior to dump time. This decreased to 60 - 70% from surface to 6m and suddenly dropped to

15% at 8m and slowed to approximately 0% at 10m during the dumping time. At D + 60 the entire column had returned to between 60 - 75% transmittance.

Transmittance prior to (D - 10 minutes) and following dump times (D + 30, D + 55) were made from a nearby fixed station 100m east of and slightly south of E and F (see Figure I-7, 11 March 1975). At D-10 minutes before dump time, the transmittance was between 65 - 80%. One-half hour after the dump, the transmittance had recovered to the same value down to 12m and dropped to 20% at 13.5m and 4% at 16m. Fifty-five minutes following the dump, the transmittance had recovered to 14m and dropped to 12% at 16m.

See Figure I-8 for transmittance during dump times of the dump (D - 0, D + 5, D + 15) at stations 30 meters out of the dump area and 200 meters west of the dump area. Station locations and % transmittance curves are also shown on Figure I-8.

Transmittance varied between 25 - 50% from the surface down to 8m and then to 0% at 12 - 14m except at the 200m W station where transmittance remained between 36 - 47% over the entire depth. Suspended sediment samples taken during these stations read 500 - 700 mg/l at 14m depth.

At the site near the disposal area, the effects of dumping were detectable (Fig. I-6) at depth greater than 8m (25 ft.) immediately after disposal operations. One hour later at this site, excess turbidity from the dumping was no longer detectable;

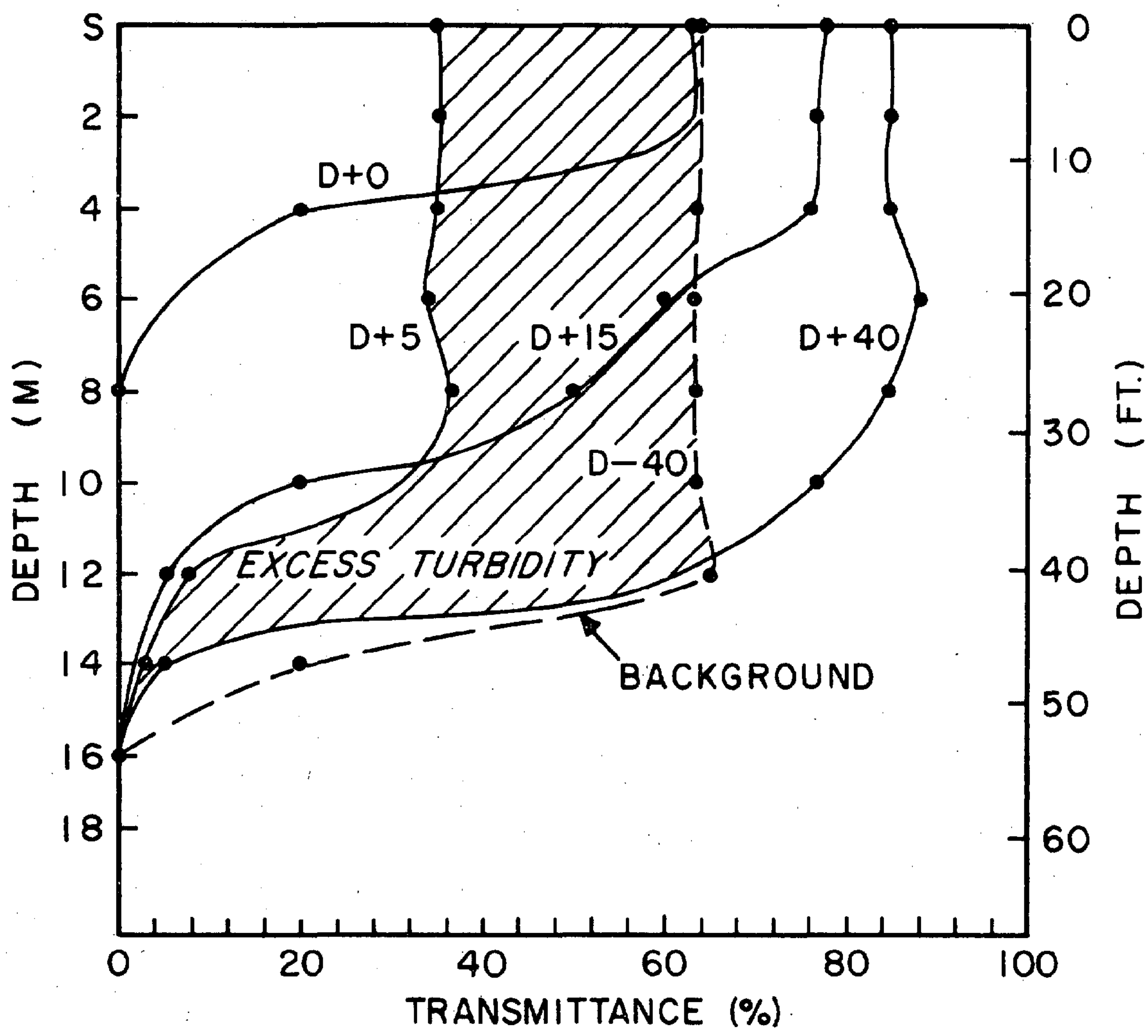

Figure I-5. % transmittance prior, during, and following dump (25 Feb 75). Background levels and excess turbidity 5 minutes after dumping (D + 5) are indicated.

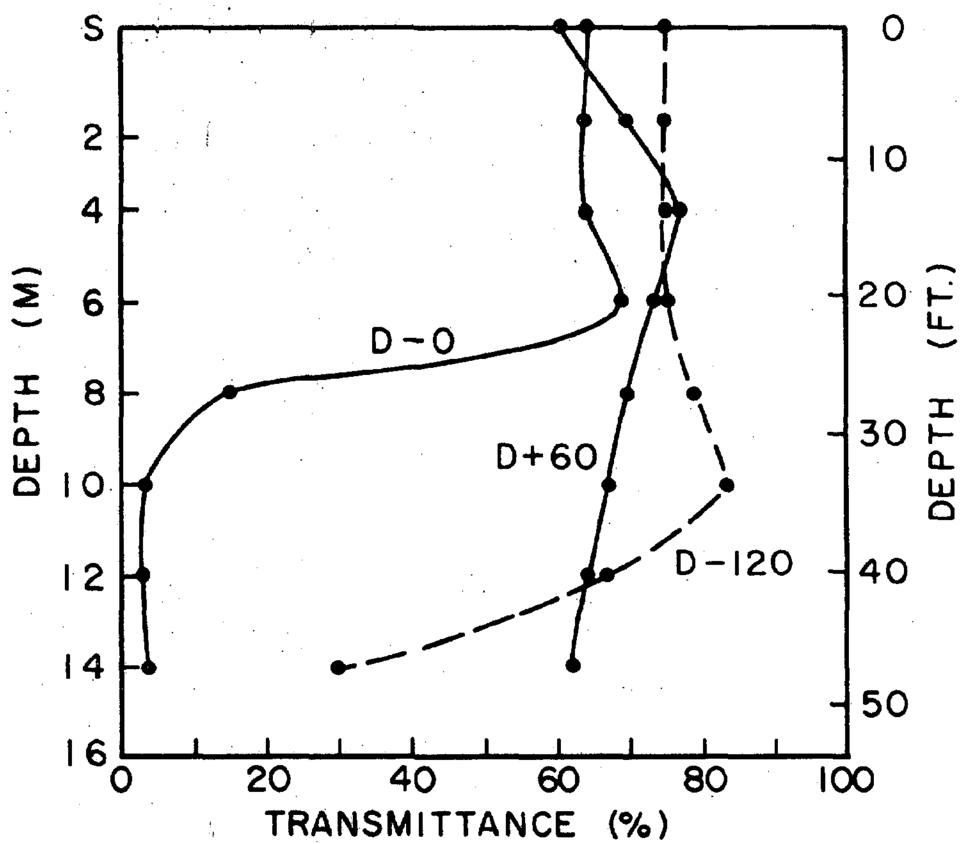

Figure I-6. % transmittance between E and F prior, (D - 120), at start (D - 0), and post (D + 60) 26 Feb 75 - near dump area.

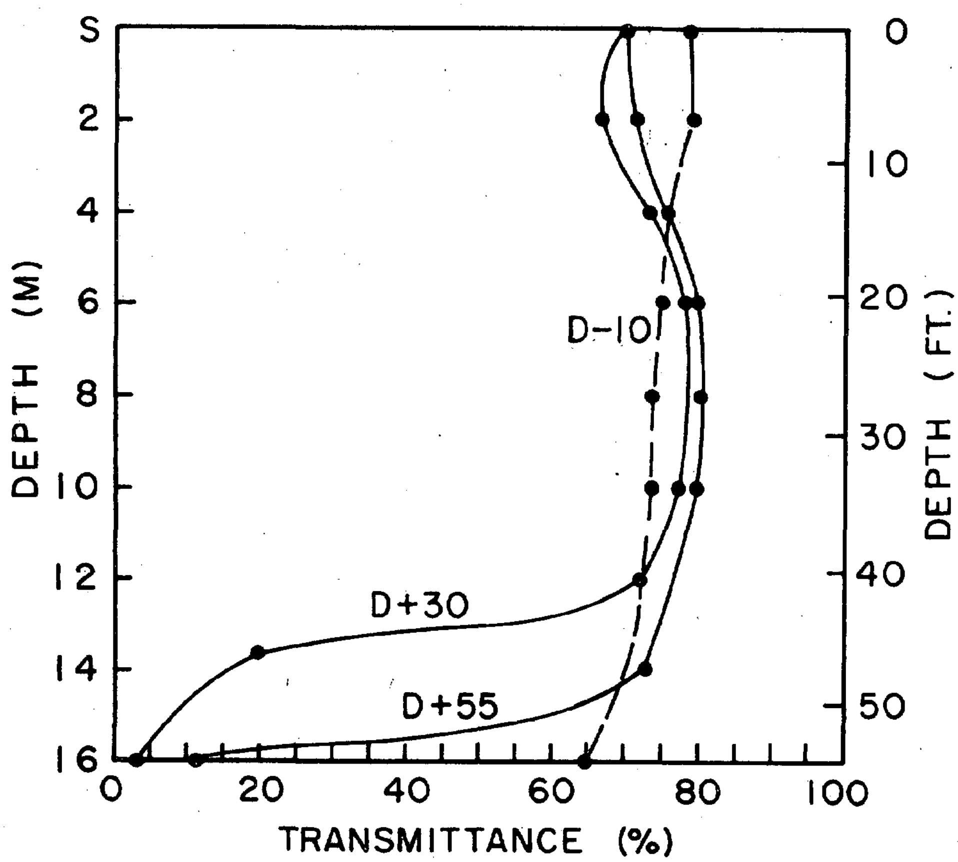

Figure I-7. % transmittance prior and post dump from a nearby fixed station (11 Mar 75, 100 m E of dump).

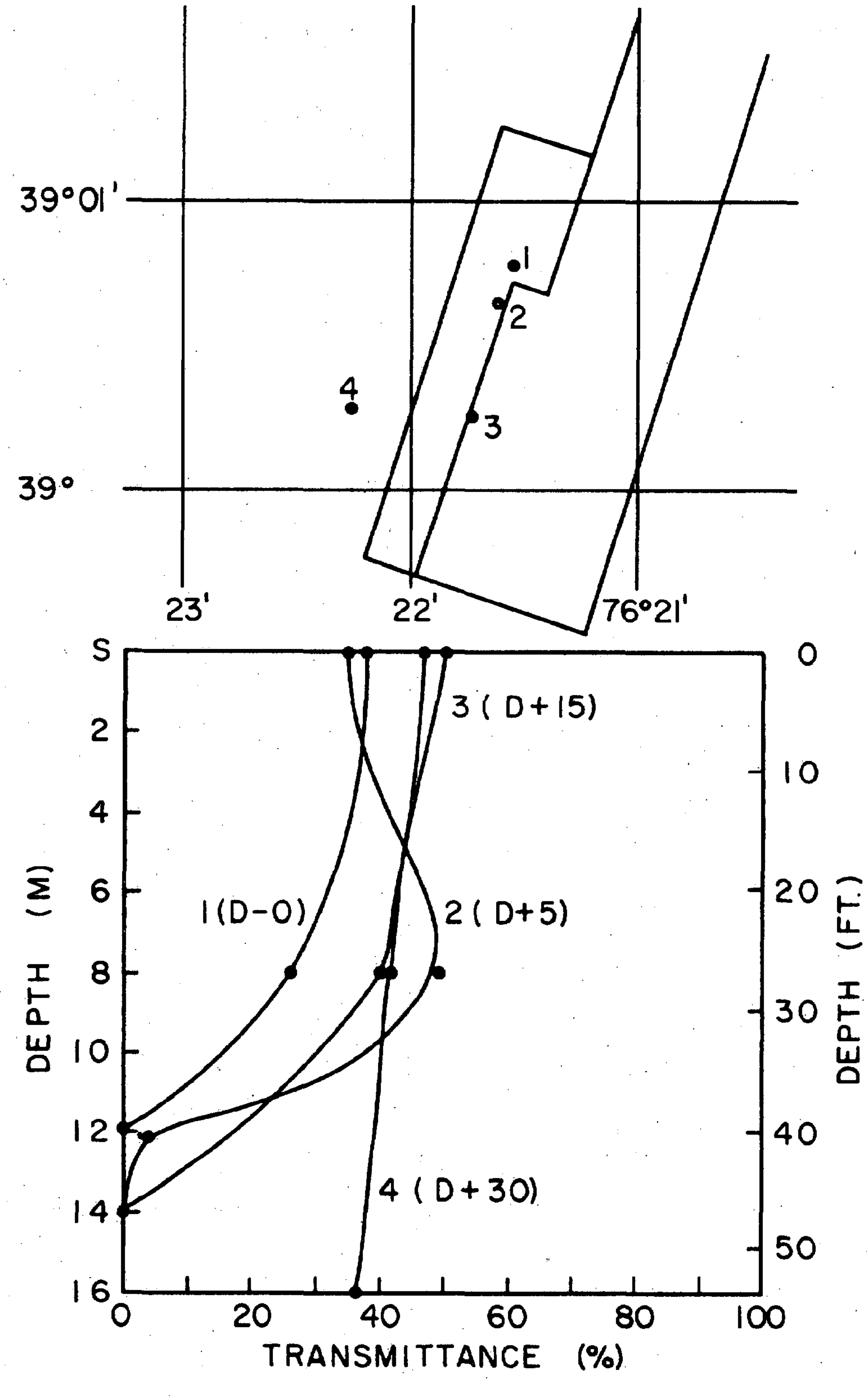

Figure I-8. % transmittance during dump 30 m E of dump area (1, 2, 3); 200 m W (4), 26 Feb 75.

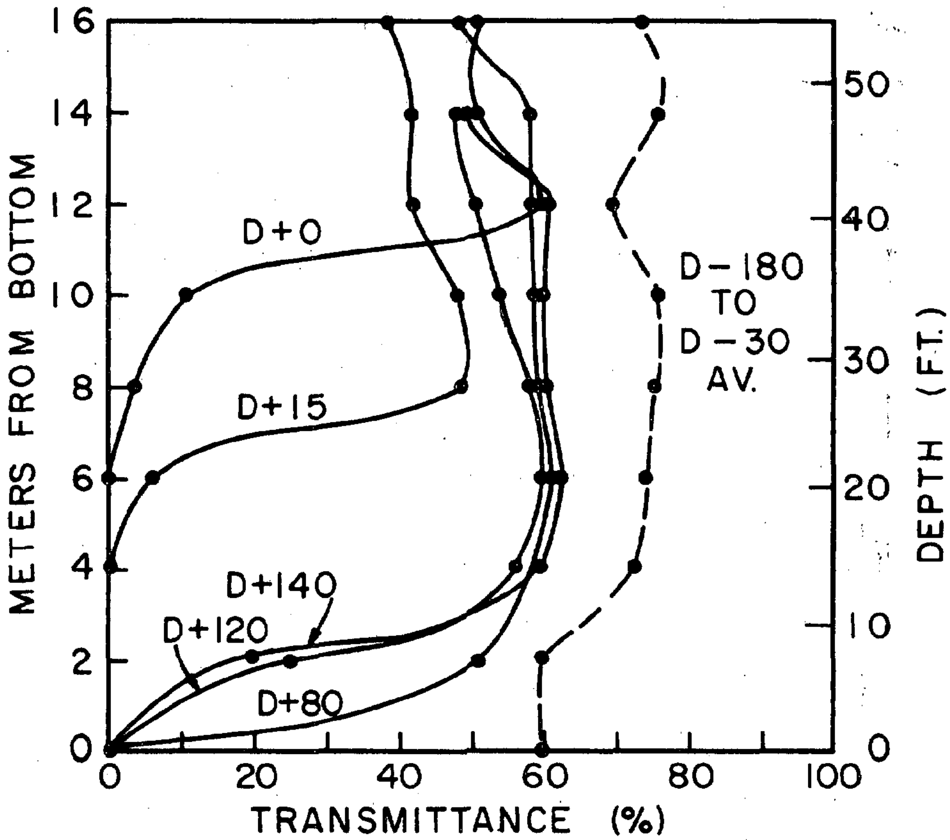

Figure I-9. % transmittance following current drogue set at 12 m (vertical scale reads from bottom to surface to give common origin for different depths of stations) 11 Mar 75.

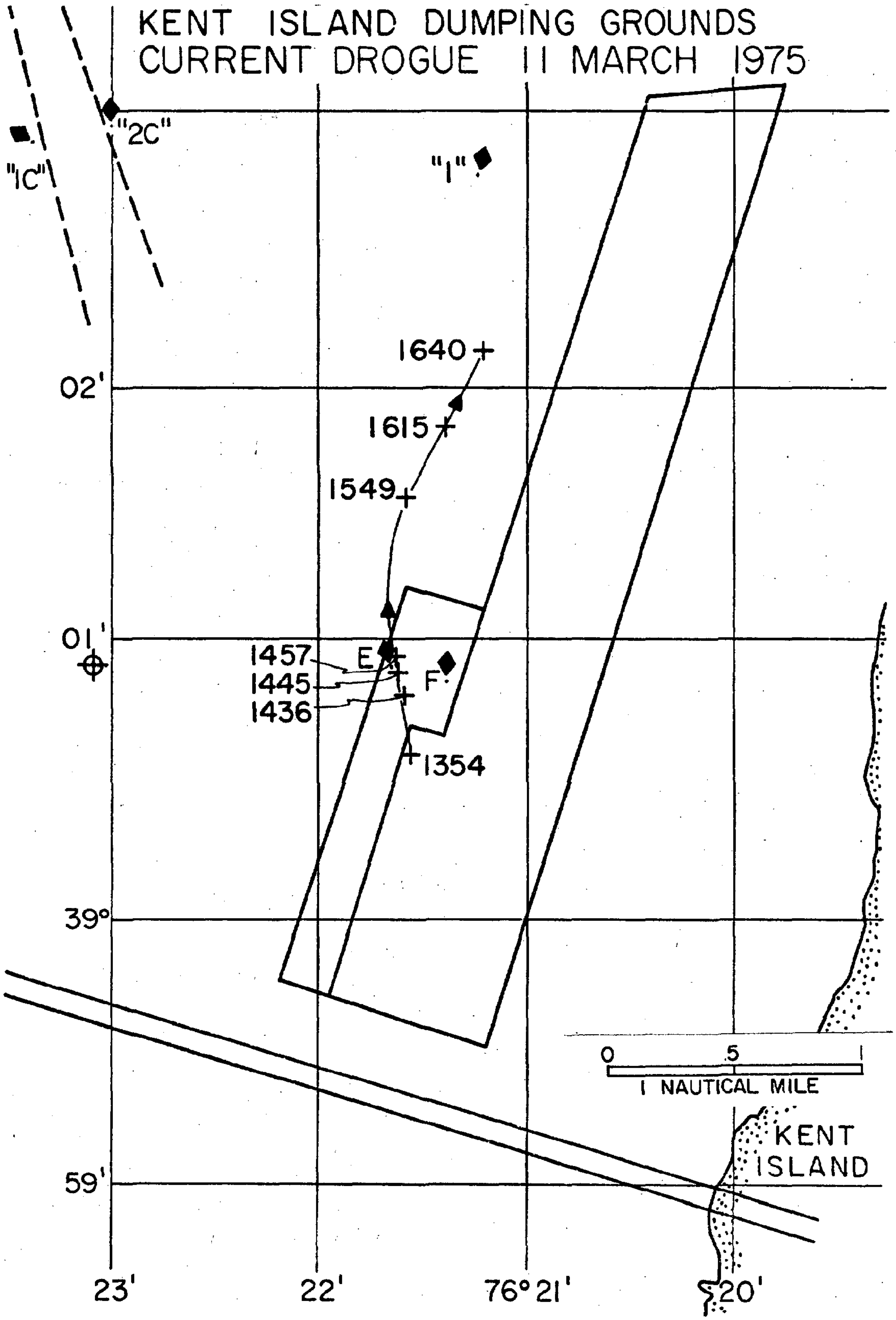

Figure I-10. Track of current drogue at 12 m (11 Mar 75).

indeed the turbidity was slightly clearer than before dumping began. Comparable results were obtained on other days at locations near the disposal operation.

These observations suggest that the plume of turbidity from dumping remained primarily at depths greater than 8m (25 ft.) at locations within a few hundred meters of the dump site.

Excess turbidity in a water parcel

A study was made of the plume of turbid water formed by a single disposal operation. In this experiment, a drogue was set at 12m (40 ft.) on a flooding tide at 39° 00' 37" N, 76° 21' 33" W . The boat tracked the drogue, thus staying in the same water, and periodically measured water turbidity. Results are shown in Figure I-11.

Immediately following the discharge, the top of the turbid cloud was observed at approximately 5m (16 ft.). Fifteen minutes later, the top of the turbid water was at approximately 8m (25 ft.) and at approximately 15m (50 ft.) at 80 minutes after the release. After 80 minutes, turbidity in the water column was essentially normal except near the bottom.

Note that there was no evidence from this set of observations to indicate that the plume of turbid water reached within 5m of the surface.

If we assume that the ship was indeed able to stay in the plume for the period of observations and further that particles settled out by gravitational settling, the data indicate settling

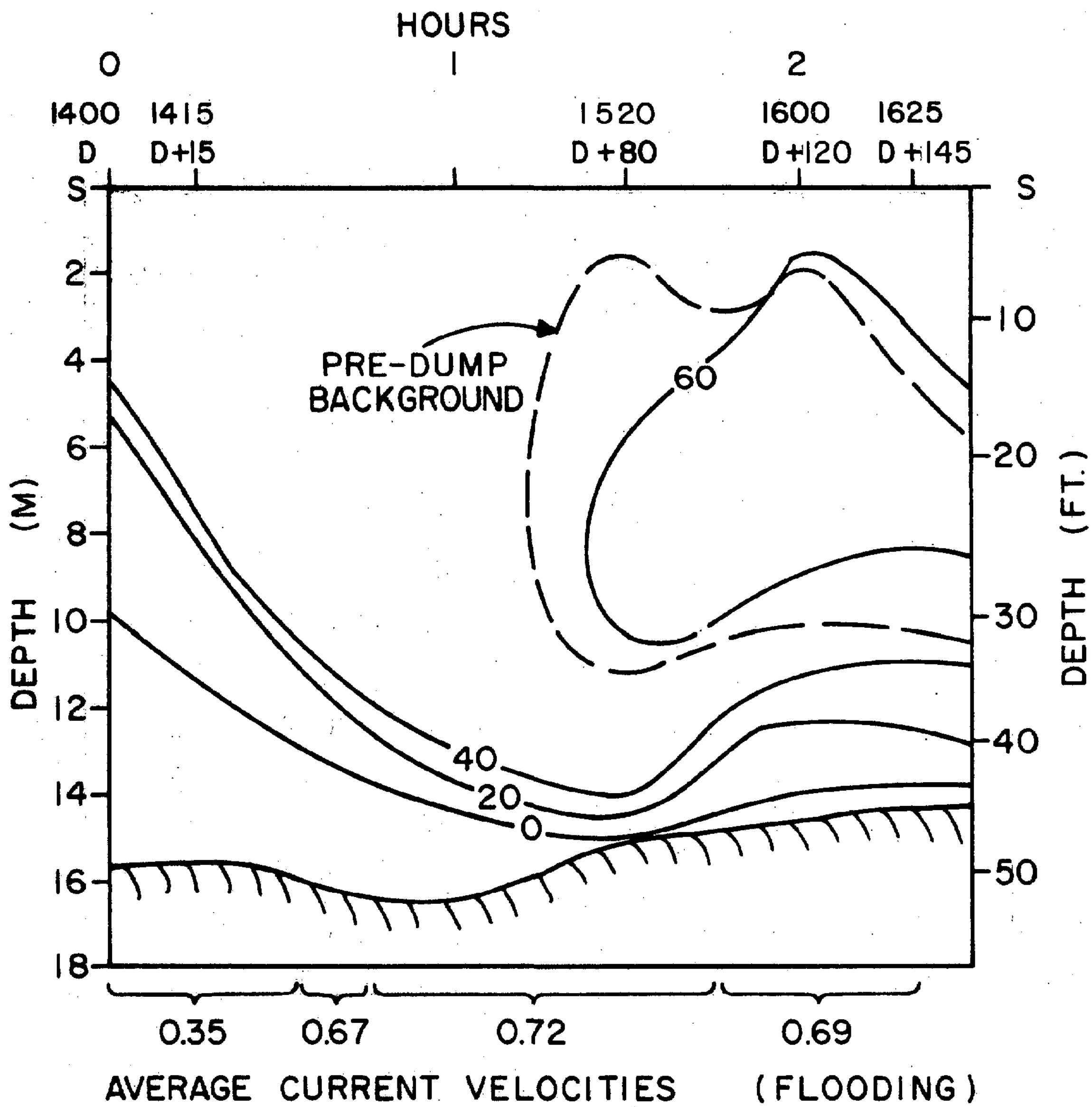

Figure I-11. Temporal sediment suspension (in transmittance %) following dump at 1400 11 March 1975.

rates of 0.2 to 0.4 cm/sec (0.08 to 0.16 inches/sec.).

Figure I-12 shows hypothesized behavior of the plume of dredged materials released during disposal operations. The material originally settled to the bottom as a discrete mass with little or no material reaching the surface. About 15 minutes after release most of the course materials had settled out of the water leaving a plume of turbid water a few meters thick that was moved by tidal currents. After about two hours, the plume of turbid water had settled even more leaving only a thin layer of turbid water very near the bottom. This layer of turbid, near bottom water has been ascribed to resuspension of sediment by the action of tidal currents.

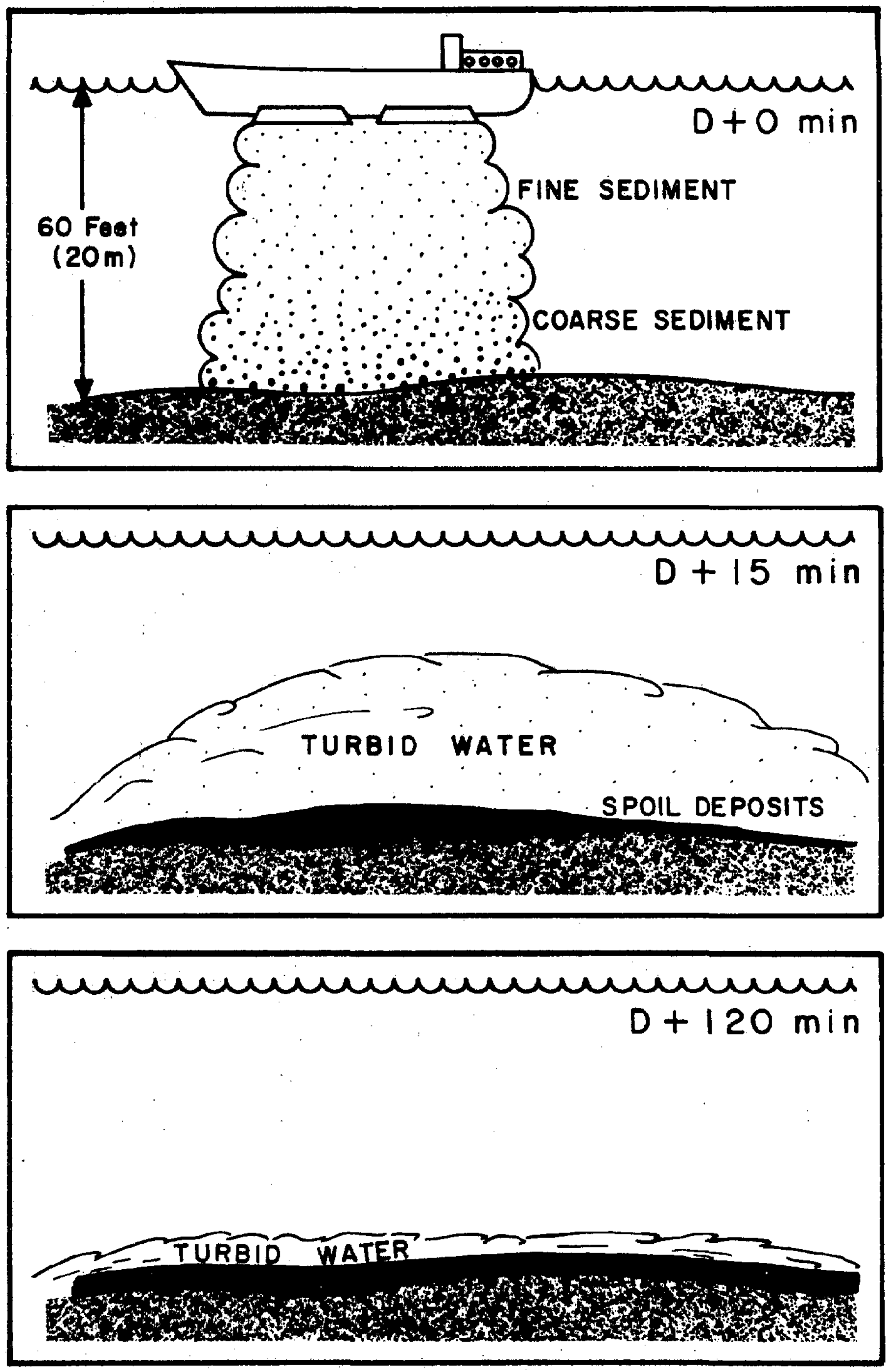

Figure I-12. Probable behavior of plume of dredged materials and turbid water following disposal by hopper dredge in the open waters of the Kent Island site.

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CHAPTER II. PARTICLE SIZES AND SETTLING VELOCITIES

Settling Velocities

Movement of sediment particles released to Chesapeake Bay by disposal operations can be evaluated in two ways. First, if the spoil were thoroughly dispersed by mixing with a large volume of water (relative to the amount of sediment involved) the particles would settle slowly as predicted by Stokes law. For example, a sediment particle 10 microns in diameter (density 2.6 g/cm^3) would have a settling velocity of about 4×10^{-3} cm/sec (1.5×10^{-4} ft/sec) and would require 10 days to settle through 40 meters (130 ft) of water. Particles 100 microns in diameter would have a settling velocity of 0.4 cm/sec (0.015 ft/sec) and would require about 2 1/2 hours to settle through the same water column. In the presence of strong tidal currents, thoroughly dispersed particles could be carried long distances in Chesapeake Bay.

Instead of individual particles settling through the water, the dredged spoil could remain as a discrete mass and settle as a unit through the water. Such vertical density currents have been observed in laboratory experiments where sediment-water slurries sink at rates 50 times more rapid than the settling velocities of individual particles (Bradley, 1965). Such currents are likely formed when hopper dredges discharge. If so, the bulk of spoils should settle out of the water within a few minutes.

Behavior of the waste plume for a bottom -opening hopper barge has been modelled by Koh and Chang (1973). While the model was formulated for deep ocean conditions (S = 37‰, T=2°C), it could probably be used in Chesapeake Bay, ignoring tidal current effects.

Particle Size

Particle sizes of suspended material at the Kent Island Disposal Site were measured in a small number of samples to investigate the probable sources of turbidity and to provide data needed for analysis of settling velocities and possible dispersion by tidal currents. Sampling and analytical procedures are described in Appendix B. Samples were taken at surface, middle, and near-bottom depth in the Bay between the bouys used to mark the location for starting dumping operations; sampling was done prior to and just after dumping.

The data (Figures II-1, II-2, II-3) indicate that on March 11, 1975 the surface particles were identical before and after dumping (D_V of 10μ). Greatest change in particle size was observed in the mid-depth and near-bottom samples where the volume mean diameter (D_V) of the particles were 15 microns before dumping and 30 microns afterward at mid-depth and 12 microns before and 24 after dumping in near-bottom waters.

Schubel (1968) reported D_V values of 4 to 28 microns in 1966 and 1967, with particle size gradually increasing with depth. Schubel considered D_V values 10 to 15 microns to be representative of the Upper Bay. Comparable measurements of the mean Stokes diameter gave the following results:

Mean Stokes Diameter (microns)

	75% of observation	(Range)
Surface	2.3 - 4.0	(2.3 - 6.0μ)
Mid-depth	3.4 - 6.0	(3.4 - 6.8)
Near-bottom	4.2 - 8.0	(4.2 - 12.2)

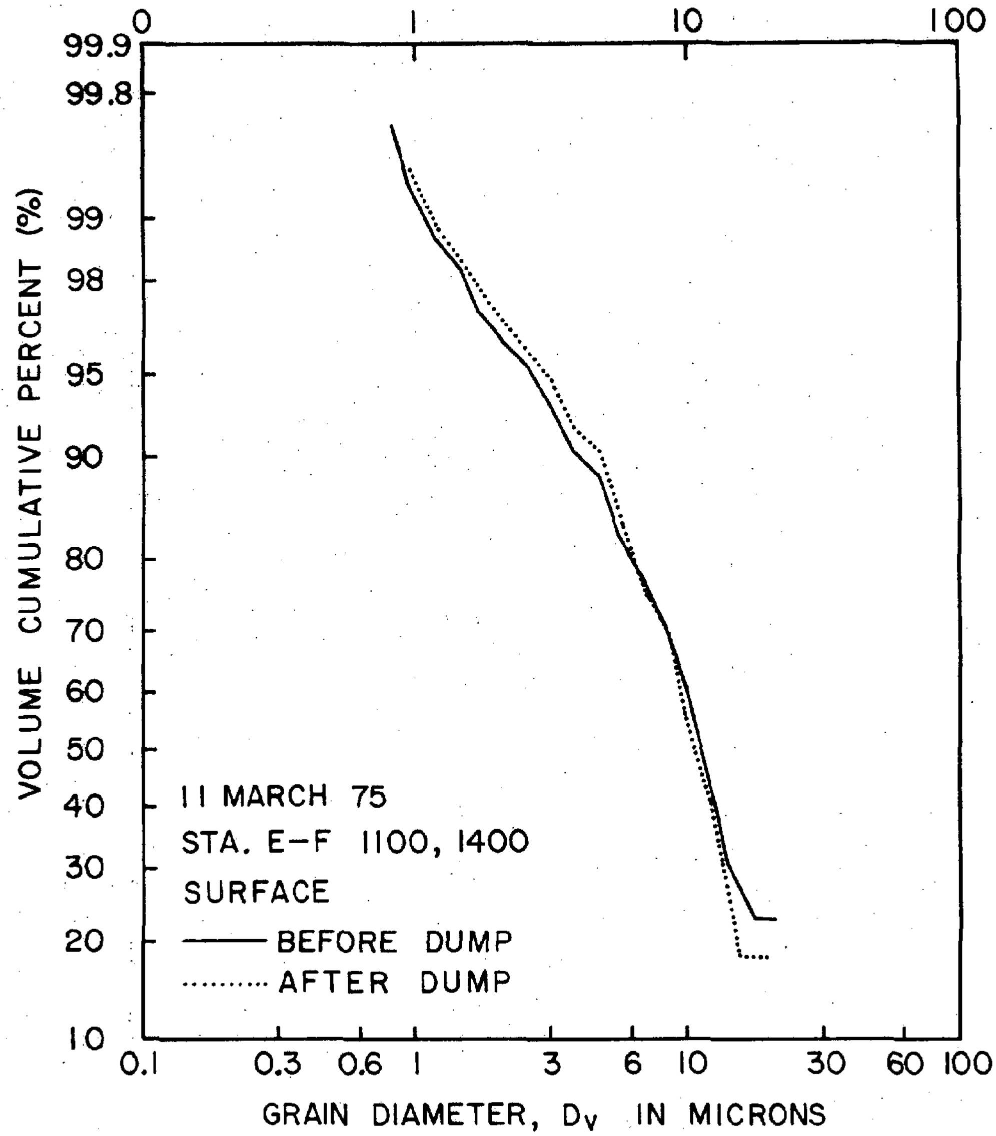

Figure II-1. Grain diameter (microns) surface, 11 Mar 75.

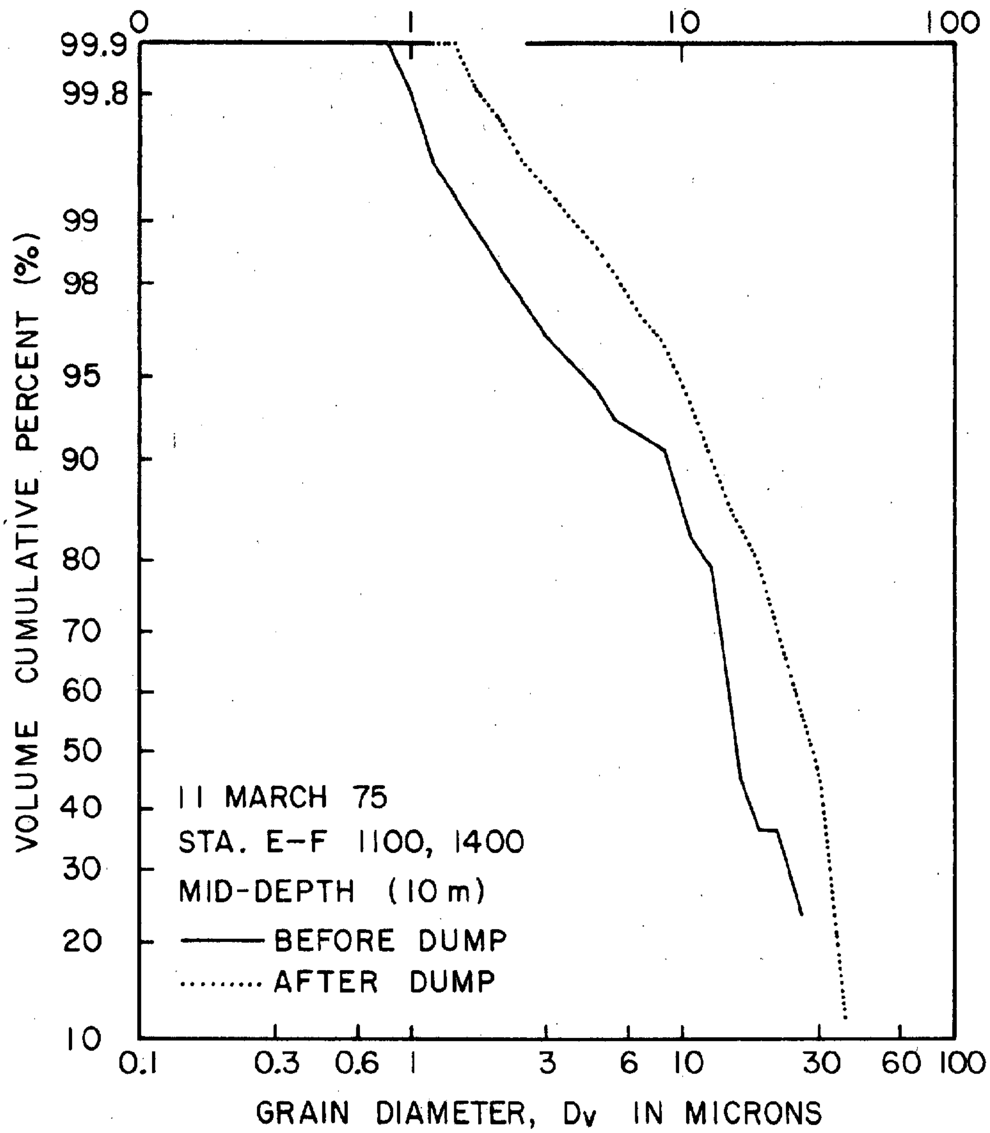

Figure II-2. Grain diameter (microns) mid-depth (10 m) 11 Mar 75.

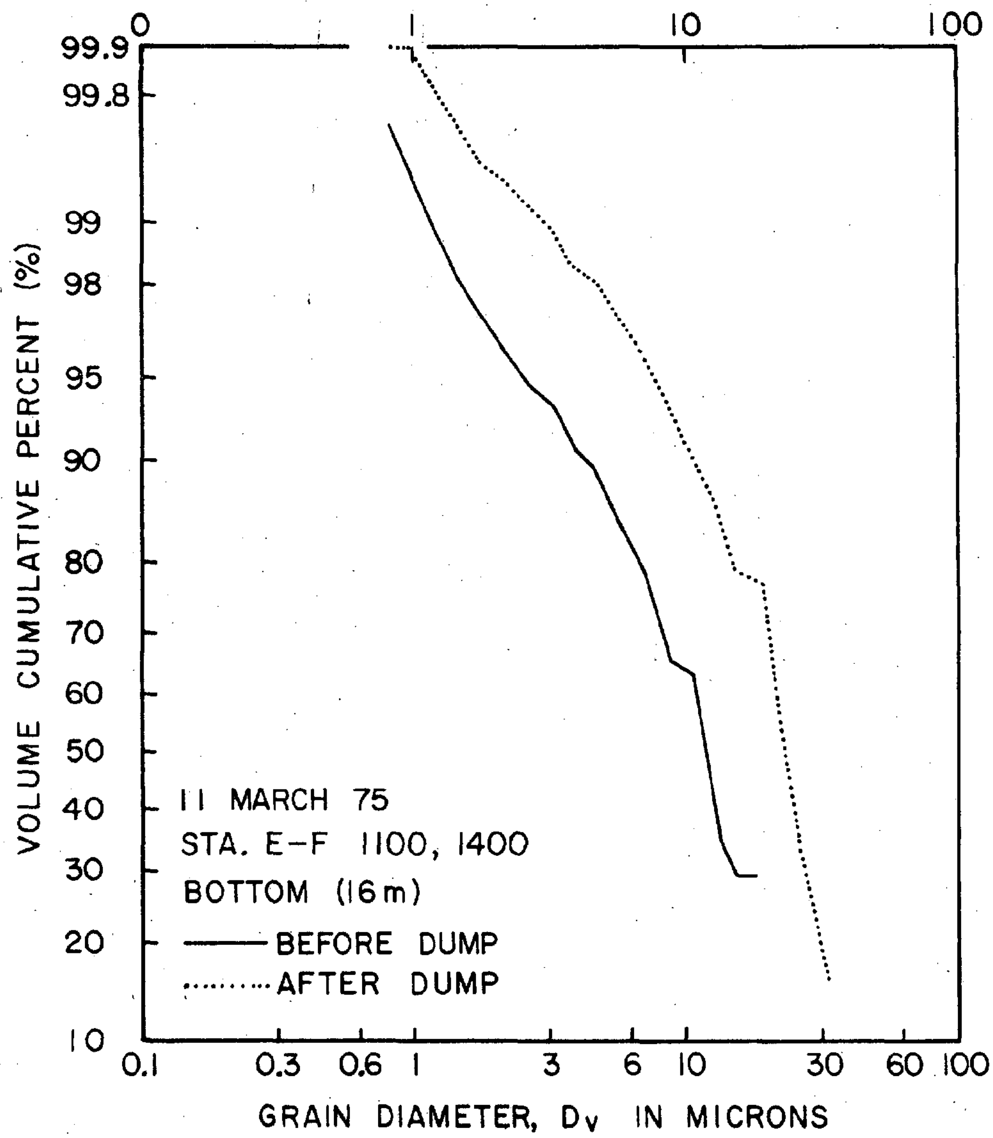

Figure II-3. Grain diameter (microns) bottom (16 m), 11 Mar 75.

Note that the Stokes diameters, based on settling velocities are approximately half of the volume mean diameters. In general, Stokes diameters will be used in estimating settling velocities and tidal current transport.

The data collected indicate that the particles in the disposal area were relatively large compared to normal particle sizes observed in the Bay. This could be either the result of previous disposal operations or the result of the large sediment discharge from the Susquehanna River during the two weeks preceding the study.

It is also apparent that the particles in the materials being dumped are substantially larger than those normally present in the area. The larger particle size promotes rapid settling of particles out of the water and therefore minimizes transport by tidal currents.

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CHAPTER III. SEISMIC REFLECTION PROFILING RECORDS

On January 17, 1975, prior to initiation of disposal operations in the Kent Island site, several high resolution seismic reflection profiles were obtained along tracks normal to the long axis of the designated disposal area.

In certain segments of the Upper Chesapeake Bay, seismic reflection surveys have encountered regions of "acoustically transparent" materials. Palmer (1972, 1974) has presented records from the Chester River which contain examples of such features, and others have reported similar observations. Schubel (1974) and Schubel and Schiemer (1973)discuss the general lack of success in profiling surveys in most areas of the Upper Bay, a situation which they ascribe to the presence of gas in the Bay sediments. We have experienced similar difficulties, but in certain areas penetration in excess of 30 feet (10 m) has been achieved. Cores from both the "soft" or acoustically transparent materials and from the "hard" areas which exhibit no penetration reveal marked differences in physical properties. The corer employed weighed approximately 80 pounds and was dropped from a height of 12 feet above the bottom. Penetration in the soft materials was about 46 inches (106 cm) while in the hard materials it was 11 inches (27 cm). The hard bottom consists of a stiff grey clay, while the softer materials are loose grey to grey-black silt and clay. Water content of the soft sediments was 62 - 69%; that of the hard materials 49 - 55%. We believe that these softer sediments represent recent Bay muds which have filled in old topographic surfaces which originated during a lower stand of sea level. For reference, the water content of spoil material (see Chapter V) ranges from 10% to 25% higher than for the hard areas.

Originally, it was felt that determination of the difference in thickness resulting from comparison of the pre- and post-dump surveys would provide a better measure of the volume of materials accumulated during spoil disposal than would bathymetric difference. This is due to the fact that should compaction of the Bay sediments beneath the spoil mound occur, the net difference in bathymetry would not represent the true volume, but some value less by the amount of depression of the older surface. Therefore, isopach maps (Figure III-1) were prepared for those areas displaying acoustically transparent materials.

Thickness (isopach) lines were prepared as in the technique employed for bathymetric difference. The final difference in thickness (Figure III-2, right) was drawn, and planimetry of the contours produced a volume of 1,101.9 x 10^3 yds^3. This amount is in excess of the volume dredged (840 x 10^3 yds^3, U.S. Army Corps of Engineers data, personal communication, Frank Hamons, 1975), and sources of the error are considered to lie in the resolution of the lower reflecting horizon forming the contact between the spoil and the Bay floor. Inspection of the pre-and post-dump surface beneath accumulations of spoil shows no measurable depression of Bay floor. Similarly, the records from a January 1975 cruise (Figure III-3) (pre-dump inspection) suggest that no compaction of the bottom has occurred under older spoil mounds, but since we have no earlier survey data, this question must remain open.

During the course of this survey, we extended the seismic reflection lines well eastward of the dumpsite extension in order to cover the Broad Creek oyster bar. No accumulations of materials were noted in the post-dump survey lines. On the basis of these survey lines, it is clear that no detectable accumulation of new material (spoil) was present on this bar.

The presence of several mounds south of the marker bouys E and F suggest that: (1) dumping of single loads took place in stages, (2) release points varied, or (3) bottom currents redistributed the materials dumped between bouys E and F. (See Figs. III-4 through III-7.) We are informed that the dumping routine remained the same throughout the period, and that a single release point was established for all dumping. The third possibility, distribution by bottom currents, is supported by measurements of strong near-bottom currents flowing about 195°, a trend nearly parallel with the alignment of the separate mounds. This, plus the displacement of spoil fines to the south (discussed elsewhere), points to a hydrodynamic factor as the cause of this distribution. It is well-known that finer material can accumulate in discrete deposits behind obstructions to flow. It may be that the distribution shown in Figure III-2 reflects a hydraulic response to lee effects behind the major deposit between the two bouys but at present, we can only speculate as to the efficiency of such a mechanism.

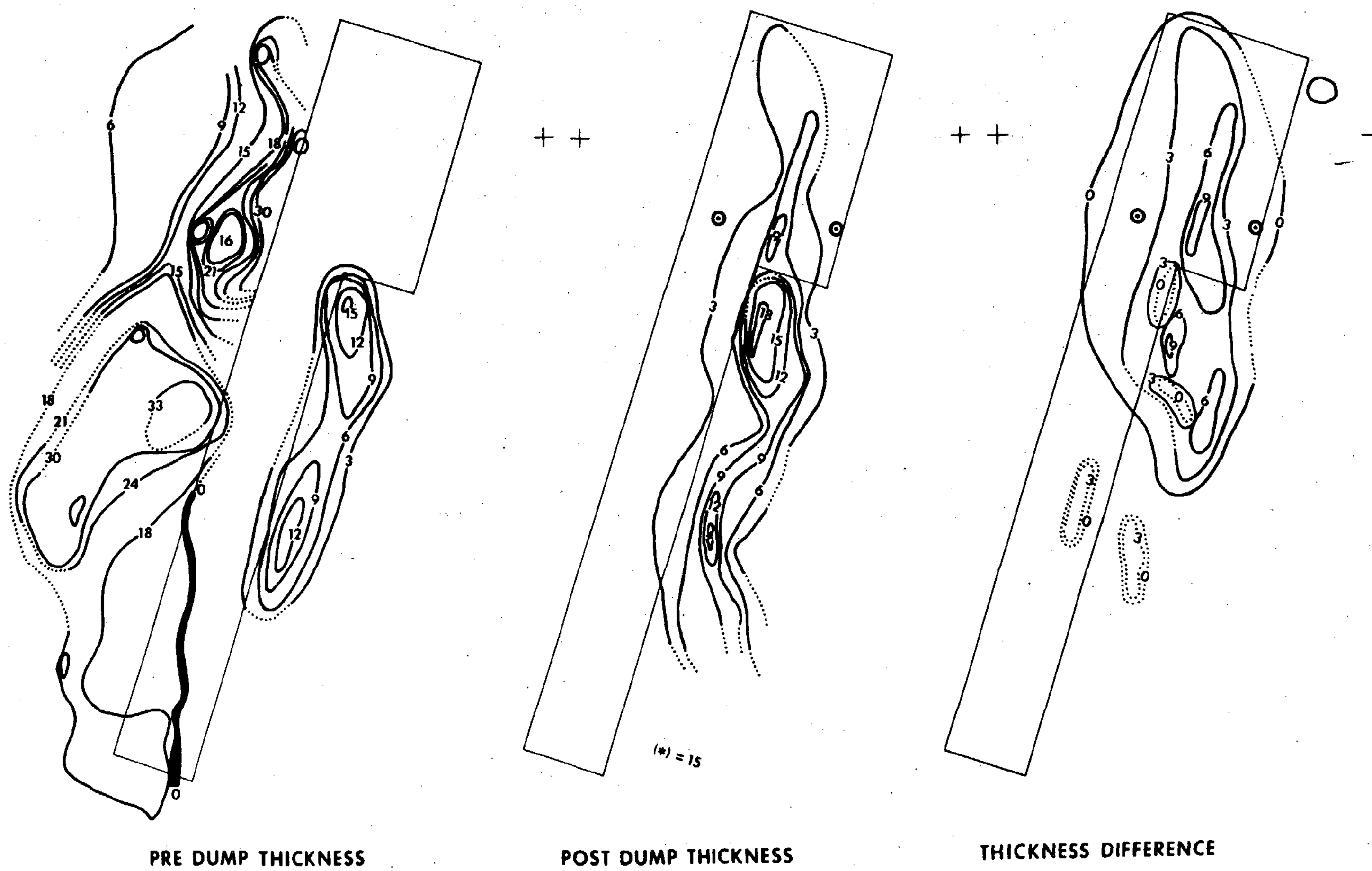


Figure III-1. Isopach maps of thickness, acoustically transparent sediments. Note buried channel at left (west) of the dumpsite extension. Pre-dump (left), post-dump (center) and difference (right) are in feet.

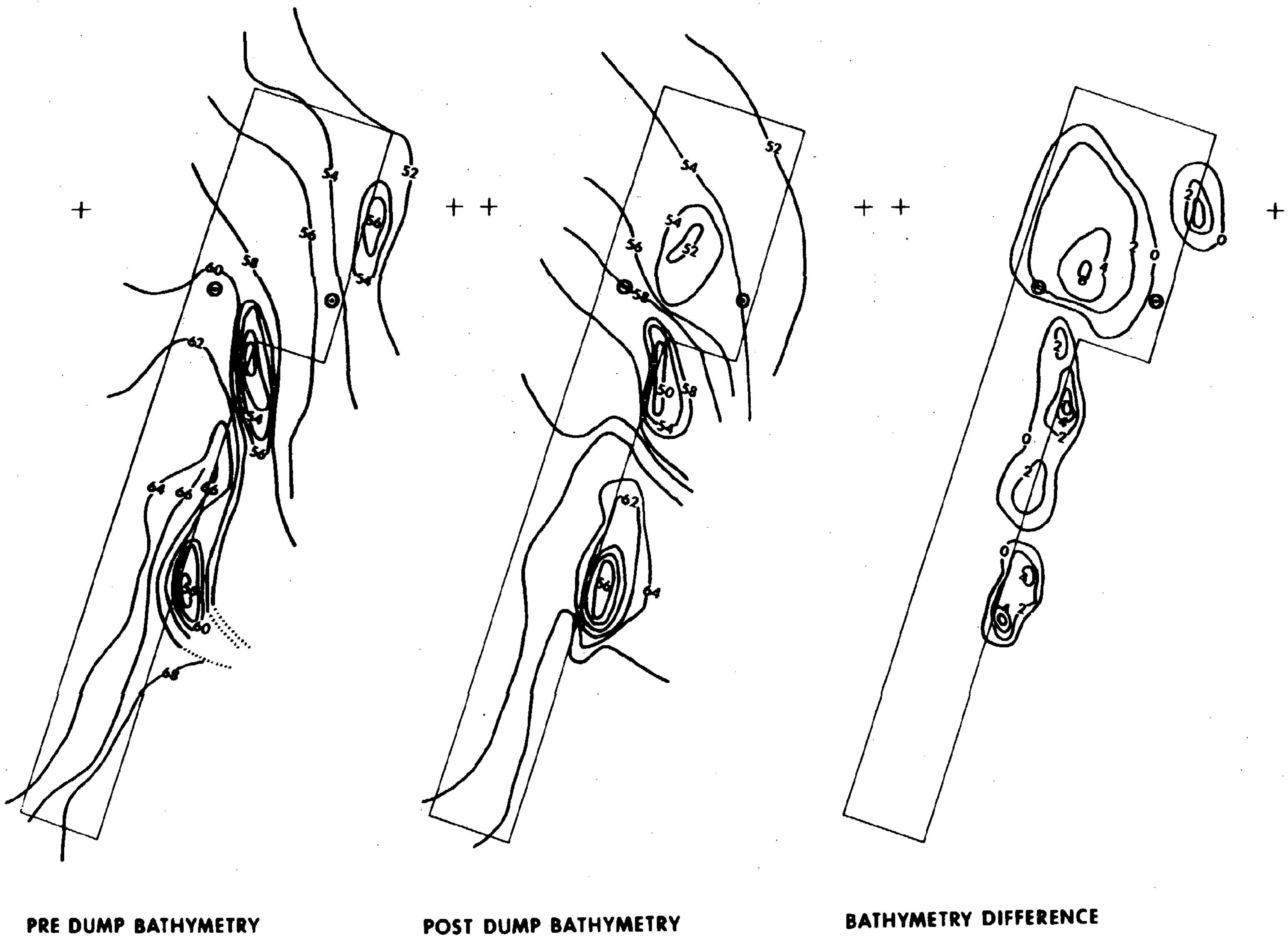


Figure III-2. Bathymetric charts for pre-dump (left), post-dump (center) and difference (right). Contours are in feet.

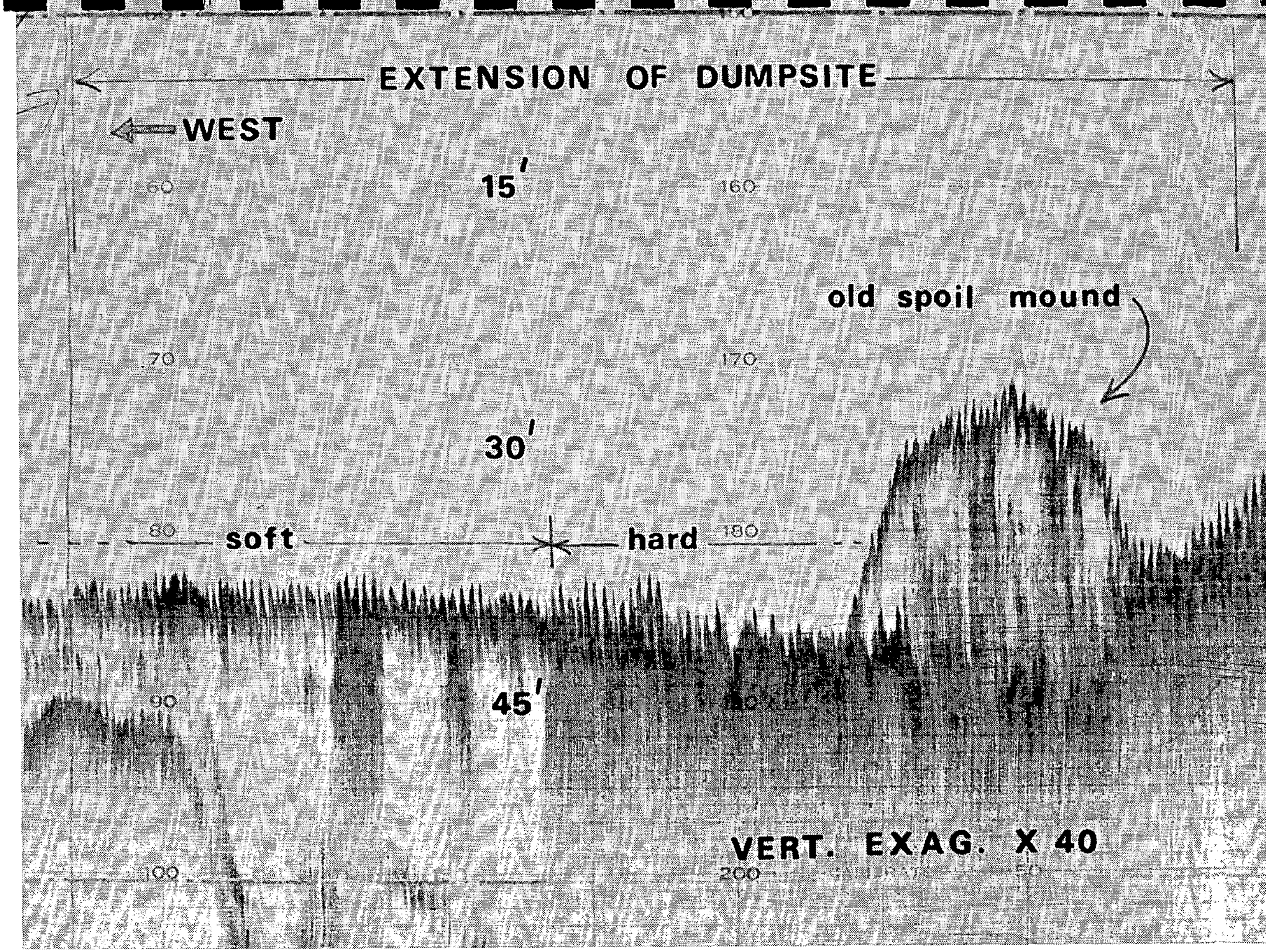
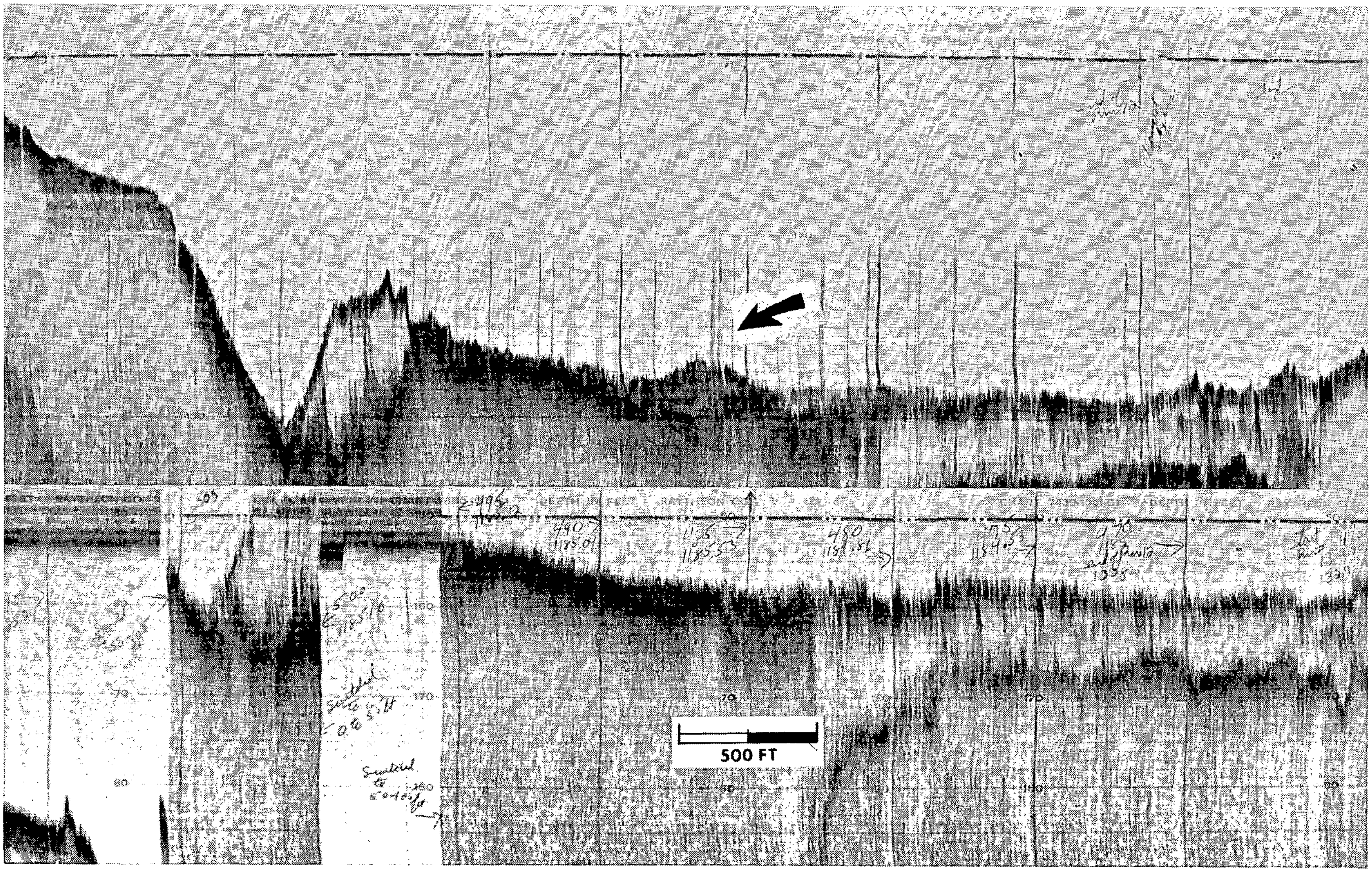
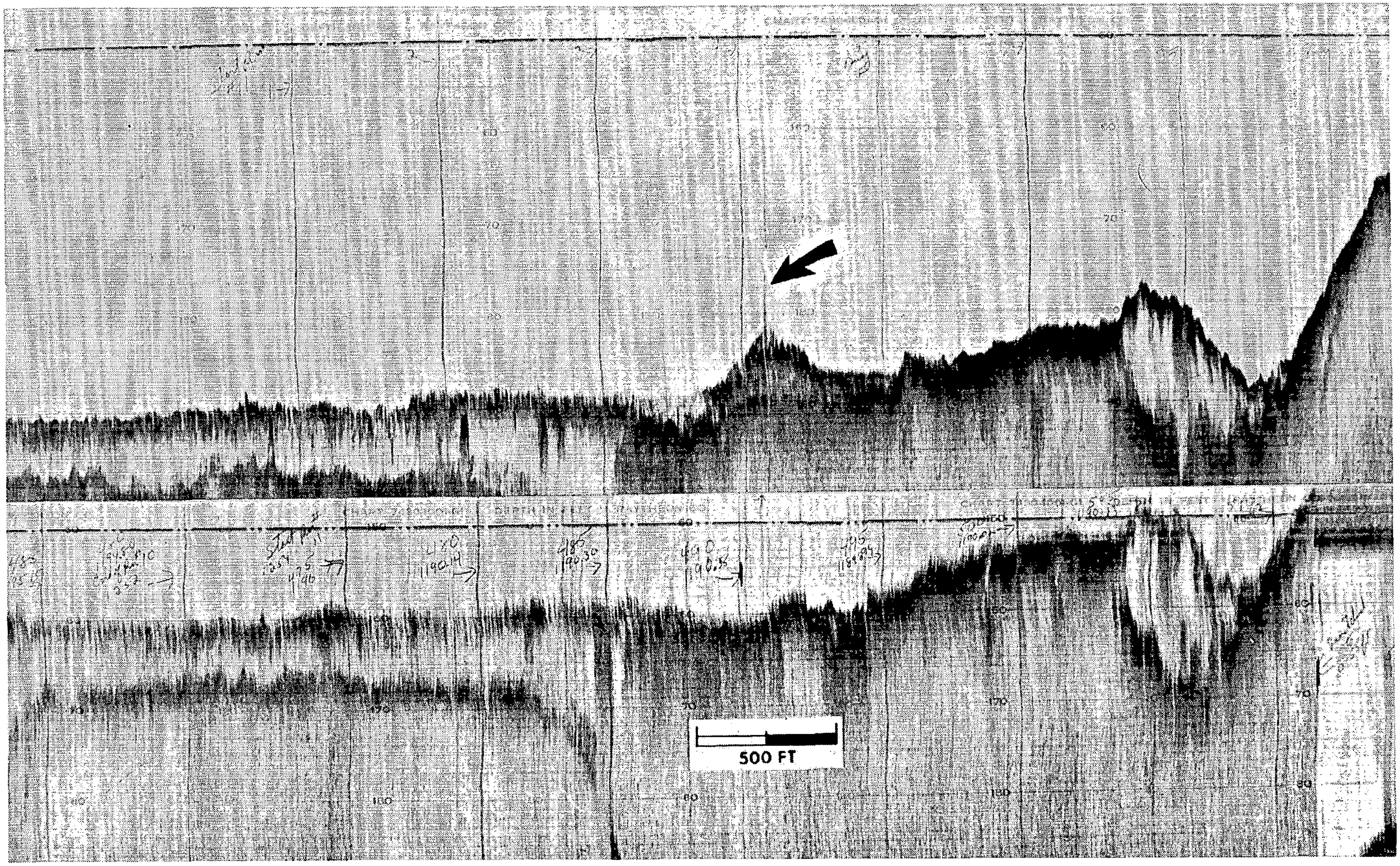


Figure III-3. Pre-dump profile run 17 Jan 1975. The "acoustically transparent" sediments to the left (labelled "soft") consist of loose bay muds which have filled in and obliterated older topographic irregularities on the Bay floor. The more reflective "hard" materials consist of stiff clays. The old spoil mound is at least 3 years old. Depth in feet.



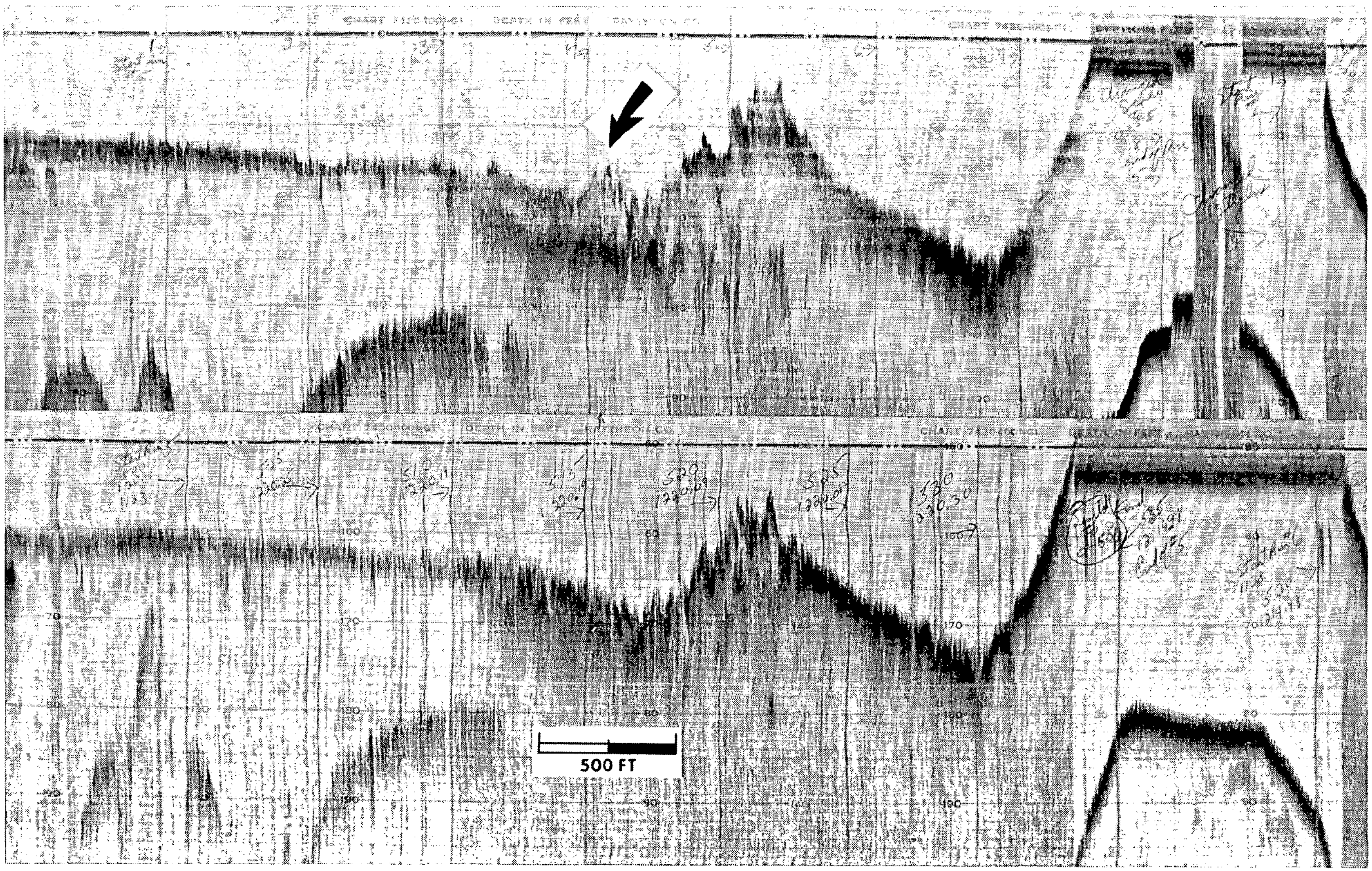
Typical fathometer records showing bottom topography and deposits of dredged materials, Kent Island Disposal site.

Figure III-4. Arrows show accumulations, pre-dump on bottom, post-dump,top.



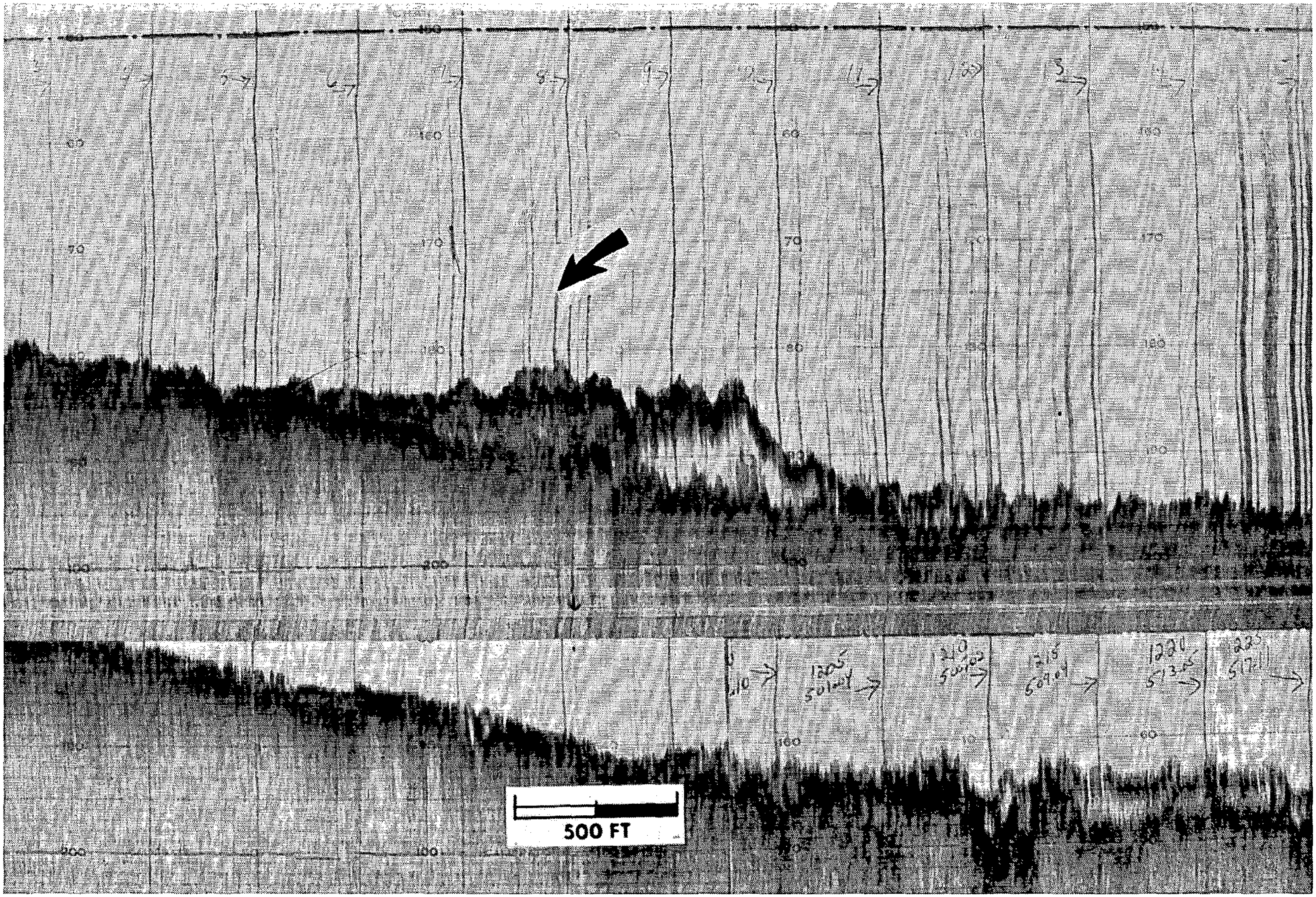
Typical fathometer records showing bottom topography and deposits of dredged materials, Kent Island Disposal site.

Figure III-5. Arrows show accumulations, pre-dump on bottom, post-dump, top.



Typical fathometer records showing bottom topography and deposits of dredged materials, Kent Island Disposal site.

Figure III-6. Arrows show accumulations, pre-dump on bottom, post-dump, top.



Typical fathometer records showing bottom topography and deposits of dredged materials, Kent Island Disposal site.

Figure III-7. Arrows show accumulations, pre-dump on bottom, post-dump, top.

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Gordon, R.B. 1974. Dispersion of Dredge Spoil Dumped in Nearshore Waters. Estaurine and Coastal Mar. Sci. 2:349-358.

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CHAPTER IV. BATHYMETRIC PROFILE SURVEYS

Open water disposal of dredged material involving hopper barges usually results in a localized and measurable accumulation of spoil on the sea floor around the point of release. An excellent study of spoil disposal, and the depositional mound was made by Gordon (1974) who investigated hopper barge disposal effects in the New Haven, Connecticut, dumpsite. Although the vessel used in the Baltimore Harbor Approaches dredging activities released four to five times the volume studied by Gordon, the dynamics of settling, deposition and accumulation should be similar to those observed at the New Haven site. Trajectories of the spoil plume and turbidity associated with individual dumping events were discussed in Chapter I. This section describes the results of acoustical surveys completed: on 14 February "pre-dump" on 18 March 1975 (Figure IV-1) and on November 1975 (Figure IV-2).

Results

On the basis of bathymetric change noted in the pre- and post-dump surveys, we conclude that approximately 520,000 yds^3 of newly deposited material (presumably spoil), can be identified within, and slightly east of the Kent Island dumpsite extension. The fact that some material was apparently deposited slightly east of the boundary is not significant, since our records indicate no significant spoil accumulation has occurred in the Broad Creek oyster bar east of the dumpsite. Discrepancies between the amount dredged (as reported by the U.S. Army Corps Of Engineers) and that determined by our study indicates that about 338,000yds^3 (256,000 m^3)

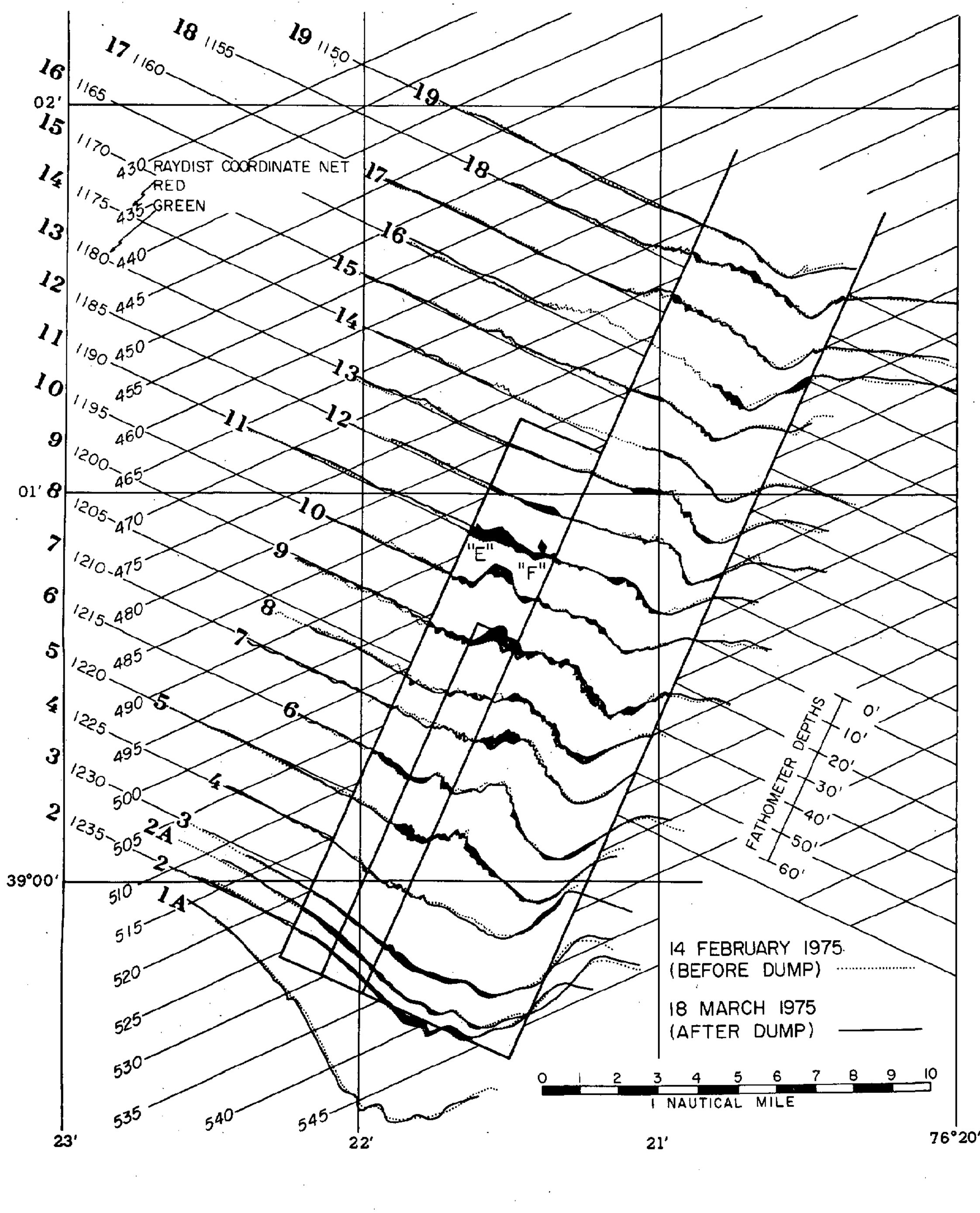

Figure IV-1. Bottom topography prior and post dump.

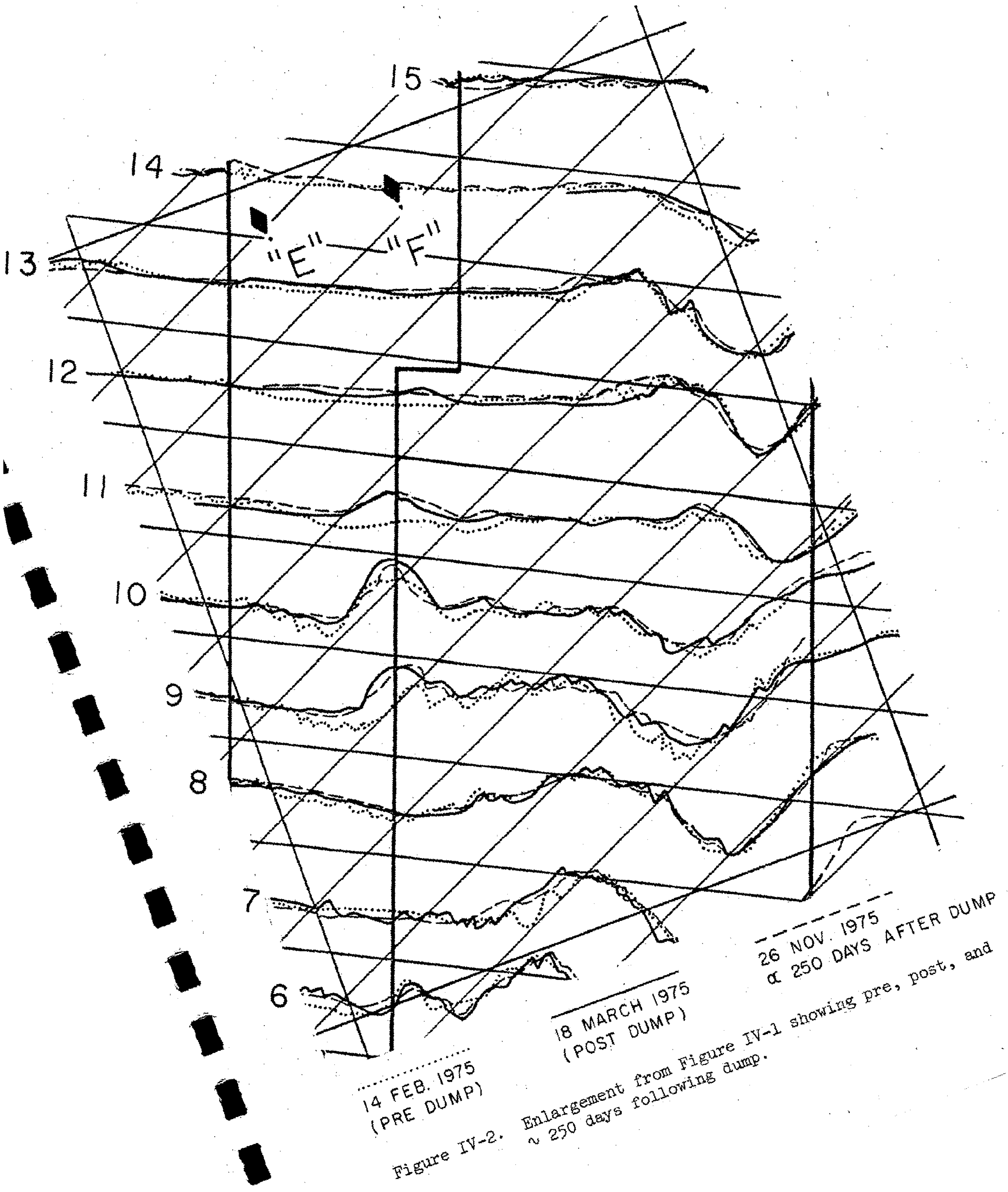

Figure IV-2. Enlargement from Figure IV-1 showing pre, post, and ∿ 250 days following dump.

have been deposited elsewhere. In other words, 60.6% of the material transported by the ESSAYONS could be detected in the designated disposal site.

A final bathymetric survey was made on 26 November 1975, approximately 250 days after disposal activities had ceased. The purpose of this survey was to determine if major changes in bottom topography had occurred in the summer. Specifically we were interested to find if there was any evidence of major removals of dredged materials from the disposal site after completion of the operations.

The results are shown in Figure IV-2. Comparison of the two post-operational surveys shows no compelling evidence for removal of dredged materials from the disposal site. Only one sounding line (line 10) shows any difference between March and November 1975. This could be the result of navigational problems in which the two lines did not measure exactly the same portion of the rather irregular bottom topography left by the disposal operations. The adjacent lines of soundings did not exhibit significant losses of materials.

REFERENCE

Gordon, R.B. 1974. Dispersion of Dredge Spoil Dumped in Near-shore Waters. Estaurine and Coastal Marine Science. 2:349-358.

CHAPTER V. CORING OPERATIONS

Upon completion of disposal operations, cores were taken to attempt to determine the areal spread of the dredged materials. A 6.5 cm Benthos corer[1] and a 3.5 cm Hydro Products[2] corer, both with plastic liners, were free dropped for 0.5 - 3 m as only superficial characteristics were desired. On 25 March a total of 13 cores were taken with the Benthos corer, four in the dump area, four in the north fringe area, and 5 in the south fringe area. The locations are shown in Figure V-1 and a graphical representation of each core in Figure V-2. All cores showed a base of black, dark brown, or dark grey clays usually homogeneous (except #8 which was all sand). The upper 200 mm (average) was normally a mixture with occasional shells or sand and the uppermost 10 - 20 mm always a fine brown silt. Core #3 was taken in the dump area and was very "soupy". Figure V-3 shows the water content of cores 1 - 3.

Fourteen analyses of the uppermost 20 cm of these three cores (approximately 8 inches) averages 54.8 $\pm$ 8.8% water. Thus the deposits in the disposal area will be assumed to consist of 55% water and 45% solids with a grain density of 2.6 grams per cubic centimeter. Therefore, the dry solid content of the deposits will be taken as 1.2 grams per cubic centimeter (or 1.2 metric tons per cubic meter).

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[1] Benthos, Inc. Edgarton Drive, N. Falmouth, MA 02556

[2] Hydro Products, 11777 Sorrento Valley Rd., San Diego, CA 92121

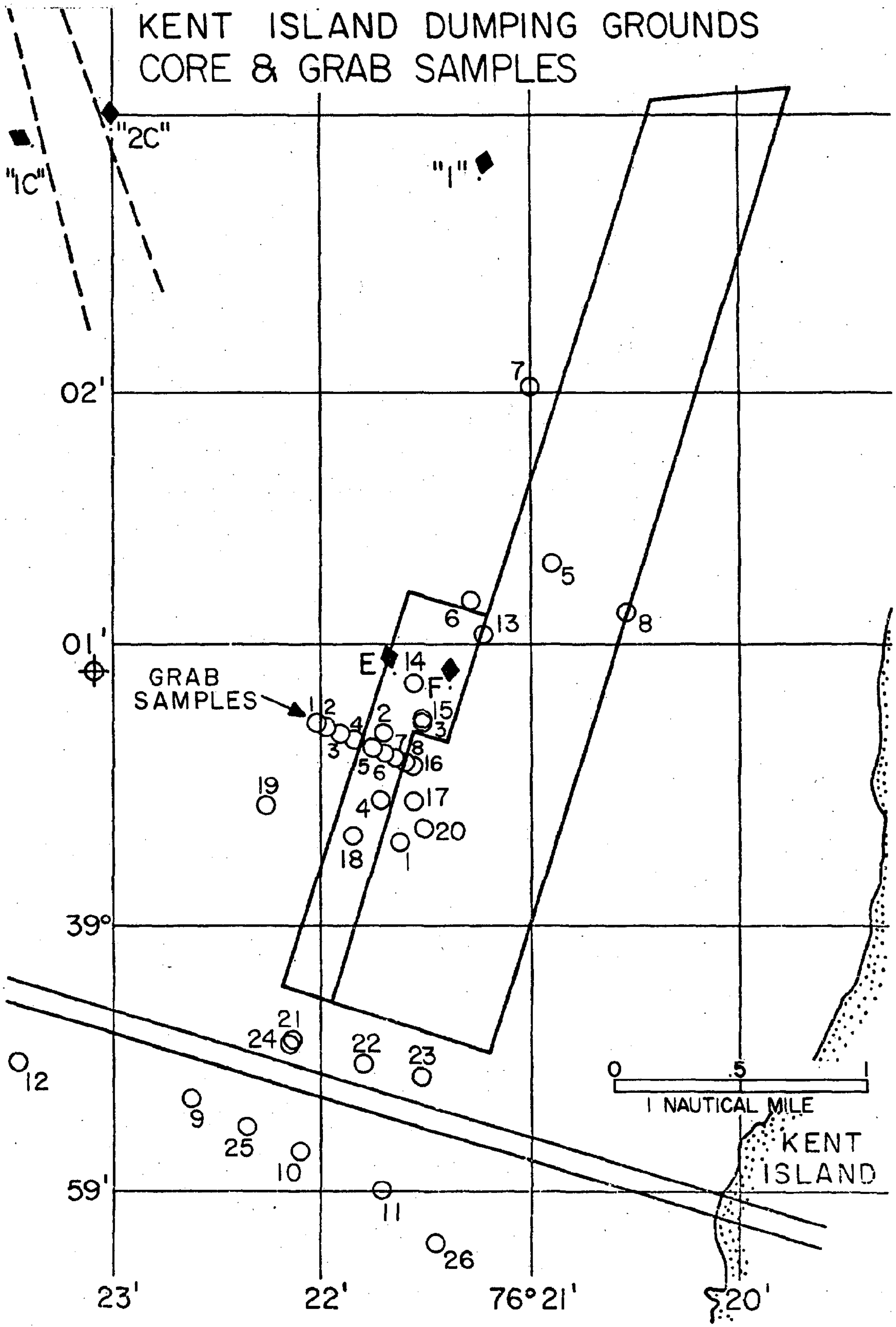

Figure V-1. Station locations, core and grab samples, 25 Mar, 2 Apr, 9 Apr 1975.

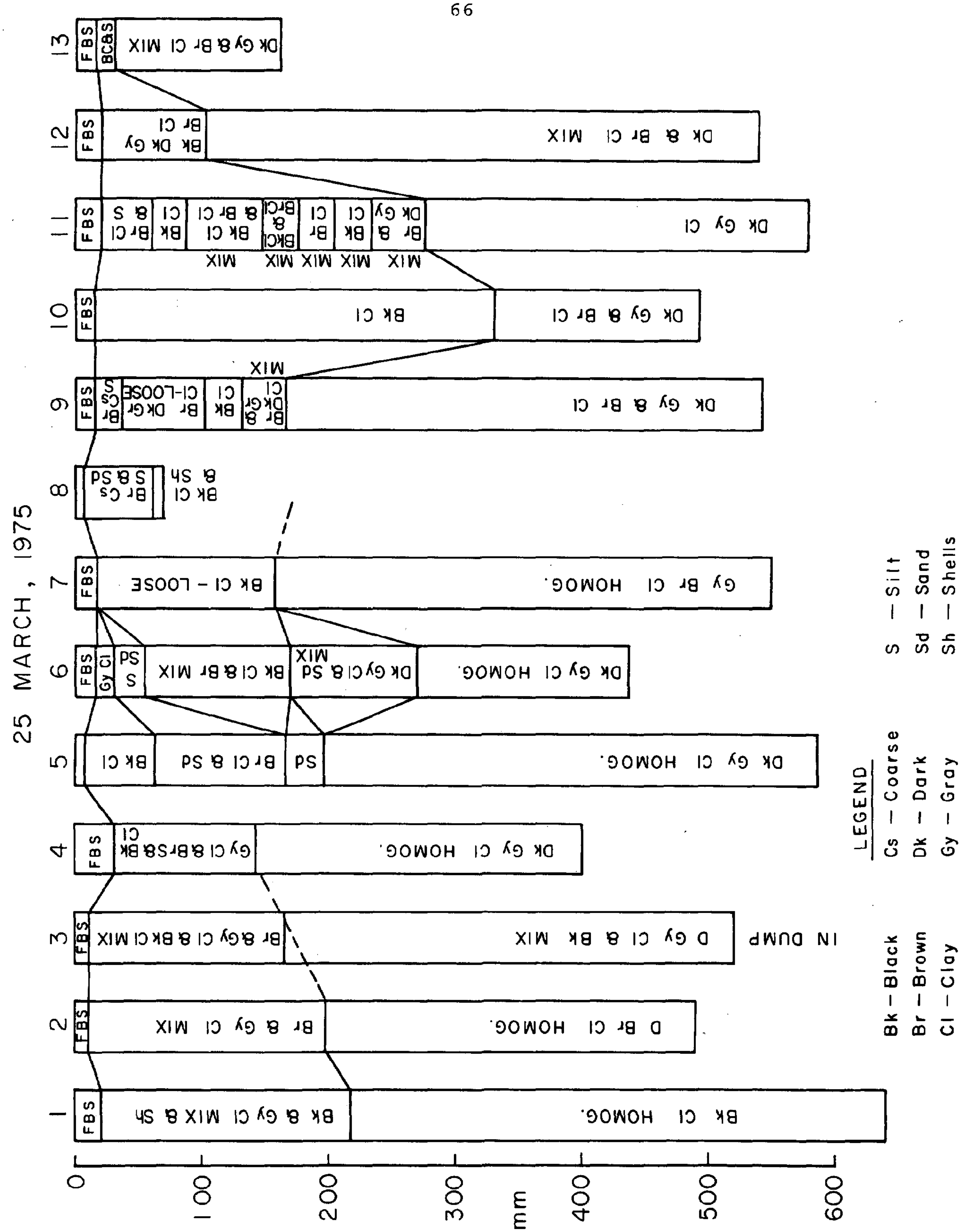

Figure V-2. Schematic of cores taken 25 Mar 75.

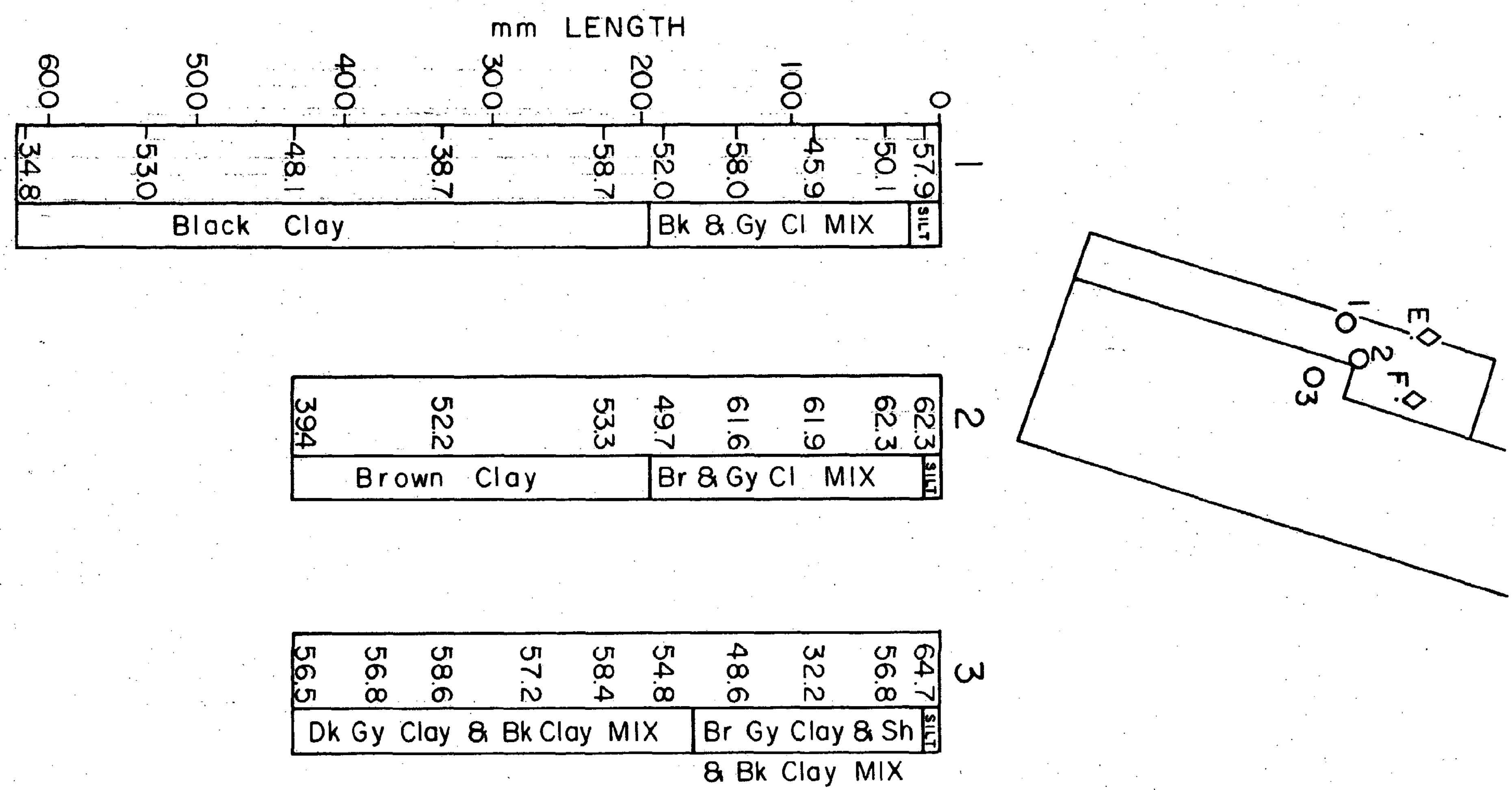

Figure V-3. Water content (%) and sediment descriptions of cores 1 - 3, 25 March 1975.

Using these values, we calculate that approximately 470,000 metric tons of dredged wastes (dry solids) remained in the disposal site in accumulations more than 0.3 meters thick. This compares with the estimated 670,000 metric tons of sediment brought into the Chesapeake Bay during the dredging operations.

In April another series of 11 cores (13 - 23)were taken, the first 8 to confirm unusual sub-sonic records, Core #13 showed a 350 mm layer of brown silt, Core #14 no silt (from center of dump area just S of "E" and "F"). Core #16 showed 350 mm of brown silt; Core #17, 300 mm; Core #18, 10 to 15 mm, (inside dump area, western side, hard stiff grey clay, water 49 - 55%, good seismic reflection). Core #19 showed very thin 3 to 5 mm brown silt (outside dump western side, soft, black silty clay, water 62 - 69%). This is a sonically transparent channel fill outside the dump area. Cores 21 - 23 showed 50 - 60 mm of brown silt on top, with brown and grey clay mixed below. (See Figure V-1).

Another series of "mini" cores were taken by pushing a glass tube into the undisturbed top layer taken by grab sampler. The CBI grab sampler is a modified Van Veen with a top-opening trap door to allow access to the top layer of sediment. Mini cores were taken approximately every 100 m beginning 800 m west of the dump area approximately 800 m S of "E" and "F". Mini cores #'s 1 - 5 showed 20 - 30 mm of fine grained silt on the surface layer. Mini core #6 showed no surface layer and was very "soupy" and was taken from the disposal material. Core #7 showed irregular lumps of brownish clay with very little interstitial material for the first 200 mm.

Possibly the fine grained material had been resuspended.

Cores just north of the Chesapeake Bay Bridge (21 - 23) were sampled with the Hydro Products corer; all 3 showed 20 - 30 mm of fine grained silt in the surface layer. Core #22 showed lumps of grey clay mixed with black clay while #1 and #2 showed only black clay. All three had coarse grained sand mixed with the clay.

On April 9, ten cores were taken with the Hydro Products corer (#24 - #33). (Core #24 was a duplicate of #21 formerly taken.) Cores #25 and #33 were all taken below the Bridge. All of these cores showed a surface layer of fine brown silt from 40 - 130 mm deep underlain by a black clay. The end cores on each side showed a diminishing of fine brown surface layer and a change to sand. In general, the deeper the water, the deeper the fine brown silt layer. Core #32 in 108' of water showed a layer 130 mm deep, see Figure V-4.

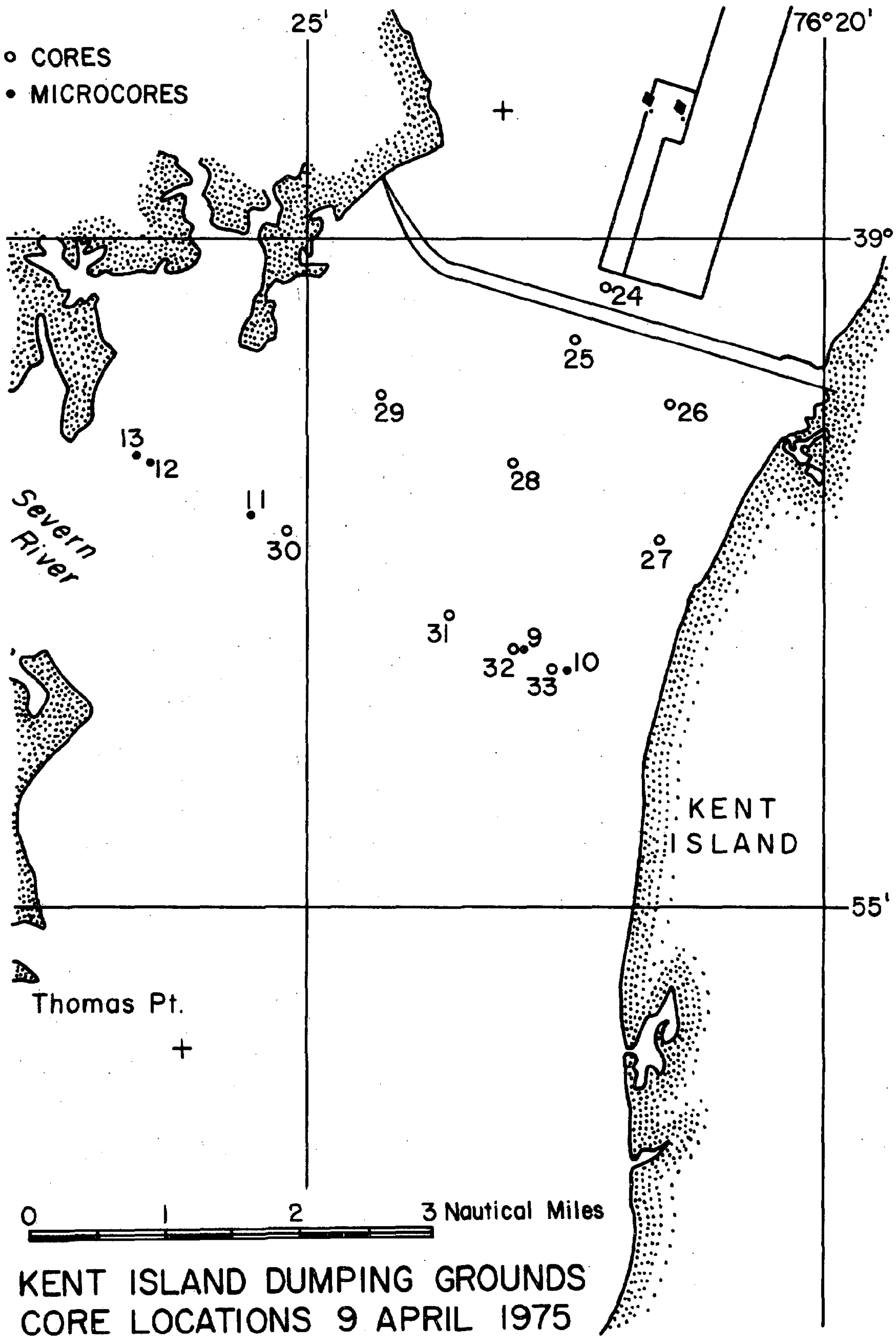

Figure V-4. Core and microcore locations.

CHAPTER VI. SUSQUEHANNA RIVER INPUTS

Discharge of water and suspended sediment has a major influence on Upper Chesapeake Bay, which extends into the Kent Island Disposal site. The late February-early March period is typically one of low river discharge (Figure VI-1). But during the period of the dredging operations, the Susquehanna River had small flood, 24 February to 2 March 1975, in which the discharge was more than twice normal for the period (Figure VI-2). This depressed surface water salinity in the disposal site and increased the level of background turbidity owing to the large amount of suspended sediment discharged with the floor waters.

Before considering the amount of sediment discharged by the flood it is worthwhile pointing out that the flood was not a large one and in fact was smaller than the one that occurred in the Susquehanna River as a result of Tropical Storm Eloise on 24 - 30 September 1975. The late February flood had a peak flow of about 370,000 cubic feet per second at Conowingo Dam corresponding to a flood with a recurrent period of five to six years. The Eloise floods with their peak flow of 584,000 cubic feet per second on 27 September 1975 correspond to a flood with a recurrence period of about 23 years. (See Figure VI-3.) Thus, the period during the following the dredging and disposal activities in the Kent Island disposal site was one of unusually high river flow.

High river flow results in large discharges of suspended sediment. The February floods brought about 600,000 short tons of

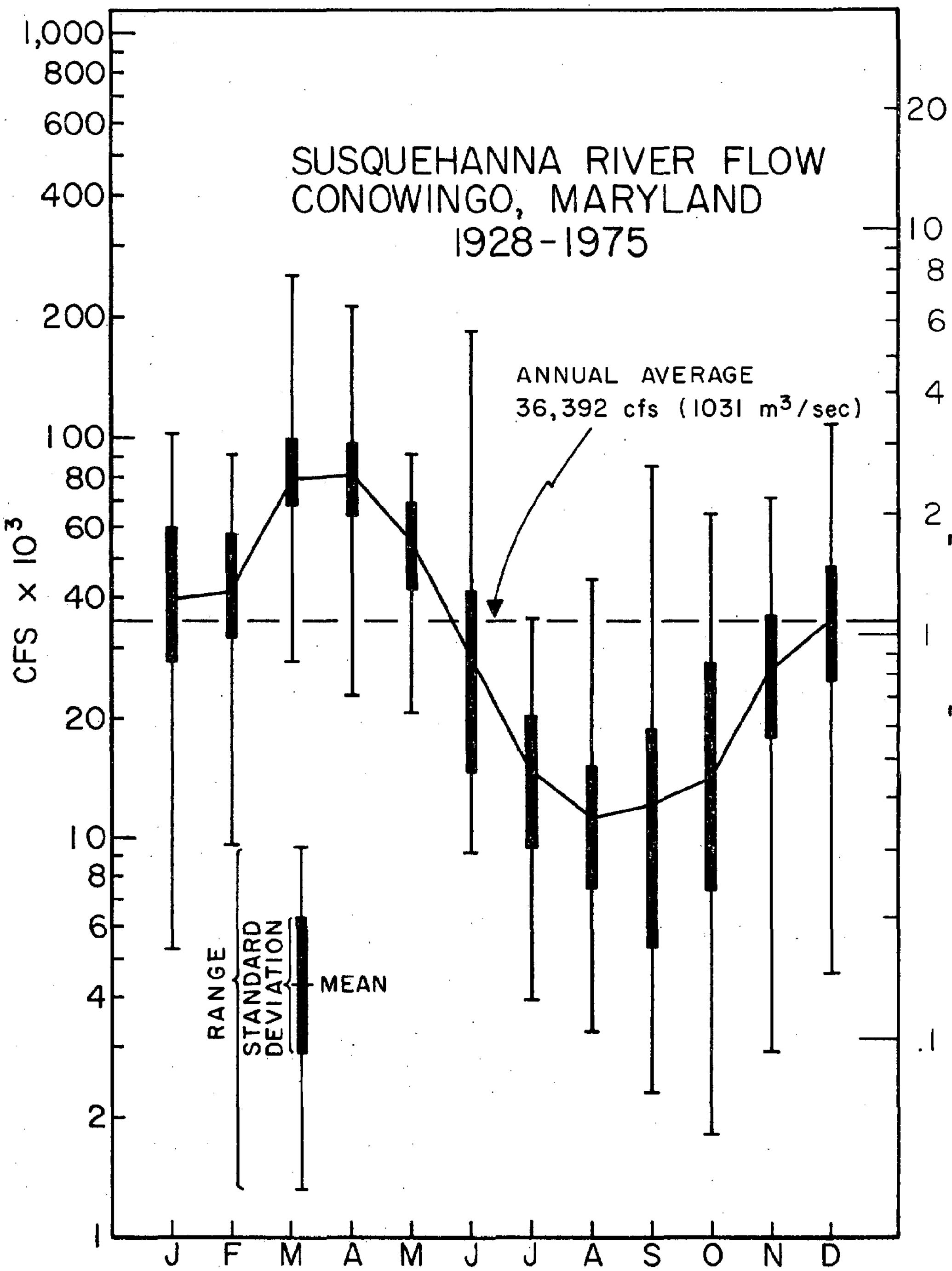

Figure VI-1. Susquehanna River flow at Conowingo, MD 1928-1975.

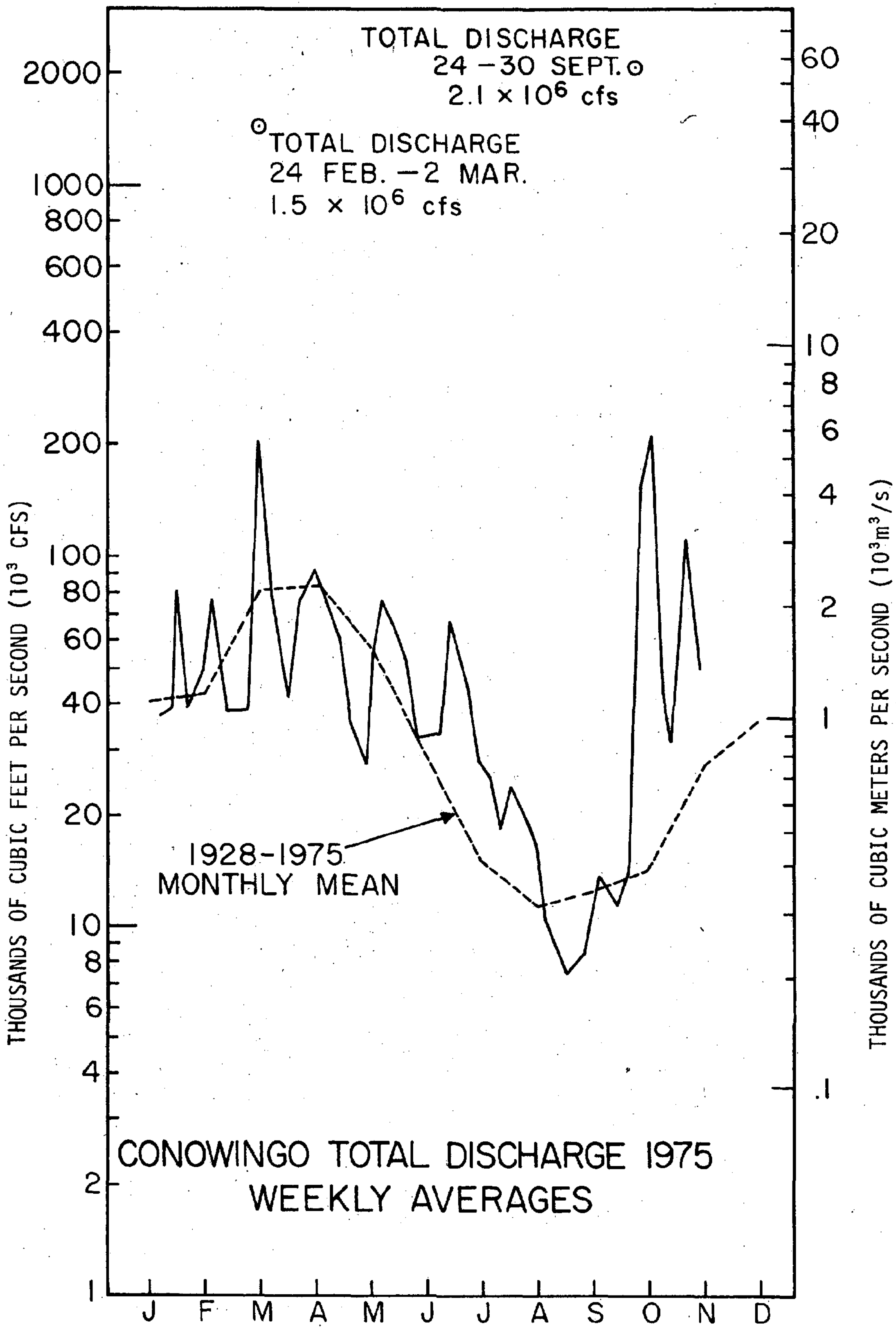

Figure VI-2. Weekly average Susquehanna River discharges at Conowingo, MD 1975.

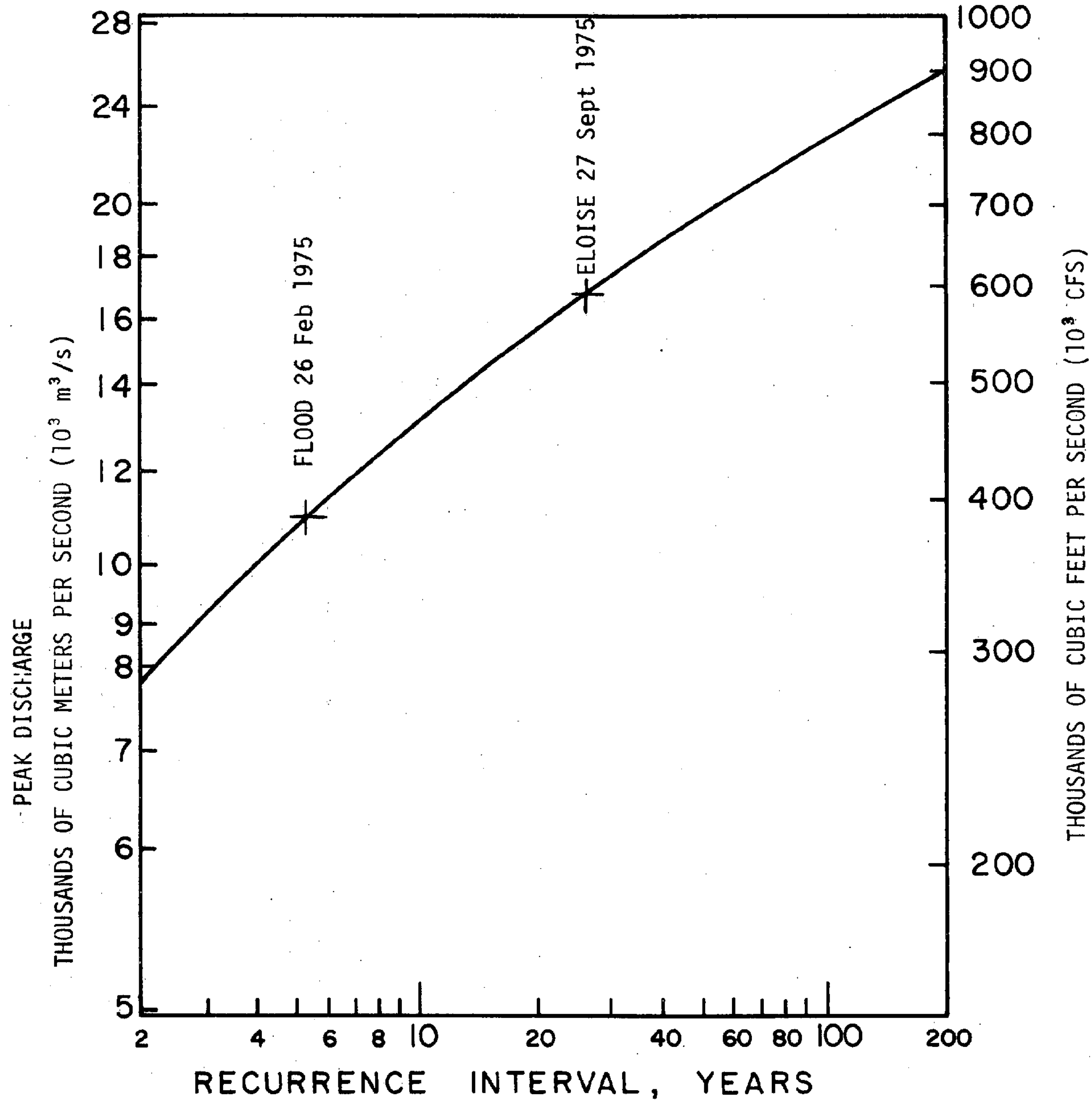

Figure VI-3. Recurrence intervals of peak river flows at Conowingo, Maryland (natural flow) (after U.S. Geological Survey) sediment to Chesapeake Bay; whereas the Eloise floods brought about 9 million short tons (Figure VI-4). The February floods brought as much sediment to the Bay as is normally transmitted during an entire year while the Eloise floods, a sediment supply that would normally take ten to fifteen years to reach the Bay (Schubel, 1972). Thus, during the last half of the disposal operations, the Bay received more sediment from the Susquehanna River than was moved during the dredging operations. (see Figure IV-5.)

The depositional sites for the Susquehanna River sediment is poorly known and probably only a small fraction reaches the Kent Island area. Nonetheless, the high suspended sediment discharges caused an appreciable increase in turbidity in the Kent Island area.

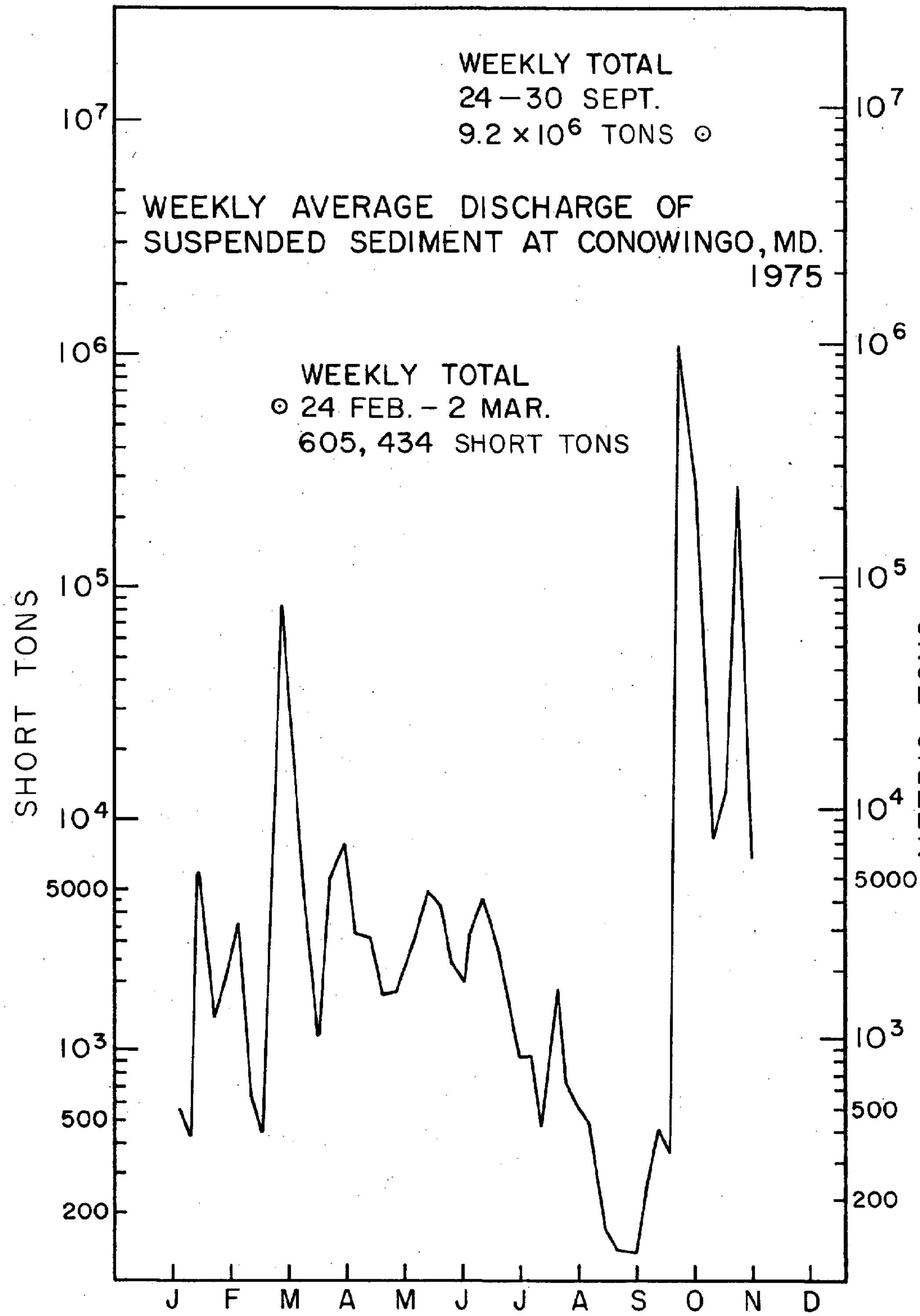

Figure VI-4. Weekly average discharges of suspended sediment at Conowingo, MD, 1975.

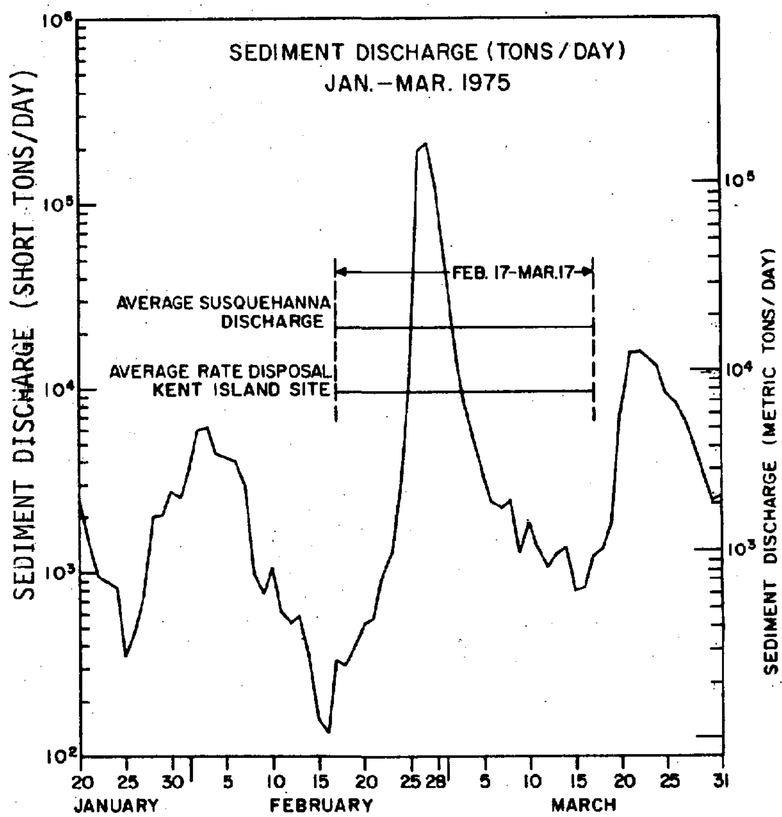

Figure VI-5. Susquehanna sediment discharge (short tons/day, metric tons/day) during period of dredged material disposal.

REFERENCES

Schubel, J.R. 1972. The Physical and Chemical Conditions of the Chesapeake Bay. J. Wash. Acad. Sci. 62:57-87.

APPENDICES

APPENDIX A Characteristics of Dredge ESSAYONS and R/V D. W. Pritchard

Hopper Dredge ESSAYONS - Department of the Army, Corps of Engineers Philadelphia District

The seagoing hopper dredge ESSAYONS is the largest hopper dredge owned by the Corps of Engineers, U.S. Army. She is normally assigned to improving and maintaining Federal navigation projects between New York and Norfolk.

	Feet	Inches	Draft	Ft	In
Length Overall	525	2	Light-Fwd	13	0
Length between Perp's	499	0	Light-Aft	20	6
Beam, molded	72	0	Loaded-Fwd	29	2
Depth, molded amidship	40	5	Loaded-Aft	30	7 1/2
Displacement, Light (Long Tons)	9,516	Tons			
Displacement, Loaded (Long Tons)	22,410	Tons			

Hopper Capacity: 12 Hoppers, 8,270 Cubic Yards total capacity

Material of Hull: Steel

Material of Superstructure: Steel
Construction Started: 15 December 1947
Vessel Commissioned: 16 January 1950

Number in Crew: 114
Accommodations for 155: 34 officers, 115 crew, 6 dispensary

Propulsion Power: Turbo-Electric, D.C., 8,000 H.P., twin screw
- Horsepower per motor: 4,000 at 92 - 110 rpm
- Reduction Gear: Ratio 9.055 to 1
- Propellers: Two, 4 bladed, 16 ft. 0 in. diameter; pitch 15.2 ft.

Pumping Power: Total 3700 H.P., 2 motors
- Horsepower per motor: 1850 at 150 - 180 rpm
- Dredge Pumps (2): 150 - 180 rpm
  - No. of Vanes: 4
  - Suction Pipe I.D.: 36 in.
  - Discharge Pipe I.D.: 32 in.
  - Discharge Pipe Velocity: 20 ft./sec.

Boilers: 2 water tube-single pass boilers operate at 600 lb/sq.in. pressure; heating surface 9,050 sq. ft. each boiler

Fuel: Bunker C; capacity 7,000 barrels; type of burner, steam-mechanical; cruising radius, approximately 7,700 statute miles.

Speed in Statute Miles: Light 17.3 mph Loaded 16.0 mph

R/V D.W. PRITCHARD

The vessel employed during these studies was the R/V D.W. PRITCHARD of the Chesapeake Bay Institute, The Johns Hopkins University, which has the following specifications:

Built:	November, 1967
Length:	(LOA) 42'
Beam:	(Exterme) 14'
Draft:	(max) 2/6"
Crew:	one
Scientific Personnel:	3
Main Engine:	One 6-71 Detroit diesel engine of 300 H.P.
Speed, cruising:	15 kts
Speed, Full:	18 kts
Speed, Minimum:	3 kts
Range:	200 miles
Enclosed Work Area:	100 sq ft

Vessel has two davits with hand winches

APPENDIX B Navigational and Field Techniques

Navigation and Station Locations

Precise navigational methods are needed to make "same track" fathometer records. In this series, the Raydist T (Maryland Network #1) furnished locations accurate to within 3 m (10 ft.). In this system, a master and a slave station transmit a simultaneous signal and the shipboard receive displays the lane count (a difference in micro-seconds in time) for each station. The Raydist T system does not indicate the lane count but only the phase difference between the two stations; the whole micro-second (or lane count) must be obtained from a calibration point. Calibration points can be computed for any accurately known (± .1 second latitude or longitude) on shipboard using an HP-65 programmable calculator. The lanes for any given micro-second count from a hyperbola either from the master or slave station, whichever is closer. A second set of master and slave stations give a second curve and where the two lanes intersect is the station. The two sets of master-slaves stations are called Red or Green networks. There are three separate networks covering the Chesapeake Bay region. The Maryland networks are maintained by the Engineering Section of the Department of Natural Resources and charts showing the lane counts were furnished by them.

Bathymetric Surveys

Surveys of the dumping site were made with a Raytheon Model DE119D Survey Fathometer before dumping began to obtain a detailed map of bottom topography.

The runs of 14 February represented the bottom topography prior to the dump and on 18 March conditions after disposal operations were completed. These were photographed and projected to the best fit.

Bathymetric and High Resolution Seismic Profile Surveys

Echosounding equipment consisted of a Raytheon Portable precision depth sounder operating at a frequency of 200 kHz. The seismic reflection profiler was a Raytheon Model RTT-1000 which operates at a frequency of 7 kHz. Both systems were adjacent to the Raydist display permitting the synchronous entry of timing fixes (event marks) on both records. The transducer was mounted in a float towed alongside the vessel. Both bathymetry and sub-bottom data reported in this section were obtained from the records provided by this system.

Comments on Survey Accuracy

In any hydrographic survey, certain corrections may be applied to echosounding or seismic reflection profiling surveys. The application of such corrections is a judgement left to the operators and to those reducing the data. Corrections applied to the records generated in this survey, or the omission of such corrections with an explanation of reasons for rejection, are provided below. It should be noted that the prime objective of the surveys was to determine *changes* in depth or thickness of materials, not the preparation of highly accurate bathymetric charts of the area. Although the precision of the instruments would have permitted preparation of such charts, such was not the purpose of the investigation.

Tide correction. Water level at Matapeake (the closest tide station to the dumpsite) was monitored during the two surveys by a water level sensor placed adjacent to the tide staff at this station. Through the courtesy of the National Ocean Survey (NOS) Office in Rockville, reduction of these tide data was expedited and provided to us for use in applying corrections for Bay tides. The corrections for both periods (pre- and post-dump surveys) are shown in Figure B-1. Corrections for tide were applied in one-foot increments as shown, so that the possible error might be as high as one foot in the extreme case where the transition from minus one to minus two occurred. However, much of the tide curve during the first survey period lay between the plus and minus one-foot correction which was centered on the mean low water (MLW) datum of 4.00 feet (NOS reference, personal communication, March 1975), while the second survey required negative corrections of 1 and 2 feet. The seasonal variation for MLW used by NOS was not included in the March correction, since it is much less than one foot.

Transducer draft corrections. The transducer employed during this survey was mounted on a float, and projected one foot below the water surface. Since this depth factor remained constant between surveys, no correction was applied in the preparation of bathymetric charts.

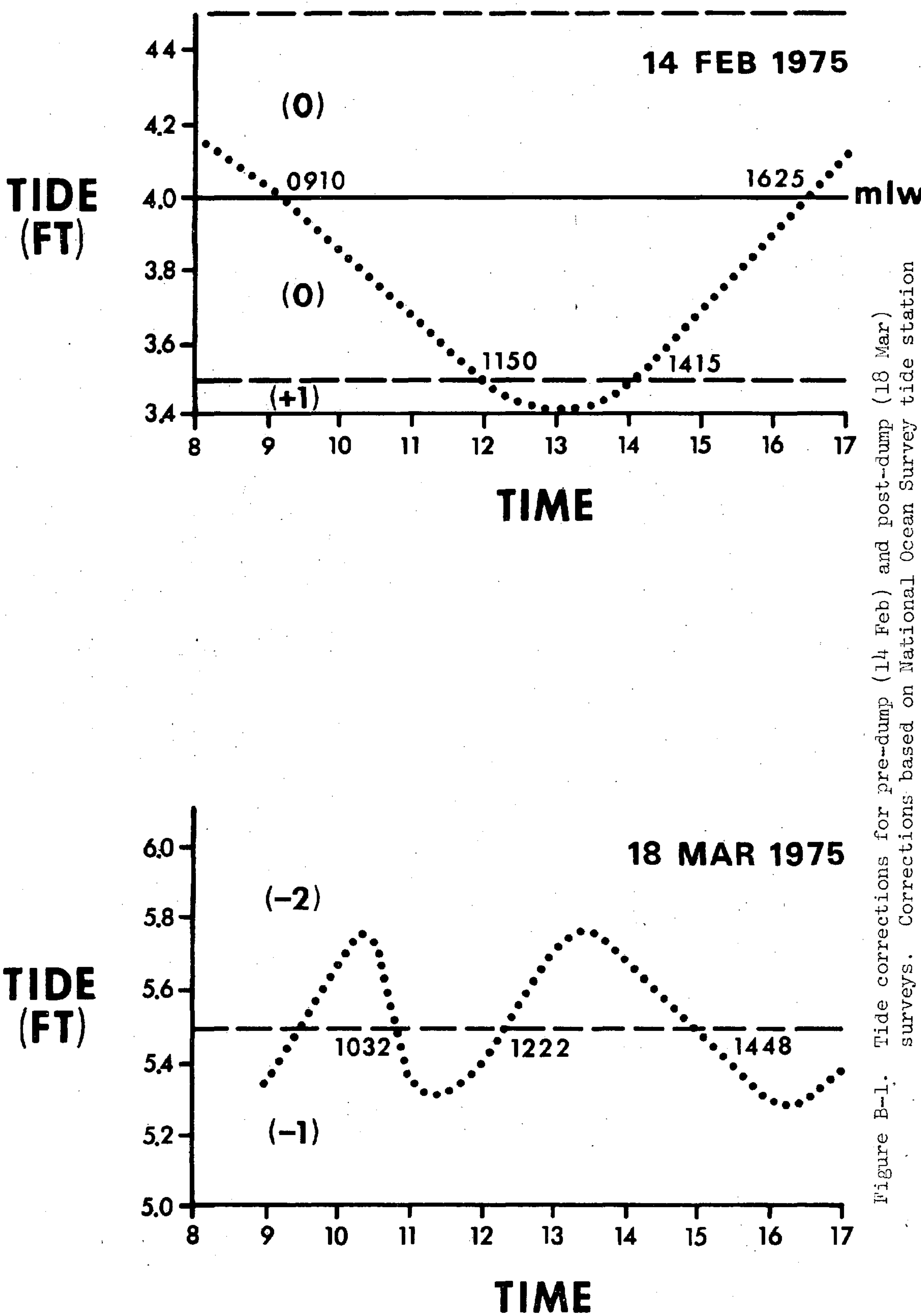

Figure B-1. Tide corrections for pre-dump (14 Feb) and post-dump (18 Mar) surveys. Corrections based on National Ocean Survey tide station at Matapeake, 3 nautical miles south of the dumpsite. Corrections, in feet, appear in parenthesis, 4.0 feet is mean low water (MLW) for February 1975.

Sea state correction. Records obtained during rough weather are generally characterized by "spikes" in the bottom trace which result from the heave of the vessel (and the transducer head). Weather conditions during both surveys were moderate, and little interference from waves was registered (see later figures of records). No correction was necessary for sea state.

Sound velocity correction. The shallow water depths present in the area and the generally non-stratified conditions of Bay waters in winter eliminate the need for a correction for changes in sound velocity.

Horizontal correction for transducer displacement. The transducer was deployed on the starboard side of the vessel and streamed alongside but outboard of hull drag and wake effects to minimize aeration effects which reduce record quality. The transducer position was 20 feet aft of the Raydist antenna; so that a point on the record is actually 20 feet "behind" the position fix at any instant. On the scale employed for plotting data, this amounts to the width of a pencil line and thus was ignored in plotting.

Record resolution. The frequencies employed by the acoustic systems used in this survey permit resolution to one foot of depth. In the case of subsurface reflectors, the resolution diminishes to at least two feet since the sharpness of these horizons is dependent upon overburden thickness as well as the physical nature of the reflecting surface (the acoustic impedance--a function of the saturated bulk density and the compressional (sound) velocity)

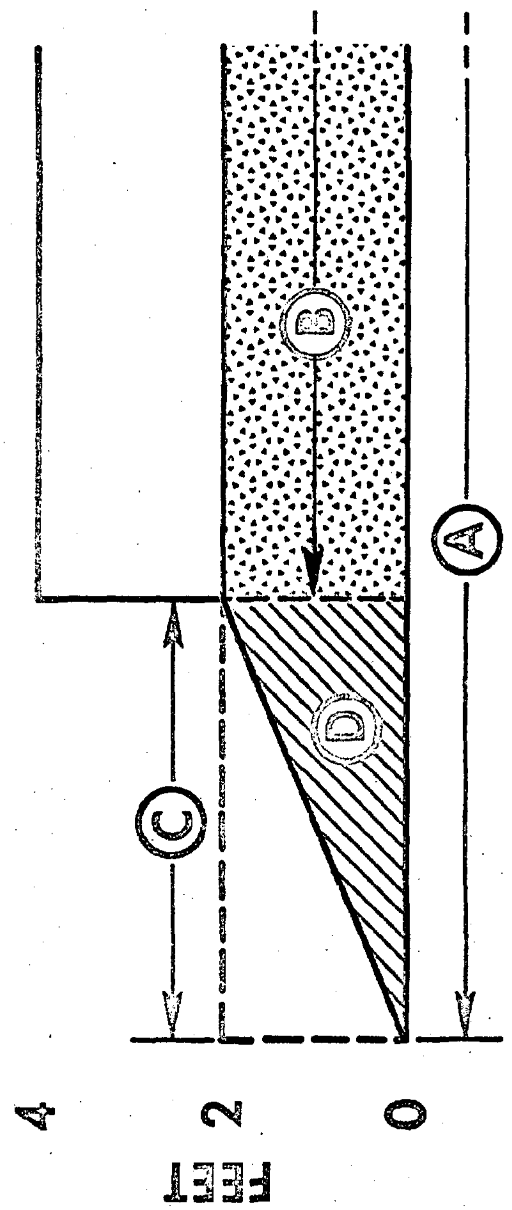

Figure B-2. Approximations used in determining volumes. The difference in area between A and B provides area C which, divided by 2, gives the "fillet" volume D. This volume, added to that of B provides the volume in cubic yards when multiplied by 0.6666 (2/3 yard) to account for the two-foot contour interval.

present at the interface between the two materials.

Bathymetry

By superimposing two sets of bathymetric profiles, it is possible to calculate the volume of dredged materials that have remained in the surveyed area. By contouring the magnitude of difference at these points of intersection, a map of net change was prepared. Planimetry of the areas and depths in the latter provided an estimate of the net volume change (spoil accumulation) which accompanied disposal at this site. Volumes were computed on the basis of areas contained within the isobaths reflecting the negative change in depth. In order to account for the slopes between isobaths, the following convention was adopted (see Figure B-2):

> The area contained within an isobath was determined by planimetry. The next shoaler area was similarly determined, and subtracted from the first, giving the area of the segment lying between the two isobaths. The volume of this area in cubic yards was computed using the area and a value of 0.666 (2/3 yd to account for the 2-foot contour interval) and this area was then added to that for the total area of the next highest isobath to provide a close approximation of a three-dimensional volume of spoil. This approach provides for the inclusion of the "fillet" of materials laying between isobaths. However, it does assume a uniform slope and therefore may contain a slight error should that slope be irregular (as it certainly must be--but to a modest degree).

Figure IV-1 shows the composite set of fathometer tracings. Also shown is a small portion of the Raydist network showing the lanes followed in the surveys. Tidal variations were on the order of 0 to -2 feet and were compensated for as nearly as possible.

Methods - Turbidity

Observations of turbidity were made by using a 513-TR transmissometer* and an EV 4 Envirotrans made by Beckman Instruments. Three different techniques were used in addition to monitoring the natural background. Turbidity observations were calibrated by collecting samples of turbid water by Van Dorn samplers and the samples taken to the laboratory for filtering and gravimetric analysis.

Background measurements were made at the same station, between dumping buoys E and F (39°00'54"N, 76°21'31"W), usually one to two hours before the dump which normally occurred between 1100 - 1200 daily.

Particle Size Sampling

Samples for particle size analysis were taken at surface, mid-depth (10 m), and bottom (16 m), simultaneously, with 2 liter Van Dorn bottles. About 100 *ml* of sample was drawn from each bottle with constant 'swirling' maintained in the beaker until placed in filter bell jar. This procedure assures suspension of fine particles prior to filtering.

Millipore 0.22 μ filters were used for analysis. Three filters were prepared for each sample with sample volume ranging from 5 to 15 *ml*, producing different densities for photomicrography. Distilled water (≈ 100 mℓ) was placed in the bell jar prior to the entry of the sample, allowing gradual settling of particles, under slight vacuum, so that particles were not distorted. The filters were rinsed three times to remove salt, never allowing the filters

*Interocean CSTD Model 513-TR turbidity monitor, 10 cm path.

to go dry under vacuum, and placed in plastic petri dishes for dust-free drying.

Photomicrographic Size Analysis

Optical microscopy was used to determine grain size distribution of finegrained sediment suspended in the water. The technique consisted of measuring particle images. The samples were photographed and analyzed without pretreatment which might alter the original size distribution. The technique also provided information on particle shape, degree or agglomeration, and on the composition of the suspended matter.

The photomicrographic sizing technique involves four steps: (1) sample collection, (2) slide preparation, (3) photography of sample, and (4) sizing the images of the particles with the Zeiss Particle Size Analyzer, TGZ-3. Operational details are discussed by Schubel (1968).

Volume means diameter ($\bar{D}_v$) of suspended sediment particles in Upper Chesapeake Bay ranged from 4 to 28μ and generally increased with depth in 1966 and 1967. No systematic seasonal or geographical patterns were observed. A value of 10 to 15μ for $\bar{D}_v$ is a good estimate for the Upper Bay (Schubel, 1968).

Mean Stokes Diameter (D_s) of suspended particles ranged from 2.3 to 12.2μ and was between 3 and 6μ in nearly 70% of the samples studied by Schubel in 1966 and 1967.

Diameter of a particle D_m is the diameter of an equivalent circle having an area equal to the projected area of the particle. The diameter D_m of a particle determined by optical techniques is not the same as the diameter (D_s) of a particle as determined by settling velocity or sedimentation analysis. In sedimentation analysis, D_s is the diameter of an equivalent sphere having the same density as the measured particle and the same settling velocity as the particle in a fluid of equal density and viscosity (Schubel, 1968). D_s and D_m as measured on a given particle are seldom the same but can be expected to be closely related.

REFERENCE

Schubel, J.R. 1968. Suspended Sediment of the Northern Chesapeake Bay. Chesapeake Bay Institute. The Johns Hopkins University Technical Report 35, Ref. 68-2.

APPENDIX C. Temperature and Salinity Observations

Temperature and salinity observations were made at a station located between buoys E & F (39°00'54"N, 76°21'31"W), usually one to two hours before the dump which normally occurred between 1100 - 1200 daily. Temperature (T°C), salinity (S‰) and current directions and speed were made at depths of every two meters from surface to bottom. Water temperatures were cooler than normal but fluctuated with and followed climatic changes. Temperature distributions show a well-mixed water column with no indications of a thermocline during the period of disposal operations. Temperature and salinity data for 1972, 1973 and 1974 are included. (See Figures C-1 through C-8).

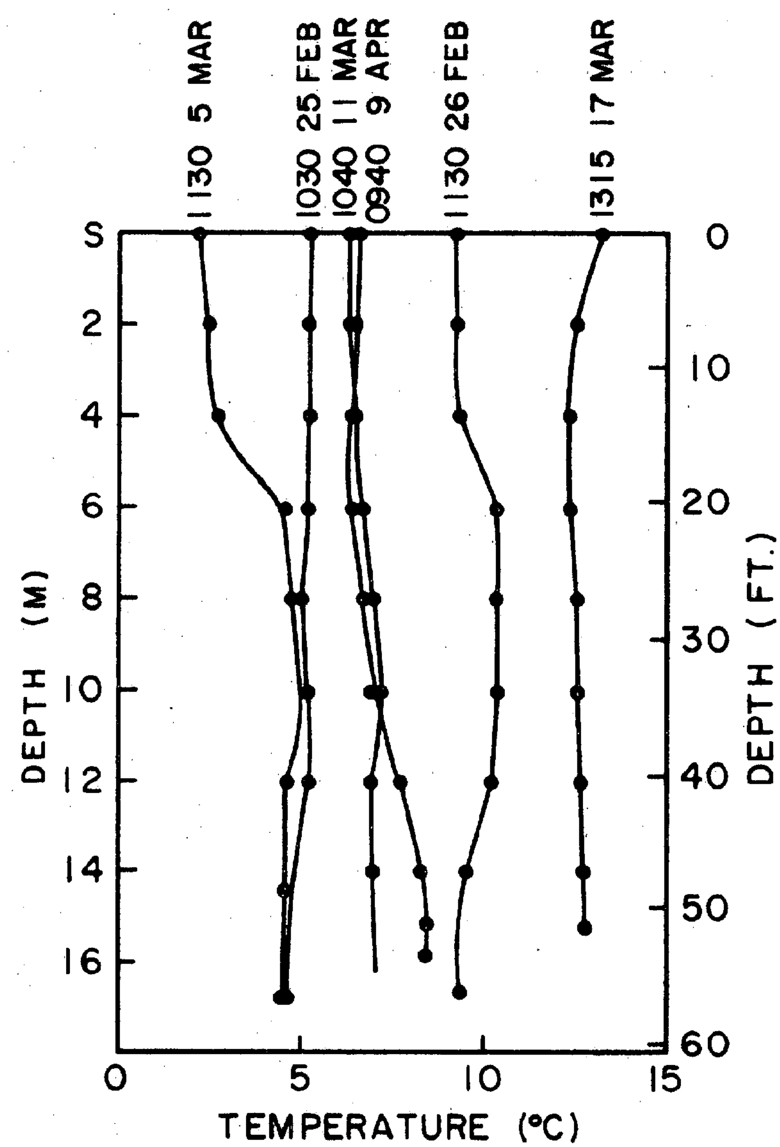

Figure C-1. Temperature °C at background station between dump buoys E and F.

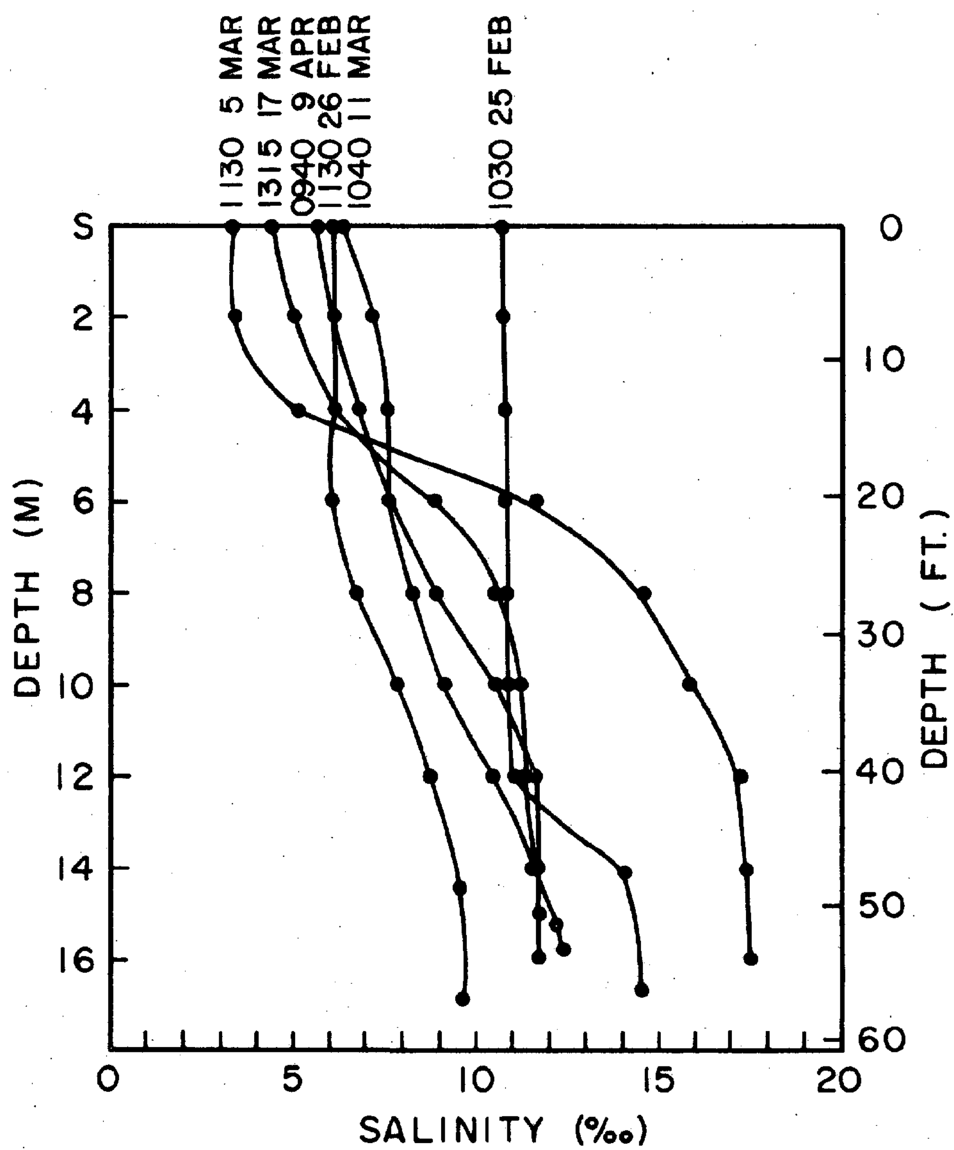

Figure C-2. Background salinity (‰) between dump buoys E and F.

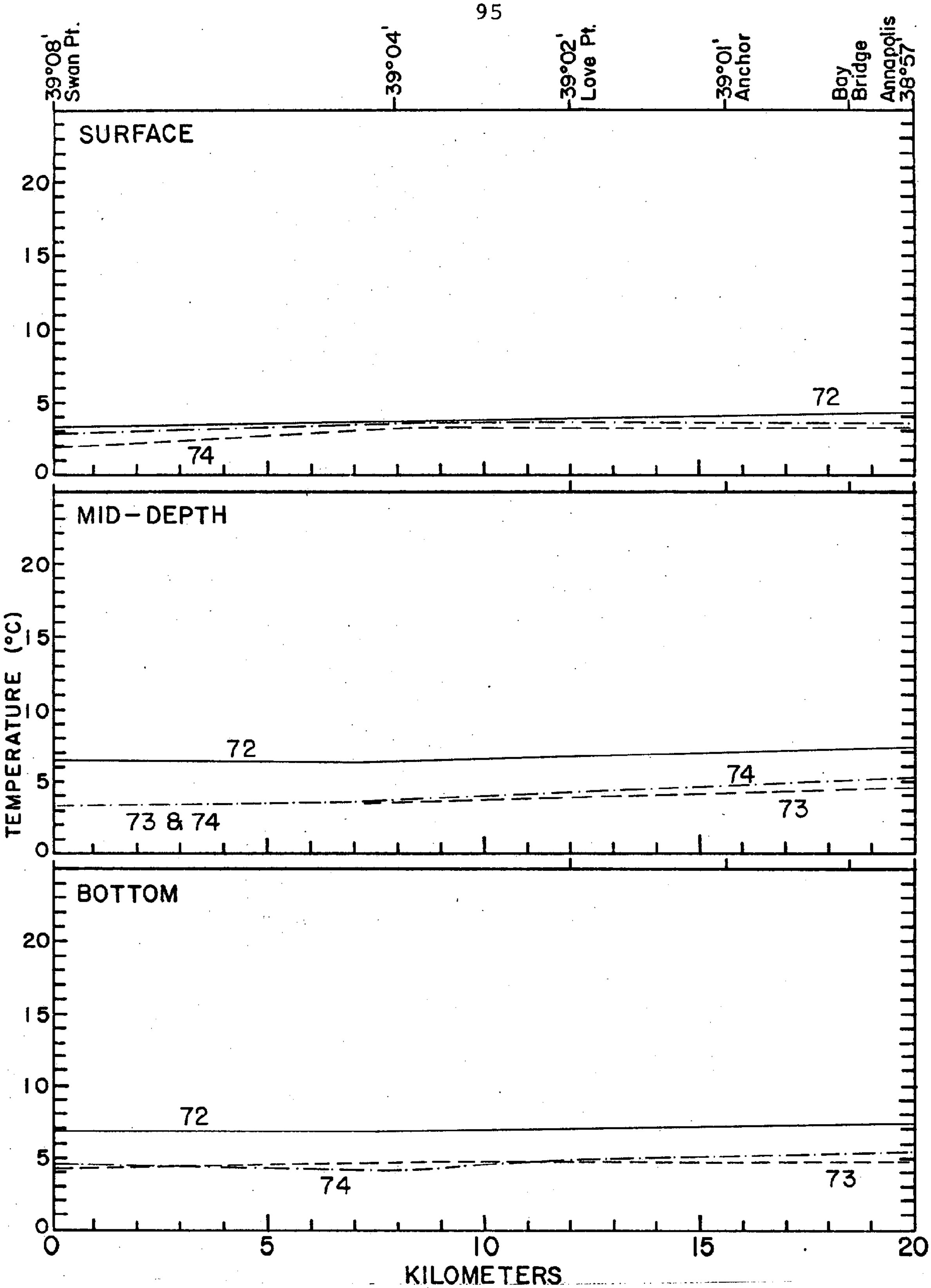

Figure C-3. Temperature (°C) Jan. 1972 - 75

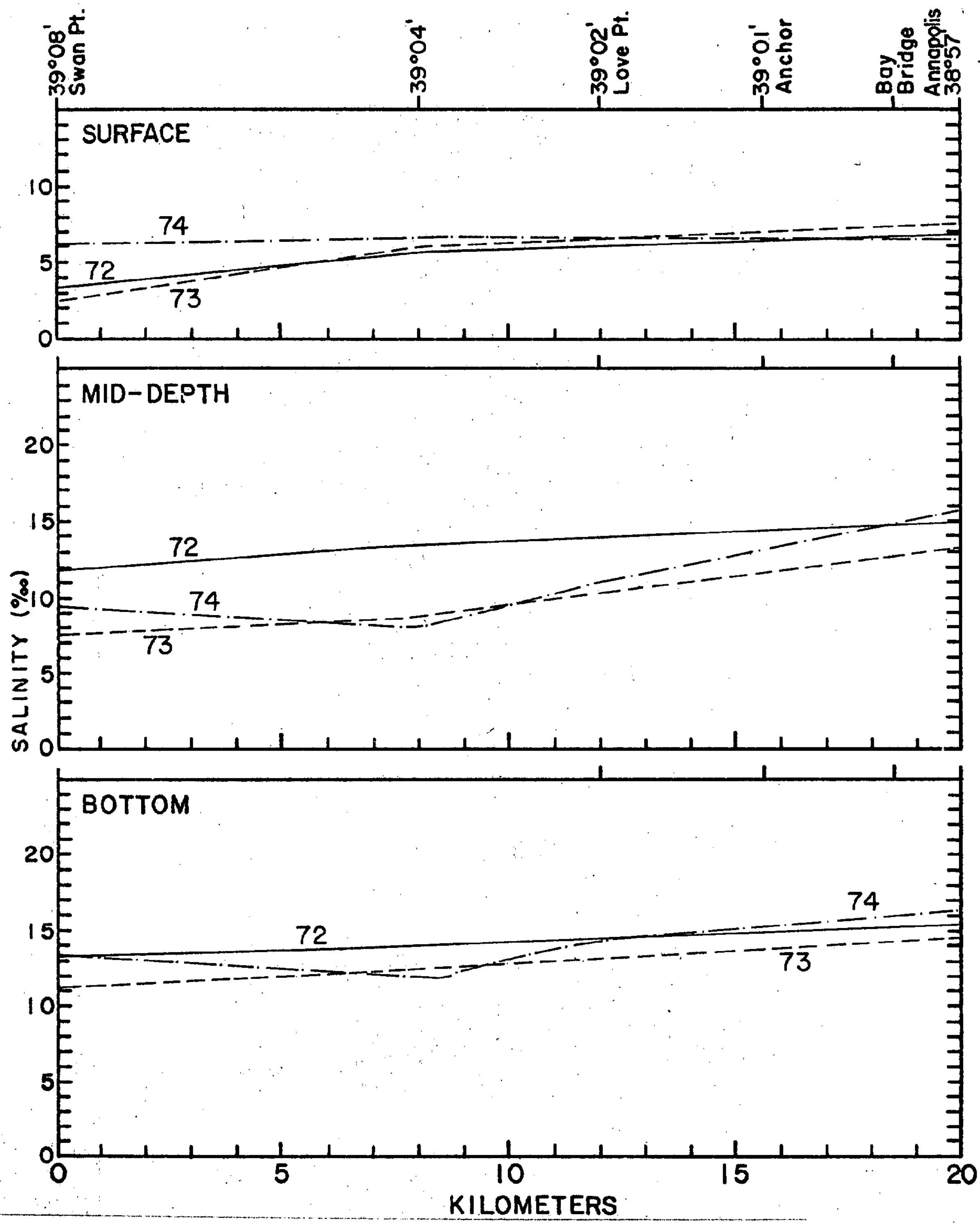

Figure C-4. Salinity (‰) Feb. 1972 - 75.

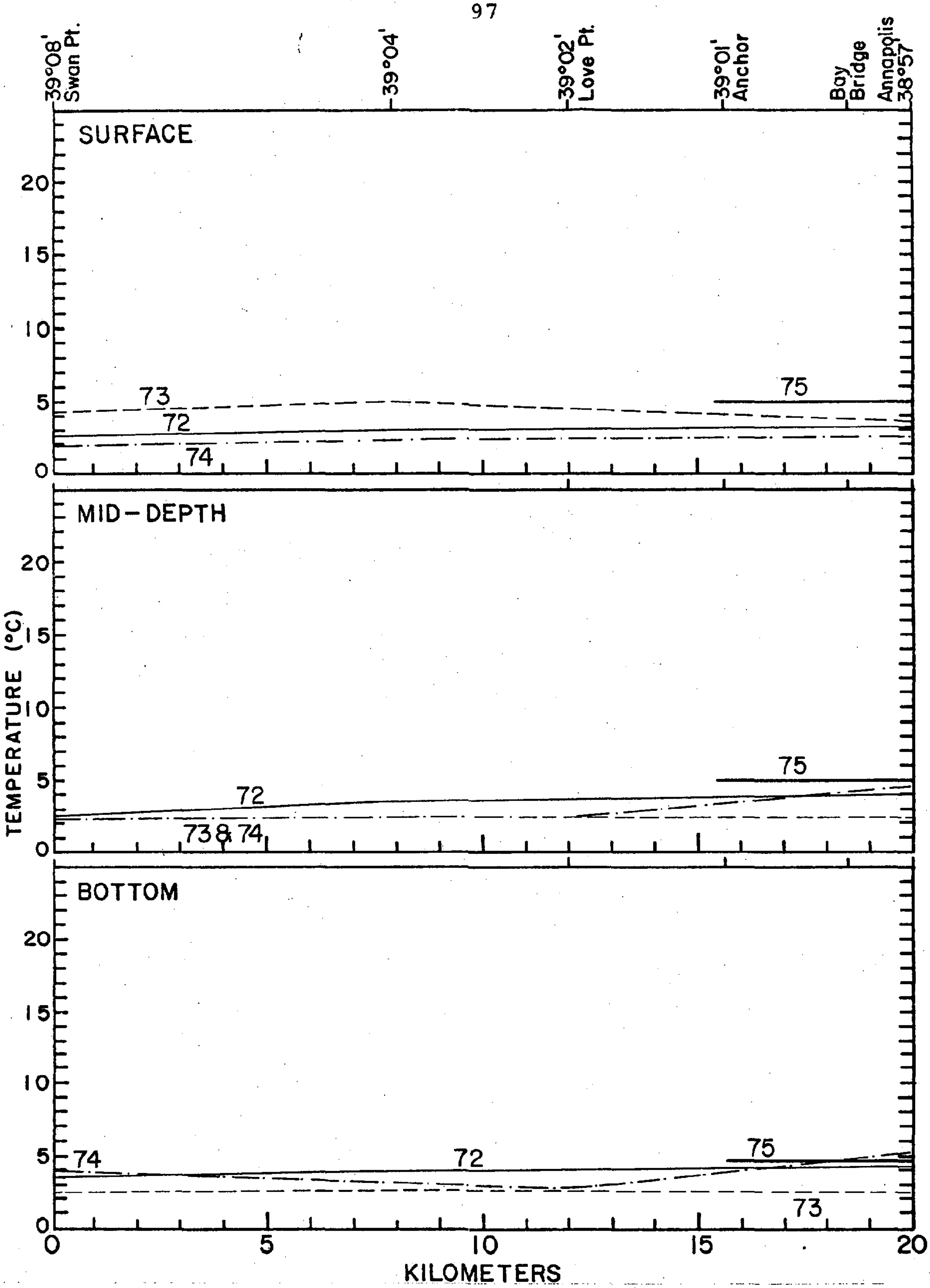

Figure C-5. Temperature (°C) Feb 1972 - 75.

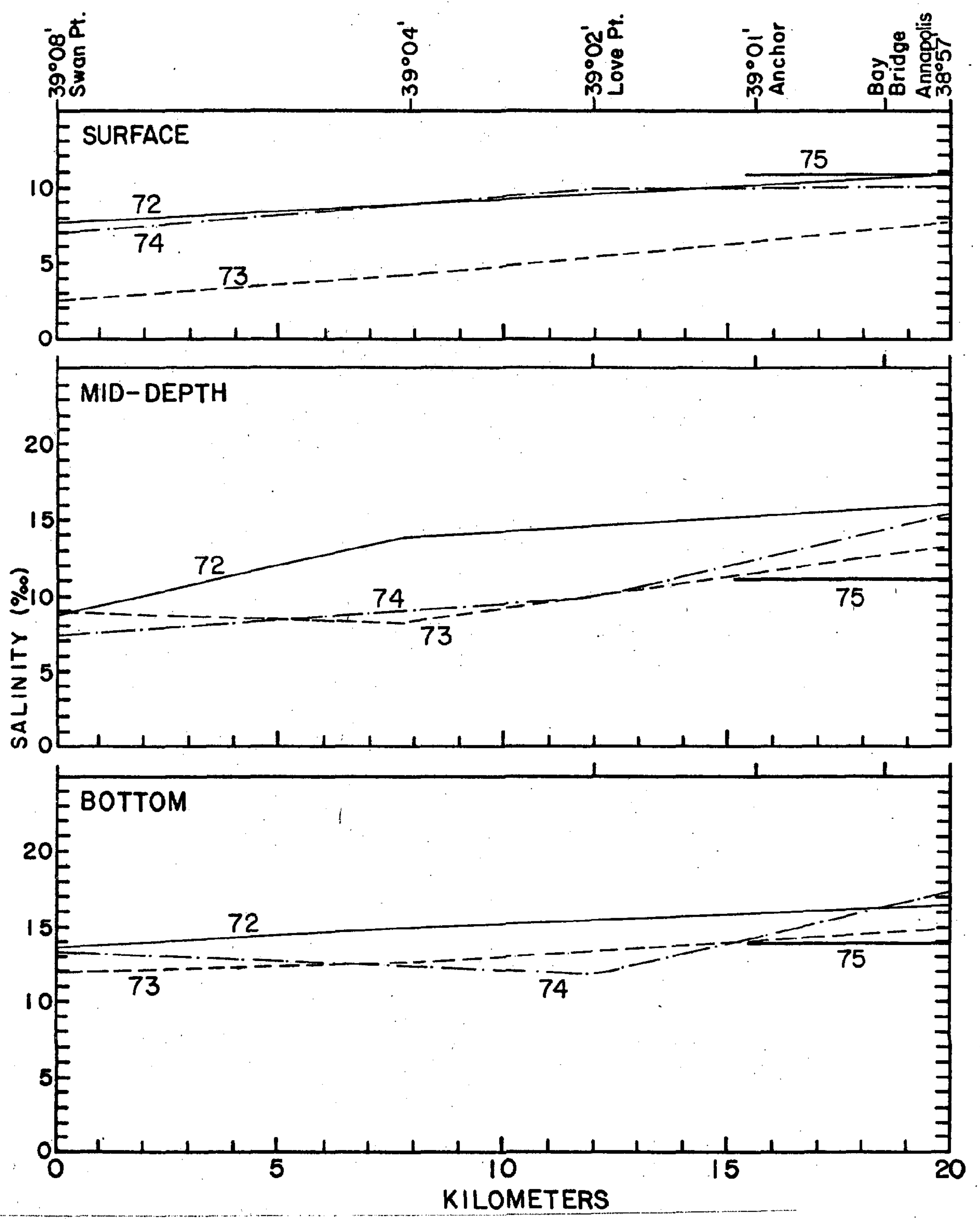

Figure C-6. Salinity (‰) Feb. 1972-75.

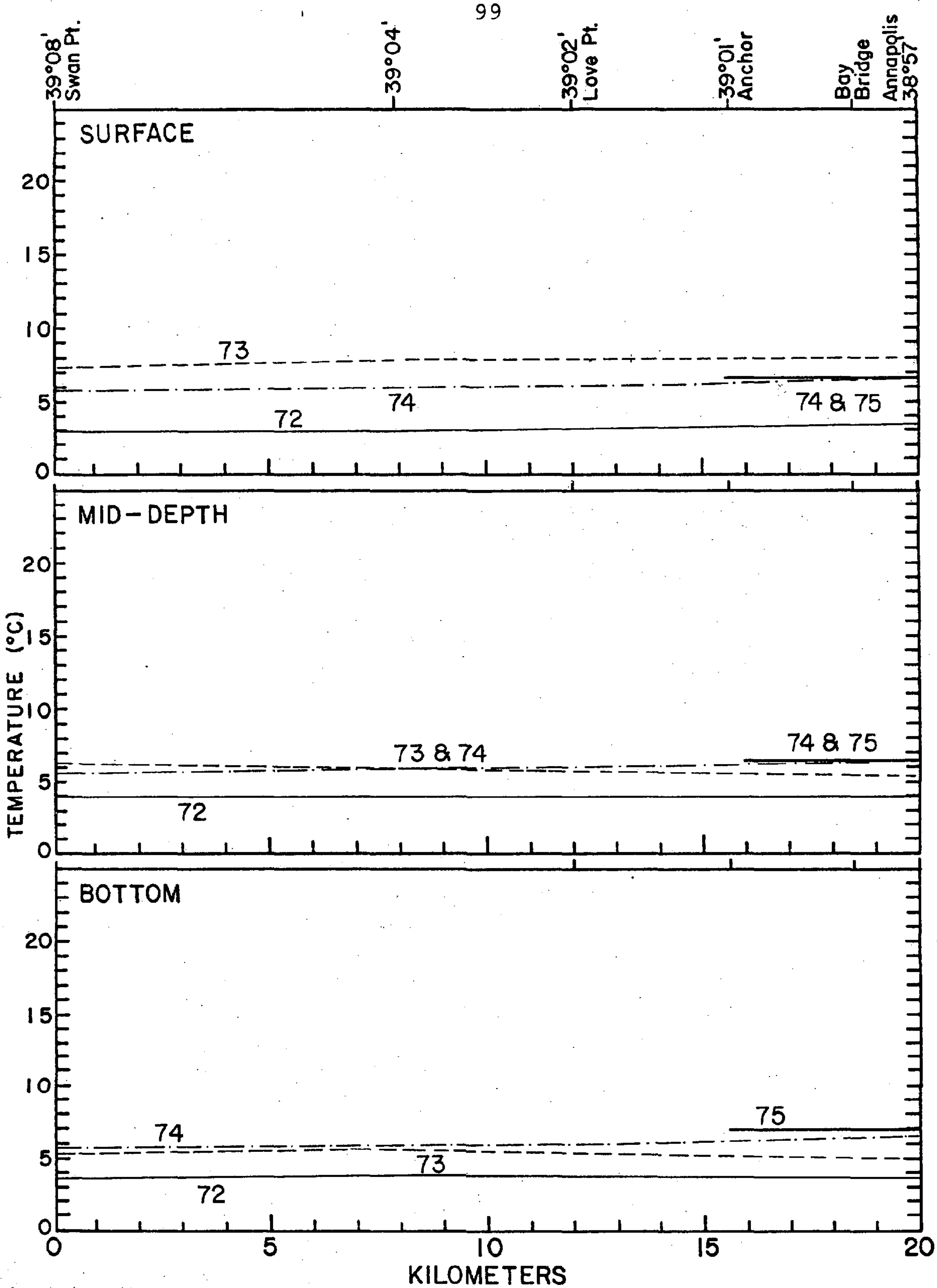

Figure C-7. Temperature (°C) Mar. 1972-75.

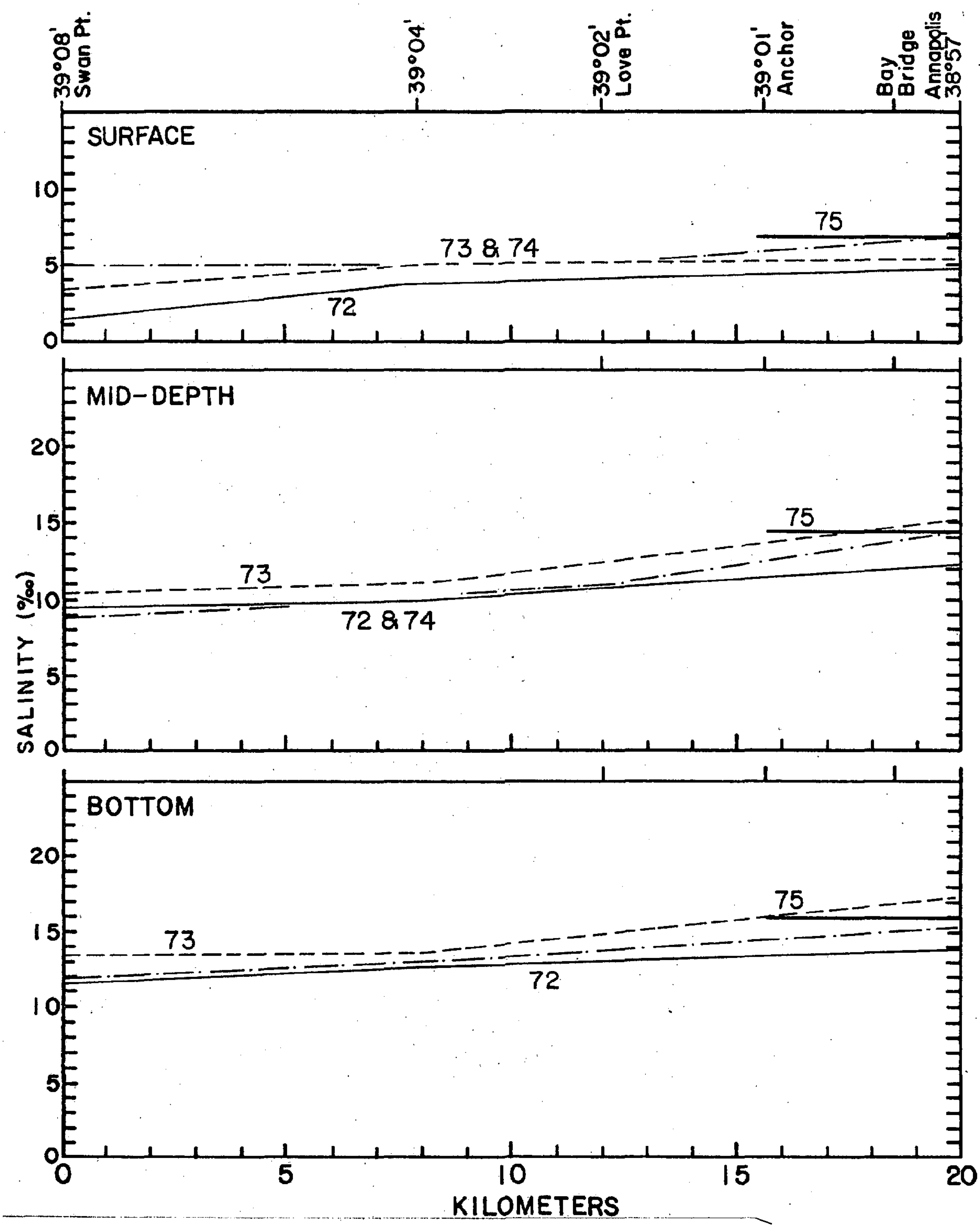

Figure C-8. Salinity (‰) Mar. 1972-75.

APPENDIX D. Observations of Suspended Sediment Concentrations and Current Speeds

Observations were made of suspended sediment concentrations in the water at the same time that transmissometer readings were taken for calibration purposes. Current speeds were also measured at the same times and locations.

Table D-1. Tabular background transmissivity.

Depth	Suspended Solids TM	Suspended Solids mg/ℓ	Current k	Current cm/sec
25 Feb 75 1105				
S	64	12		
2	64	12	.51	26
4	64	12	.68	34
6	63	12	.75	38
8	64	12	1.09	55
10	63	12	2.00	100
12	65	12	1.70	85
14	20	40	1.36	68
16	0	100	0.46	23
26 Feb 75 1200				
S	76	14	1.3	67
2	76	14	1.2	61
4	76	14	1.3	69
6	76	14	1.4	73
8	76	14	1.5	76
10	76	14	2.9	151
12	82	7	2.5	126
14		28	1.8	96
16	43	18		
5 Mar 75 1050				
S	34	27	.16	8
2	40	20	.12	6
4	48	18	.14	7
6	70	10	1.5	76
8	79	7	2.0	101
10	86	5	1.9	95
12	67	12	1.5	76
14			1.2	58

Table D-1. *(continued)*

Depth	Suspended Solids TM	Suspended Solids mg/ℓ	Current k	Current cm/sec
11 Mar 75 1050				
S	79	7	0.92	46
2	79	7	0.74	37
4	79	7	0.76	38
6	78	7	0.78	39
8	75	8	0.64	32
10	73	9	0.48	24
12	71	10	0.60	30
14	66	12	0.64	32
16	57	14	0.28	14
17 Mar 75 1345				
S	83	5	0.51	47
2	80	7	.73	37
4	84	5	.35	18
6	82	6	.27	14
8	79	7	.39	17
10	83	5	.17	8
12	83	5	.20	10
14	80	6	.28	14
			.23	12

APPENDIX E Susquehanna River Flow

Table E-1. Conowingo Flow Data Jan-Feb-Mar 1975

Date	Total Discharge (cfs)	Date	Total Discharge (cfs)	Date	Total Discharge (cfs)
Jan 1	22,775	Feb 1	89,600	Mar 1	155,325
2	52,525	2	89,200	2	113,275
3	37,100	3	81,775	3	96,414
4	32,925	4	74,800	4	80,775
5	29,725	5	61,425	5	71,475
6	38,900	6	56,775	6	61,775
7	29,825	7	56,025	7	61,825
8	33,025	8	35,775	8	51,500
9	36,225	9	25,125	9	36,000
10	50,165	10	38,750	10	50,775
11	48,200	11	29,250	11	43,600
12	53,625	12	31,550	12	40,050
13	80,725	13	33,275	13	43,650
14	113,820	14	28,300	14	47,375
15	109,715	15	13,950	15	30,775
16	82,960	16	12,550	16	29,725
17	74,100	17	30,850	17	46,175
18	53,500	18	30,450	18	44,850
19	43,025	19	36,205	19	52,875
20	51,450	20	51,475	20	83,475
21	42,425	21	52,325	21	153,694
22	36,725	22	58,000	22	151,100
23	37,200	23	49,275	23	137,950
24	37,775	24	69,825	24	129,350
25	23,740	25	208,350	25	113,625
26	35,805	26	369,875	26	102,400
27	54,255	27	321,950	27	91,275
28	48,415	28	228,225	28	81,150
29	57,050			29	74,100
30	71,715			30	66,800
31	80,200			31	68,475

Conowingo Flow Data Apr-May-June 1975

Date	Total Discharge (cfs)	Date	Total Discharge (cfs)	Date	Total Discharge (cfs)
Apr 1	64,375	May 1	43,325	June 1	26,200
2	62,050	2	45,725	2	32,350
3	65,275	3	30,650	3	29,300
4	60,700	4	37,925	4	27,100
5	61,750	5	60,125	5	28,125
6	58,625	6	81,575	6	47,645
7	71,900	7	85,050	7	41,900
8	70,225	8	98,375	8	77,475
9	67,925	9	109,830	9	82,050
10	56,600	10	87,220	10	80,250
11	53,125	11	73,200	11	62,275
12	38,750	12	73,095	12	55,250
13	31,300	13	59,050	13	64,770
14	44,650	14	66,325	14	45,050
15	41,025	15	58,275	15	44,730
16	37,100	16	61,825	16	51,375
17	30,525	17	67,500	17	46,975
18	35,475	18	56,500	18	55,350
19	26,350	19	61,350	19	46,025
20	19,700	20	62,550	20	41,700
21	34,750	21	53,125	21	25,050
22	32,775	22	49,350	22	19,750
23	30,900	23	41,650	23	28,525
24	34,650	24	37,575	24	27,325
25	42,600	25	26,000	25	25,000
26	50,475	26	33,650	26	18,150
27	48,525	27	40,325	27	34,725
28	57,900	28	36,150	28	41,375
29	54,475	29	33,700	29	26,450
30	49,375	30	34,325	30	37,425
		31	20,975		

Conowingo Flow Data July-Aug-Sept 1975

Date	Total Discharge (cfs)	Date	Total Discharge (cfs)	Date	Total Discharge (cfs)
July 1	30,100	Aug 1	22,925	Sept 1	3,300
2	29,025	2	2,450	2	21,675
3	31,900	3	225	3	20,275
4	13,550	4	10,800	4	19,850
5	20,150	5	15,075	5	23,525
6	19,250	6	11,500	6	7,825
7	22,925	7	11,950	7	2,950
8	20,675	8	21,900	8	16,300
9	22,650	9	280	9	13,775
10	16,575	10	280	10	13,475
11	12,775	11	9,850	11	14,325
12	14,125	12	13,500	12	19,975
13	13,475	13	10,775	13	275
14	43,750	14	14,750	14	250
15	27,975	15	13,900	15	22,550
16	22,275	16	275	16	20,225
17	20,775	17	300	17	2,375
18	28,925	18	13,375	18	19,675
19	10,300	19	12,725	19	23,040
20	6,325	20	13,000	20	9,500
21	31,200	21	12,275	21	22,175
22	21,550	22	10,575	22	21,950
23	19,175	23	300	23	27,625
24	21,275	24	170	24	38,025
25	24,050	25	12,225	25	60,500
26	9,325	26	11,100	26	338,850
27	7,150	27	14,575	27	583,847
28	23,900	28	10,800	28	495,000
29	20,675	29	9,850	29	357,500
30	17,100	30	375	30	215,508
31	20,700	31	325		

Conowingo Flow Data Oct 1975

Date	Total Discharge (cfs)
Oct 1	144,719
2	112,800
3	87,400
4	69,900
5	56,975
6	51,275
7	47,875
8	38,950
9	34,650
10	40,375
11	28,625
12	18,750
13	34,050
14	34,875
15	28,950
16	27,475
17	35,775
18	40,975
19	78,925
20	142,425
21	145,756
22	132,755
23	115,182
24	91,475
25	76,950
26	56,800
27	61,400
28	53,425
29	46,525
30	40,450
31	41,580

SECTION THREE:

FINAL REPORT TO:

CHESAPEAKE BAY INSTITUTE OF
JOHNS HOPKINS UNIVERSITY
313 THIRD STREET
ANNAPOLIS, MARYLAND 21403

SUBMITTED BY:

JOSEPH M. FORNS, SR. SCIENTIST
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ANNAPOLIS, MARYLAND 21404

CONTRACT #A89374 Dump

EVALUATIONS OF BIOLOGICAL
EFFECTS OF OVERBOARD DISPOSAL ON
CLAMS AND OYSTERS

TABLE OF CONTENTS

Abstract

Clams (*Mya arenaria*) and oysters (*Crassostrea virginica*) with known metal contents and similar pumping efficiencies were held in experimental cages and exposed to Chesapeake Bay waters in three locations; at Hacketts Bar and at two locations on either side of the designated disposal area, within 1,000 yards. Clams and oysters survived at all locations during the dredging and disposal operations. Some mortality of clams was observed in the cages recovered in April and later. The clam mortalities and the later oyster mortalities have no obvious connection to the dredging and disposal operations and are probably related to unusually high temperatures and lower salinity.

There was no compelling evidence of increased metal uptake of the oysters or clams due to dredging and spoil disposal for cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc. Concentrations of these metals observed in the oysters and clams from the dumpsite are comparable to those from animals collected and analyzed elsewhere in the middle Atlantic coast.

INTRODUCTION:

Biological studies of overboard disposal of dredged materials off Kent Island were made to identify associated changes in water quality of receiving waters harmful to indigenous commercially harvested clams and oysters. Quantification of these types of biological change is quite difficult, because enormous variabilities within the measured organisms can be expected (Huggett et al., 1973). None the less, ecologically based assessments must be undertaken.

Research performed by the Environmental Protection Agency has shown significant accumulation of various concentrations of "heavy metals" in the sediments of several parts of Baltimore Harbor, Villa and Johnson (1971). Also, Carpenter, et al. (1970) demonstrated that oysters accumulate heavy metals from sediments. Experiments by Shuster and Pringle (1972) showed that Mya arenaria concentrates trace metals relative to background environmental levels and studies by Tenore, et al. (1968) using sediment containing zinc-65 labeled detritus found that Rangia cuneata can accumulate metals from the sediments.

Because of the complexity of the situation, the time-scale for work--and the limited funding, a simple approach was adopted permitting in situ experimental data to be incorporated with existing water quality information to monitor effects of the Kent Island disposal operation. The principles for experimental design in this effort were: 1.) the comparative assessment of continously measured water quality parameters and 2.) the viability and metals accumulations in "normalized" stocks of clams and oysters. Particular emphasis was placed on assessments of possible adverse impact on commercially harvested shellfish stocks resulting from resuspension of metals contaminated sediments during the dredging operations.

METHODOLOGIES

Water quality data incorporated into this report was supplied by the Westinghouse Ocean Research Laboratory located at the Bay Bridge. Daily water quality records are kept and biweekly measures are made of suspended sediment concentrations and chlorophyll, using the method of Strickland & Parsons (1963).

A. IN SITU PREPARATIONS OF ORGANISMS

Working from control stocks of clams (*Mya arenaria*) and oysters (*Crassostrea virginica*) from the Westinghouse Ocean Research Laboratory, premeasured organisms with known metals content and similar behavior (i.e. pumping efficiency) were selected for *in situ* experimentation. Selected organisms were normalized by sorting procedures based on sizes, shell mass and pumping rates. Approximately 75 oysters and 75 clams were collected from off Kent Island and three measures of biomass were made: Displacement volume, wet weight in water and wet weight out of water. By performing a linear regression and correlation analysis, organisms were selected which fell on the regression line with a correlation coefficient greater than 0.750. The organisms were then slowly warmed to a temperature of 27°C and pumping was observed. Accumulations of pseudo-feces were used as an indicator of pumping and organisms with significant pump rates were selected for experimentation.

Three experimentation sites were defined (Fig.1) including two (2) within the approximated impact area and a control site off Hackett's Bar.

At each location, a package (figure 2) containing six (6) bundles of four (4) oysters and four (4) sand embedded clams were suspended four (4) meters below the water surface. Twenty-four (24) of each species placed at each location remained for five (5) months through summer conditions. These racks of organisms were deployed midway through the disposal operation on 4 March and the first samples removed on 18 March. The second series were removed 23 April, the third series on 6 June and the final series removed 11 July. Upon removal from the submerged rack, each sample bundle was placed in bay water and returned to the laboratory for biomass analysis, frozen and stored for analytical chemistry evaluations of heavy metals content. An additional series of laboratory samples was examined immediately after dumping was completed. Biomass analysis consisted of sizing individual organisms, wet weight determinations and composite meat weight measurements.

B. <u>METAL ANALYSIS</u>:

The analytical evaluation of trace metals within the meats of clams and oysters consisted of measuring levels within each animal taken during each sampling period. By this method an attempt was made to identify the interorganism variability. The metals selected for analysis were mercury, cadmium, copper, zinc, chromium, lead, manganese, nickel and iron.

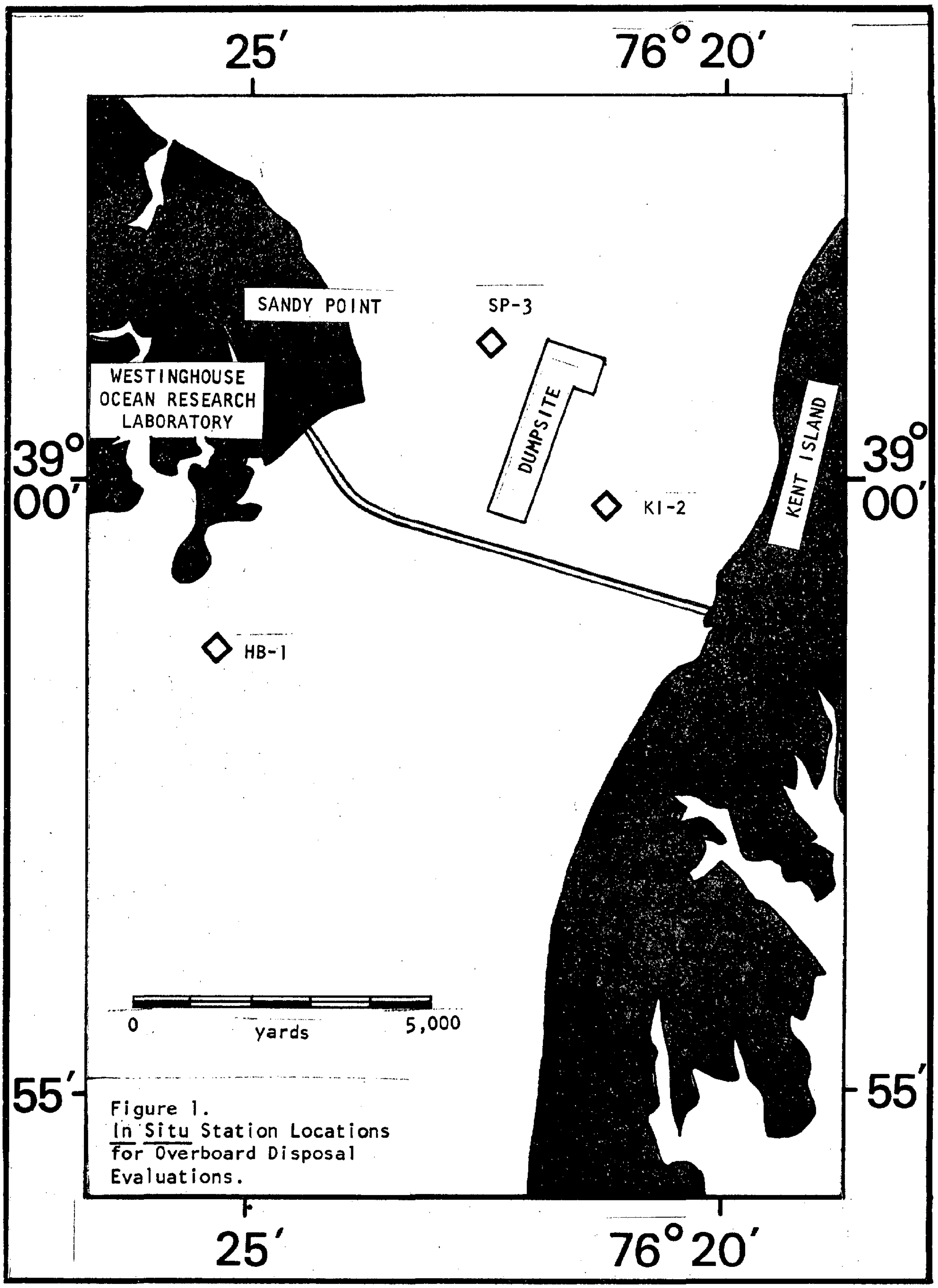
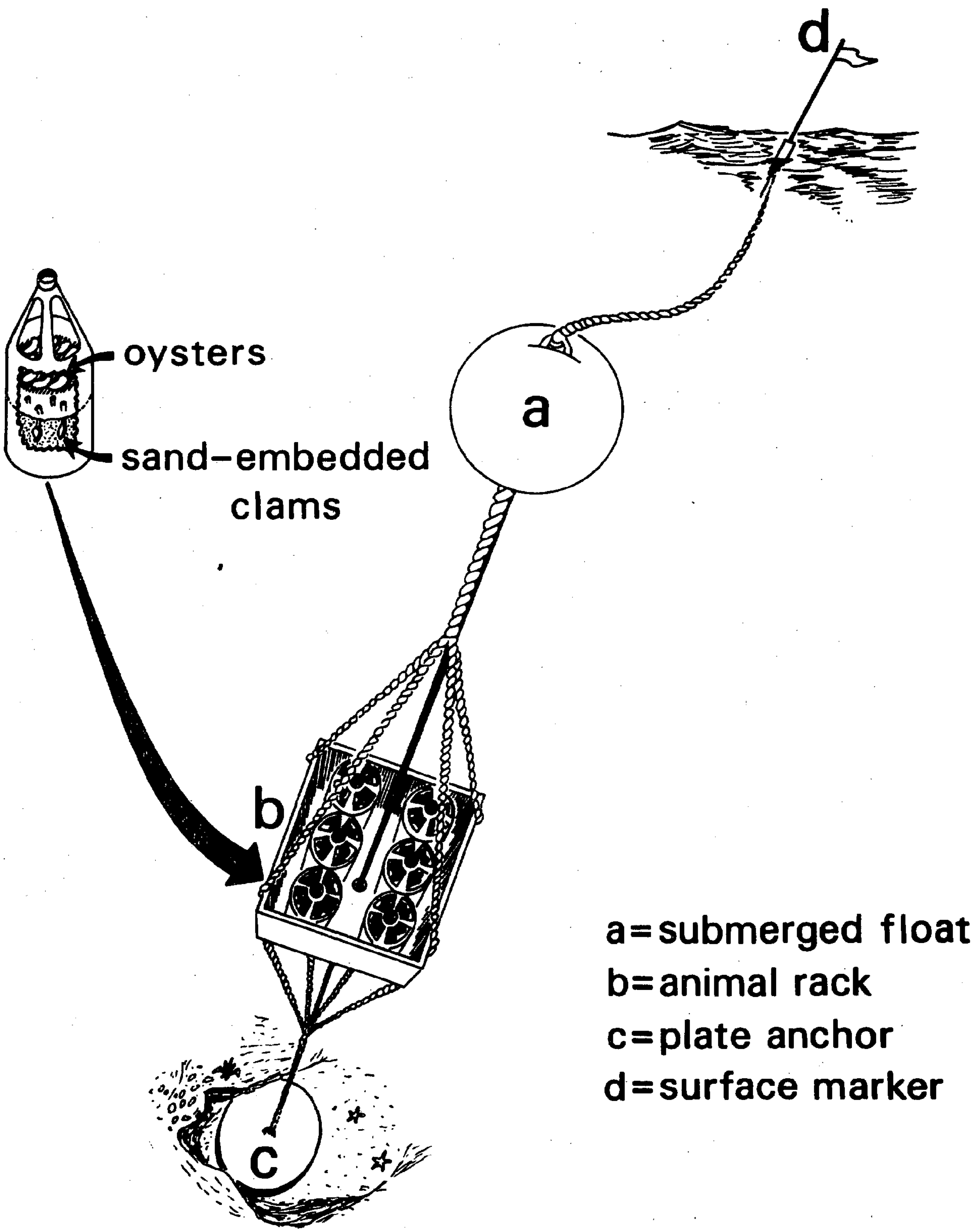


Figure 1.
In Situ Station Locations for Overboard Disposal Evaluations.

Figure 2.

IN SITU SHELLFISH RACKS



Precautions:

To avoid contamination all glassware was soaked in a chromic acid solution and rinsed with very hot tap water, followed by three to four rinses with distilled deionized water.

The shucking knife and blender blades were the only metal instruments used in this procedure. (Teflon coated or wooden spatulas were used in any transfers.) The knife and blender parts were dipped in the chromic acid solution, well rinsed, and checked before any samples were run. Contact between the shucking knife and animal was kept to a minimum.

After shucking, each animal tissue was blended until homogeneous and separated into portions needed for the various analyses. Distilled, deionized water was always used in the preparation.

Metals:

A 3-5 gram portion was placed in a pre-weighed 125 ml glass stoppered erlenmyer flask and weighed to four decimal places. After the addition of 20-25 mls of concentrated nitric acid, the samples were heated in a shaking hot water bath for at least four hours at 58°C. Cooled samples were then filtered (.45 micron millipore, type HA) and brought to volume (100 ml).

These were processed at the Annapolis EPA field laboratory for analysis by Atomic Absorption Spectrophotometry.

Mercury:

Approximately 0.5 grams (weighed to four decimal places) of homogeneous tissue was placed in a clean 300 ml BOD bottle. Four milliliters of concentrated sulfuric acid and 1 ml of concentrated nitric acid were added and the sample was placed in a 58°C hot water bath until dissolved. After cooling, 5 mls of potassium permanganate (50g/litre) was added in 1 ml increments, followed by the addition of another 10 mls KMnO. The sample was allowed to stand overnight. After the volume was adjusted to 150 mls with distilled, deionized water, it was ready for analysis in a Coleman Mercury Analyzer Mas-50.

Six to eight milliliters of sodium chloride-hydroxylamine sulfate solution (120g of each in 1 liter of distilled, deionized water) was added to reduce the excess permanganate after 5 ml of Stannous Chloride (100 g/l) was added. The maximum peak height and percent transmission were observed. Concentration of mercury was determined by comparison to a standard curve.

The standards were prepared according to the American Society for Testing and Materials method D3223-73, "Total Mercury in Water".

Results

Daily water quality data for the upper portion of Chesapeake Bay is presented in the appendix to this report and reduced data are given in Tables 1 and 2. From this data, it appears that monthly daily average temperatures are quite similar in 1974 and 1975. However, the salinity data for this same period does not show the same similarities (Figure 3). The 1974 salinities show a typical seasonal pattern with the minimum occurring in April during the spring freshet and then increasing into summertime conditions. The 1975 salinity data show two lows, one occurring in March and a second in May. Also, the monthly salinity averages are consistently lower in 1975 than in 1974. An interesting note is that during the 1974 salinity minimum the average temperature was 11.3°C and during the 1975 salinity minimum the average temperature was 18°7 C. The combination of the higher temperatures and

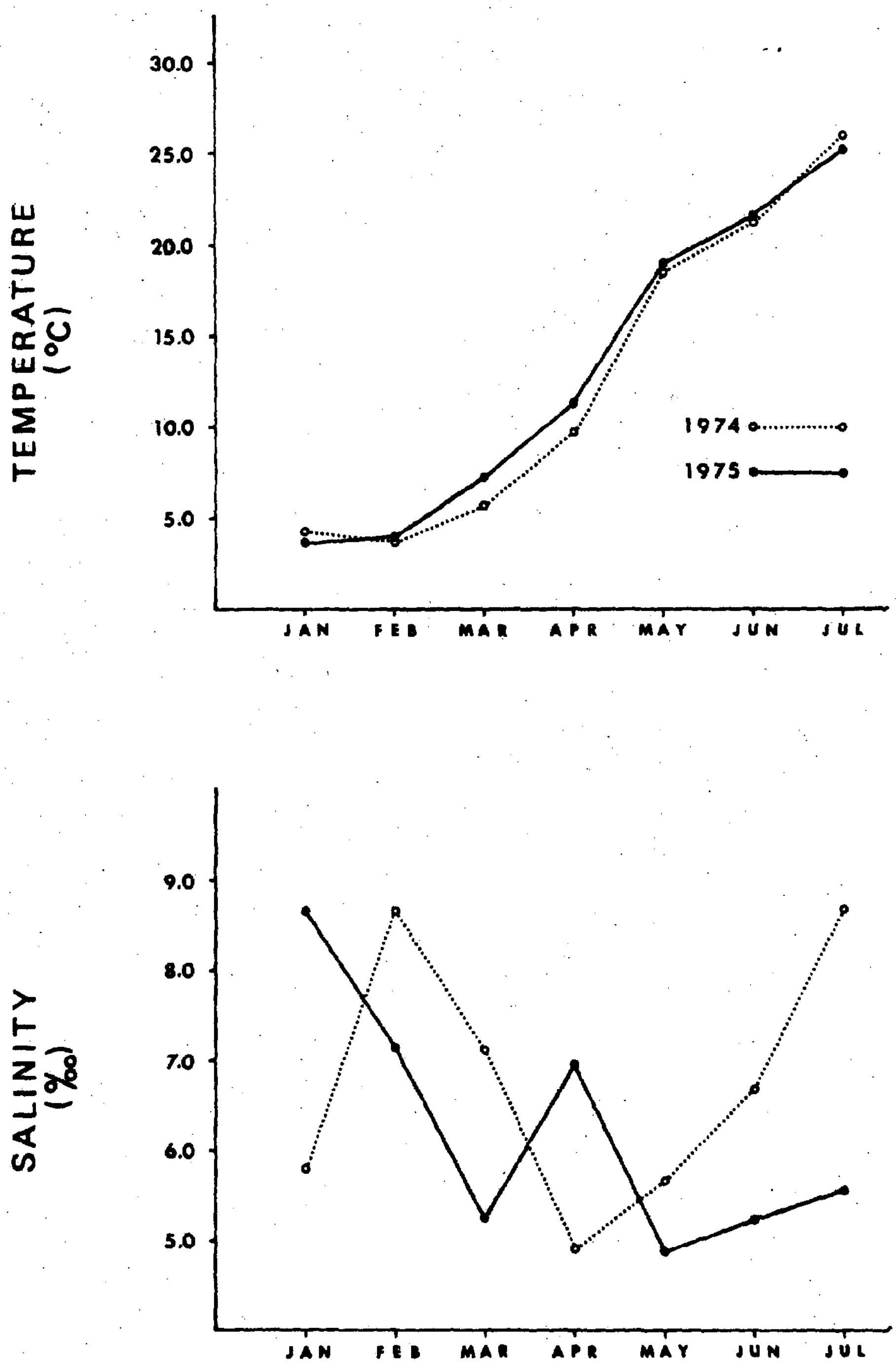


Figure 3. Comparative Average Temperature and Salinity Data for the First Half Years of 1974 and 1975.

TABLE 1

Kent Island Dumpsite Program - 1975

Water Quality Data

Westinghouse Ocean Research Laboratory

1974

Parameter	Jan.	Feb.	March	April	May	June	July
Temp $\bar{x}$(°C)	3.6	4.1	7.24	11.3	18.98	21.38	25.4
Min.	1.2	2.1	5.5	6.7	14.0	19.3	22.9
Max.	6.5	5.9	9.5	16.7	21.7	24.9	27.7
Salinity $\bar{x}$(°/oo)	5.8	9.0	7.13	4.9	5.69	6.68	8.69
Min.	2.4	6.3	5.3	2.6	4.2	4.7	7.1
Max.	10.3	11.0	9.3	6.8	6.5	8.0	10.3
D.O. $\bar{x}$(mg/l)	12.85	12.44	11.53	10.77	9.42	7.5	7.39
Min.	9.4	11.44	9.12	9.68	7.12	6.0	4.76
Max.	14.24	13.72	12.6	12.4	10.42	8.4	9.20
pH $\bar{x}$	7.6	7.8	7.7	7.6	7.87	7.43	7.97
Min.	7.4	7.5	7.5	7.3	7.49	7.0	7.0
Max.	7.8	8.0	7.9	8.2	8.50	7.68	8.6
Chl <u>a</u> $\bar{x}$(μ/l)	*	*	12.38	13.64	19.62	11.96	22.46
Min.			1.91	3.83	10.42	7.10	12.47
Max.			29.76	30.78	35.30	15.83	38.03

* No data taken.

TABLE 2

Kent Island Dumpsite Program - 1975

Water Quality Data

Westinghouse Ocean Research Laboratory

1975

Parameter	Jan.	Feb.	March	April	May	June	July
Temp $\bar{x}$(°C)	4.35	3.92	5.68	9.71	18.65	23.67	26.16
Min.	1.5	2.1	2.9	6.8	12.8	20.4	23.8
Max.	6.1	6.0	8.7	12.9	24.4	25.4	28.1
Salinity $\bar{x}$(°/oo)	8.64	7.14	5.25	6.93	4.39	5.2	5.56
Min.	5.7	3.0	4.0	4.9	3.2	4.5	4.4
Max.	11.0	9.1	6.7	8.5	5.5	6.0	6.2
D.O. $\bar{x}$(mg/l)	11.6	11.91	11.28	10.19	8.57	6.27	5.35
Min.	9.4	10.3	10.0	9.8	6.75	5.2	5.3
Max.	12.6	13.1	12.0	11.8	10.1	7.65	5.4
pH $\bar{x}$	7.97	7.97	7.71	7.82	7.8	7.5	7.37
Min.	7.5	7.65	7.51	7.6	7.4	7.2	7.2
Max.	8.15	8.3	7.8	8.06	8.3	8.0	7.6
Chla $\bar{x}$(μ/l)	19.17	16.05	12.9	16.52	21.33	22.67	61.56
Min.	12.63	9.57	6.93	11.15	17.94	15.34	39.3
Max.	30.88	20.35	19.06	20.04	30.47	39.45	96.31

lower salinities during the spring of 1975 undoubtedly caused stresses which were observed during the in situ experimentation as indicated by the mortality records given in Table 3.

Through cooperation with the NASA ERTS program three images were obtained (Figure 4, 5 & 6) of the study area during the in situ experimentation. The photo from the 21 February pass (Figure 4), during the disposal operation, does not show any traces of a visible surface turbidity plume in the vicinity of the dumpsite. However, photos from the 22 May (Fig. 5) and 9 June (Fig. 6) satellite passes which were two months after disposal operations ceased, indicate that surface turbidities from upper Chesapeake Bay do affect waters within the Kent Island disposal area.

The in situ stations were visited four times over a five month period. During each sampling divers retrieved a single container of animals and observations were made as to the viability of the oysters and clams collected (Table 3). The station (SP-3) to the Northeast of the dumpsite was lost after the first sampling period. It was during this time that a severe storm was recorded and the submerged mooring devices must have broken loose. The loss of this station was regretted but did not detract substantially from the overall results of the experimental program.

The results obtained from more than 90 individual analyses of 9 metals on clams and oysters are presented in Tables 4 and 5. This data represents average corrected values of metal concentrations based on individual animal wet weights. Each value represents the average of at least 3 individual organisms analyzed. Comparison of this information with other studies (Cronin et al. 1974 Pringle et al. 1968, Bryon 1971) indicate no obvious increases in heavy metals

TABLE 3

Survival Record for Oysters and Clams
During *In Situ* Experimentation

	STATION LOCATIONS					
	CONTROL		DUMPSITE			
	HB-1		K1-2		SP-3	
DATE	OYSTER	CLAM	OYSTER	CLAM	OYSTER	CLAM
3/18	100	100	100	100	100	100
4/23	100	100	100	75	*	*
6/3	100	50	100	50	*	*
7/11	91.6	33.3	100	58.3	*	*

* Sample rack lost.

Figure 4. ERTS Photo of Upper Chesapeake Bay 21 February 1975.

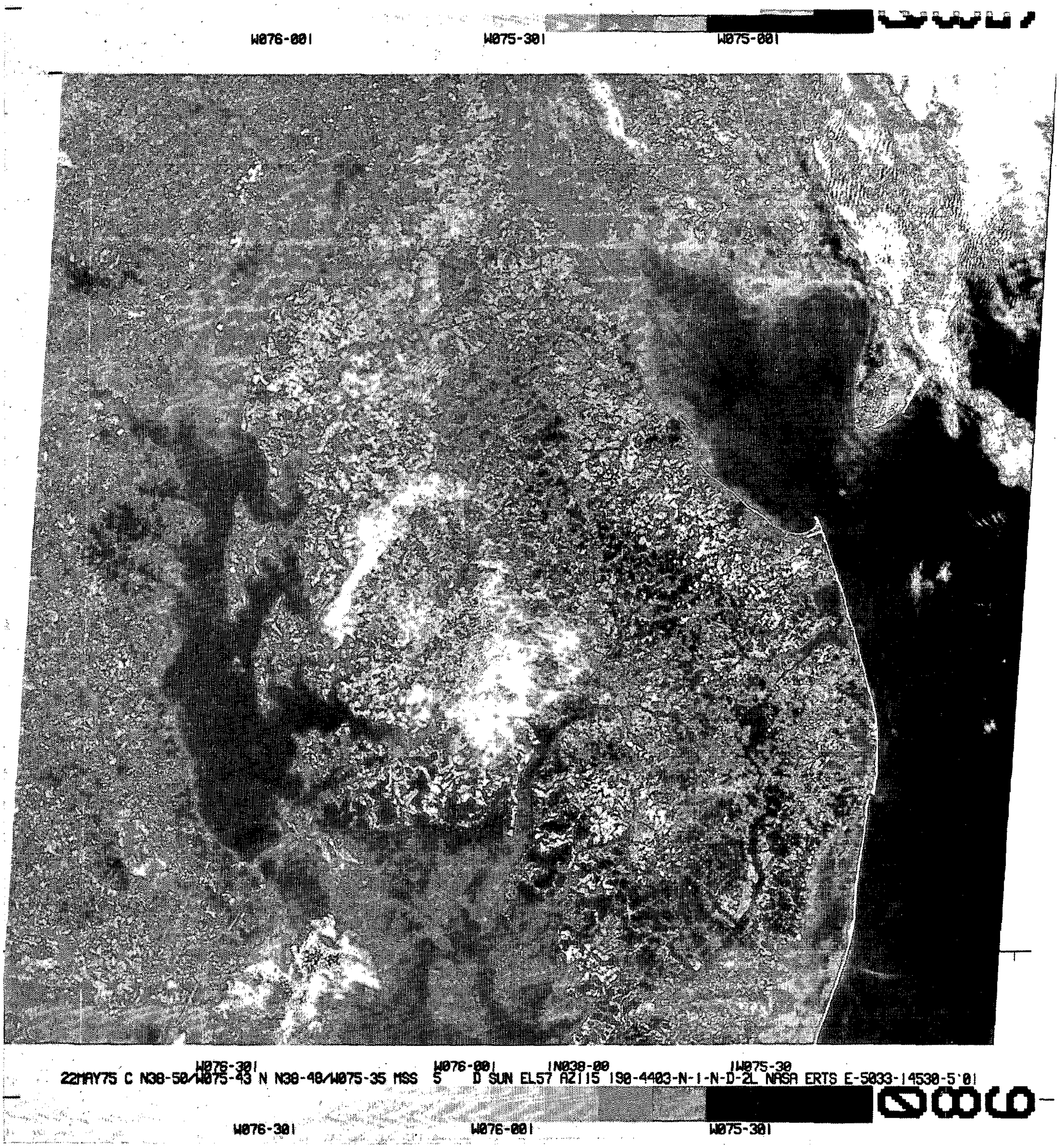


Figure 5. ERTS Photo of Upper Chesapeake Bay 22 May 1975.

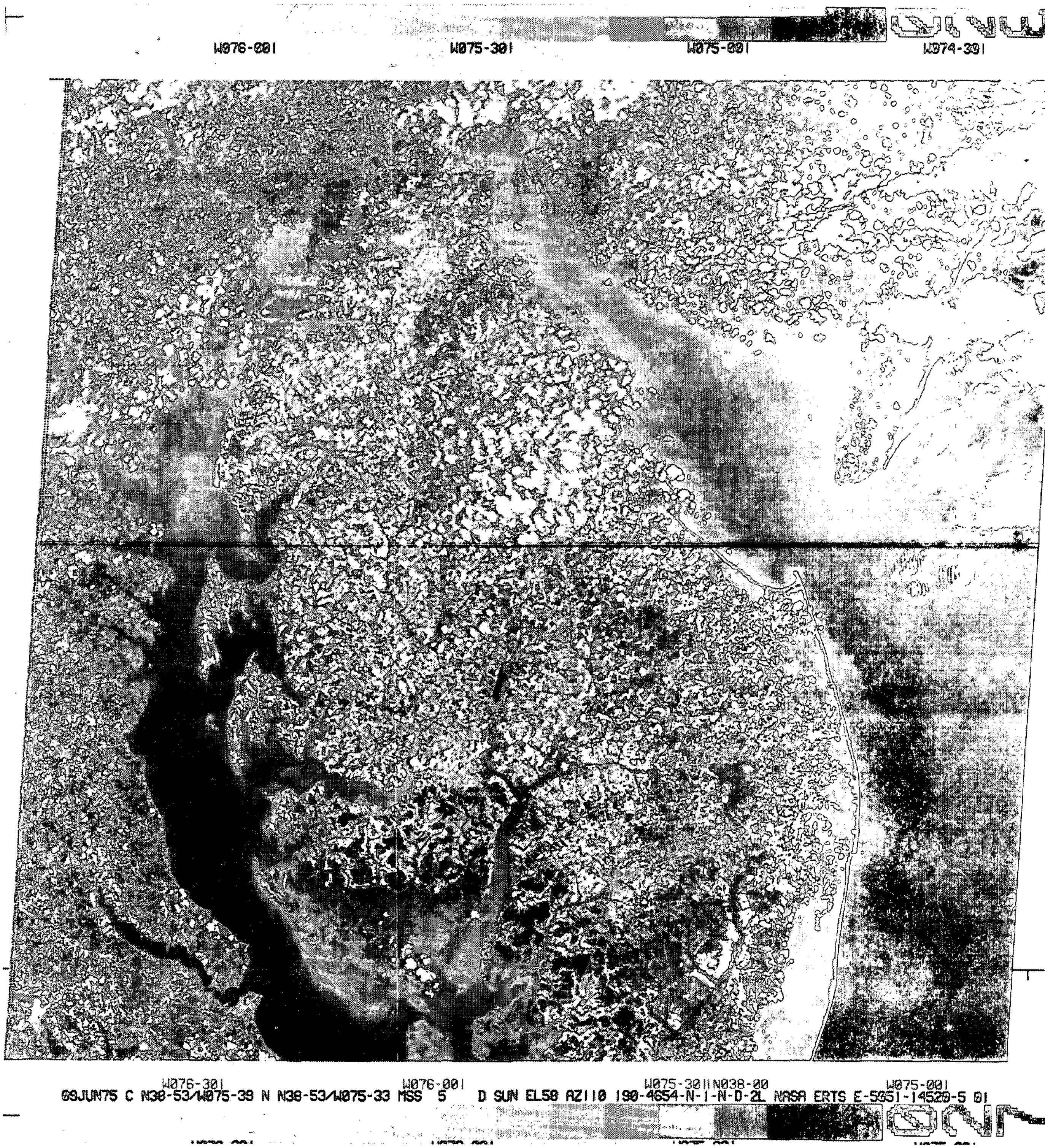


Figure 6. ERTS Photo of Upper Chesapeake Bay 9 June 1975.

TABLE 4

Kent Island Dumpsite Program - 1975

In Situ Shellfish Experimentation

OYSTER DATA

Metal Concentration (ppm wet)

Date	Location	Cd	Cu	Ni	Mn	Pb	Zn	Fe
3/18	Control	1.97 (±0.76)	47.0 (±24.2)	<0.20	1.37 (±0.60)	<0.50	995. (±576)	15.2 (±1.4)
4/23	Control	1.55 (±0.89)	47.0 (±5.5)	<0.20	1.12 (±0.99)	<0.50	1.024 (±283)	11.9 (±2.6)
6/3	Control	2.40 (±0.50)	48.7 (±11.1)	<0.20	5.06 (±1.09)	0.50	1,565 (±285)	16.8 (±5.7)
7/11	Control	3.66 (±1.44)	70.8 (±21.0)	<.20	17.2 (±11.3)	1.15 (±.96)	1,821 (±543)	25.0 (±7.8)
3/18	Dumpsite	1.97 (±0.37)	64.2 (±28.6)	0.58 (±0.74)	1.95 (±0.94)	1.02 (±0.57)	1,165 (±511)	16.8 (±8.5)
4/23	Dumpsite	0.85 (±0.54)	46.3 (±18.5)	<0.20	2.45 (±1.50)	<0.50	968 (±417)	15.7 (±8.3)
6/3	Dumpsite	1.62 (±0.44)	32.4 (±11.6)	<0.20	2.60 (±2.35)	<0.50	1,079 (±384)	12.5 (±2.5)
7/11	Dumpsite	4.35 (±1.73)	49.6 (±29.2)	0.85 (±.60)	19.3 (±10.7)	<.50	1,517 (±890)	31.9 (±11.7)

CR and Hg = <0.50 ppm for all animals

TABLE 5

Kent Island Dumpsite Program - 1975
in situ Shellfish Experimentation

Clam Data

Metal Concentration (ppm wet)

Date	Location	Cr	Cu	Ni	Mn	Pb	Zn	Fe
3/18	Control	0.97 (±1.08)	3.25 (±1.80)	0.92 (±1.19)	17.4 (±7.3)	<0.50	36.3 (±10.1)	290. (±206.)
4/23	Control	<0.50	3.02 (±1.47)	1.47 (±1.06)	38.2 (±41.9)	<0.50	27.2 (±5.0)	138. (±131.)
6/3	Control	<0.50	2.35 (±1.34)	<0.50	60.0 (±38.3)	2.20 (±0.70)	49.7 (±9.5)	127. (± 28.)
7/11	Control	<0.50	1.86 (±0.12)	<0.50	75.3 (±40.9)	<0.50	22.2 (±10.3)	145. (±87.)
3/18	Dumpsite	<0.50	3.42 (±0.68)	<0.20	4.1 (±1.4)	0.67 (±0.35)	20.7 (±1.0)	57. (±28.)
4/23	Dumpsite	<0.50	2.20 (±0.43)	0.53 (±0.57)	47.5 (±38.2)	<0.50	38.0 (±23.9)	153. (±133.)
6/3	Dumpsite	<0.50	2.35 (±2.05)	<0.50	57.6 (±45.8)	1.85 (±0.91)	20.7 (± 7.7)	164. (± 65.)
7/11	Dumpsite	<0.50	2.74 (±1.40)	<0.50	80.8 (±79.9)	<0.50	18.9 (±12.4)	90. (± 77.)

Cd <0.50 ppm for all animals

within exposed shellfish can be attributed to the disposal operations off Kent Island during February--March, 1975. Only a slight pulse above background levels was observed for Nickel and Lead in oysters during the March sampling. These small increases due mainly to a single high sample were once again at background levels during the April sampling. Comparison of heavy metal values in oysters reported by Pringle, et al., (1968) indicate that the levels of these metals are comparable (Table 6).

From Pringle's same data, metals observed in soft shell clams indicate a similar comparison in ranking as our study (Table 7). However, while iron levels in clams seem lower in Chesapeake Bay than other areas of the Atlantic coast, zinc and managnese levels appear to be somewhat higher.

Based on information gathered from pertinent literature, data acquired during this study and material from corroborative investigations, certain qualifications can be made concerning heavy metals associated with the dredge spoil and its effect on oysters and clams from the upper Chesapeake Bay.

The health and viability of clams and oysters were affected more by natural physical phenomena during these investigations than by dredge disposal operations. It appears that lower salinities, especially in late Spring, caused most of the observed clam mortalities. While Spring freshets, accompanied by reduced salinities, normally occur when Bay water temperatures are relatively cold, a second freshet occurred in upper Chesapeake in 1975 in May when water temperatures were above 18°C. The increased temperature and low salinity placed a severe strain on the clams by causing the animals to pump at accelerated rates under stressful salinities.

TABLE 6

Comparison of Kent Island Dumpsite Metals Data with Published Data on Atlantic Coast Oysters (*Cr. virginica*)

(ppm wet)

Metal	Pringle Et Al.	Control	Dumpsite
Zinc	1,428.	1,351.	1,182.
Copper	91.5	53.4	48.1
Iron	67.0	17.2	19.2
Manganese	4.3	6.21	6.59
Cadmium	3.1	2.40	2.20
Lead	0.47	0.67	<0.63
Chromium	0.40	<0.50	<0.50
Nickel	0.19	<0.20	<0.46

TABLE 7

Comparison of Kent Island Dumpsite Metals Data with

Published Data on Soft Shell Clams (MYA ARENARIA).

Metal	Pringle Et Al.	Kent Island Study Control	Kent Island Study Dumpsite
Iron	405	175.	116.
Zinc	17	33.8	24.5
Manganese	6.70	47.7	47.5
Copper	5.80	2.62	2.68
Lead	0.70	<0.92	<0.88
Chromium	0.52	<0.62	<0.50
Nickel	0.27	<0.85	<0.50
Cadmium	0.27	<0.50	<0.50

Trends of increased metals content were observed for some metals in both oysters and clams. However, comparison of control and dumpsite stations indicate no significant accumulations by shellfish held in the vicinity of the Kent Island disposal area. Though not statistically significant, observed trends of increased metals content of zinc and cadmium in oysters and manganese in the clams more clearly relate to the increasing water temperatures from March through July.

Acknowledgements:

This study was conducted for the Maryland Department of Natural Resources under the direction of the Chesapeake Bay Institute of Johns Hopkins University. We wish to express our sincere appreciation to Dr. O. Villa at the Environmental Protection Agency, Annapolis Field Office and his staff, especially Ms. P. Johnson, for their enthusiastic cooperation in performing atomic absorption analyses of these samples. Our gratitude is extended to Dr. M. G. Gross for review and comment, Mrs. A. Umpleby for typing the manuscript and to the WORL staff who assisted in the program.

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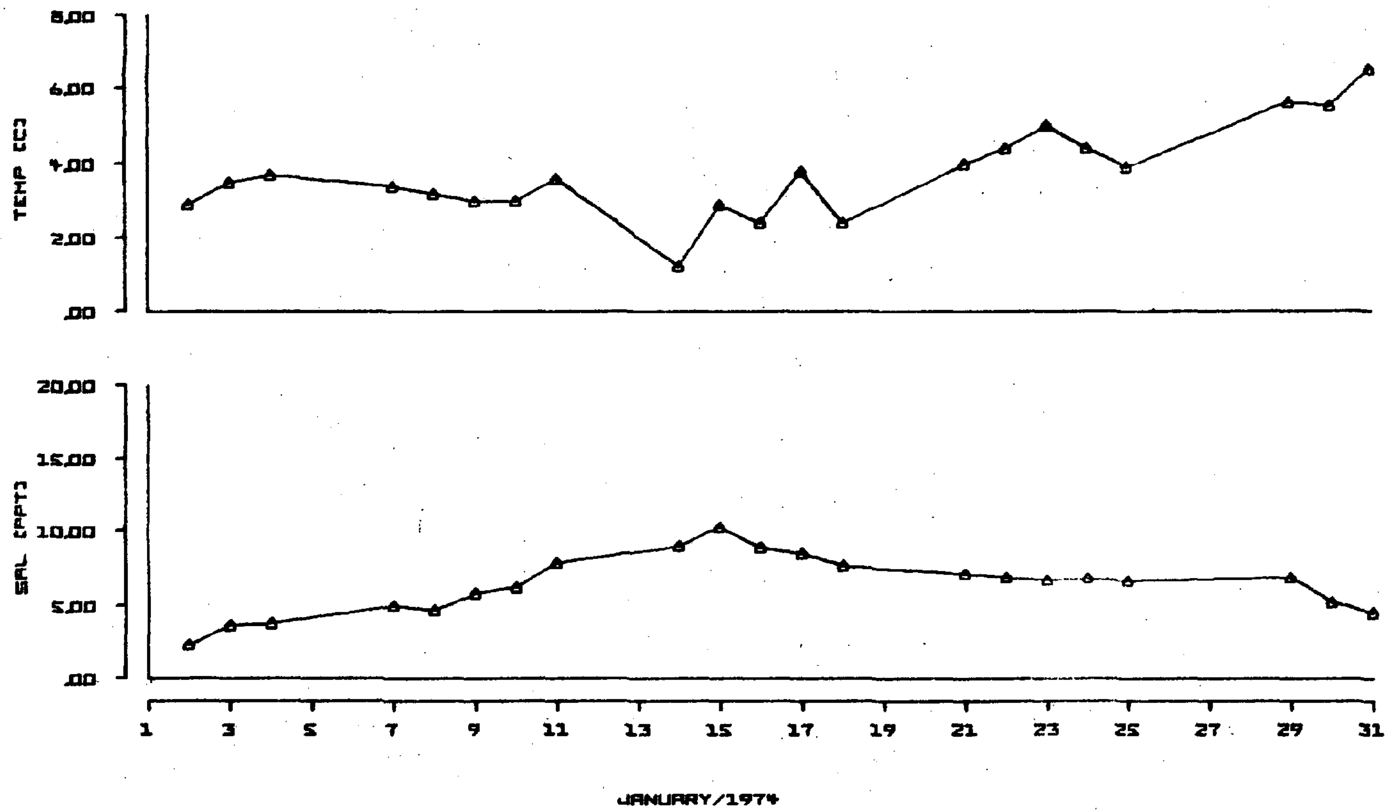
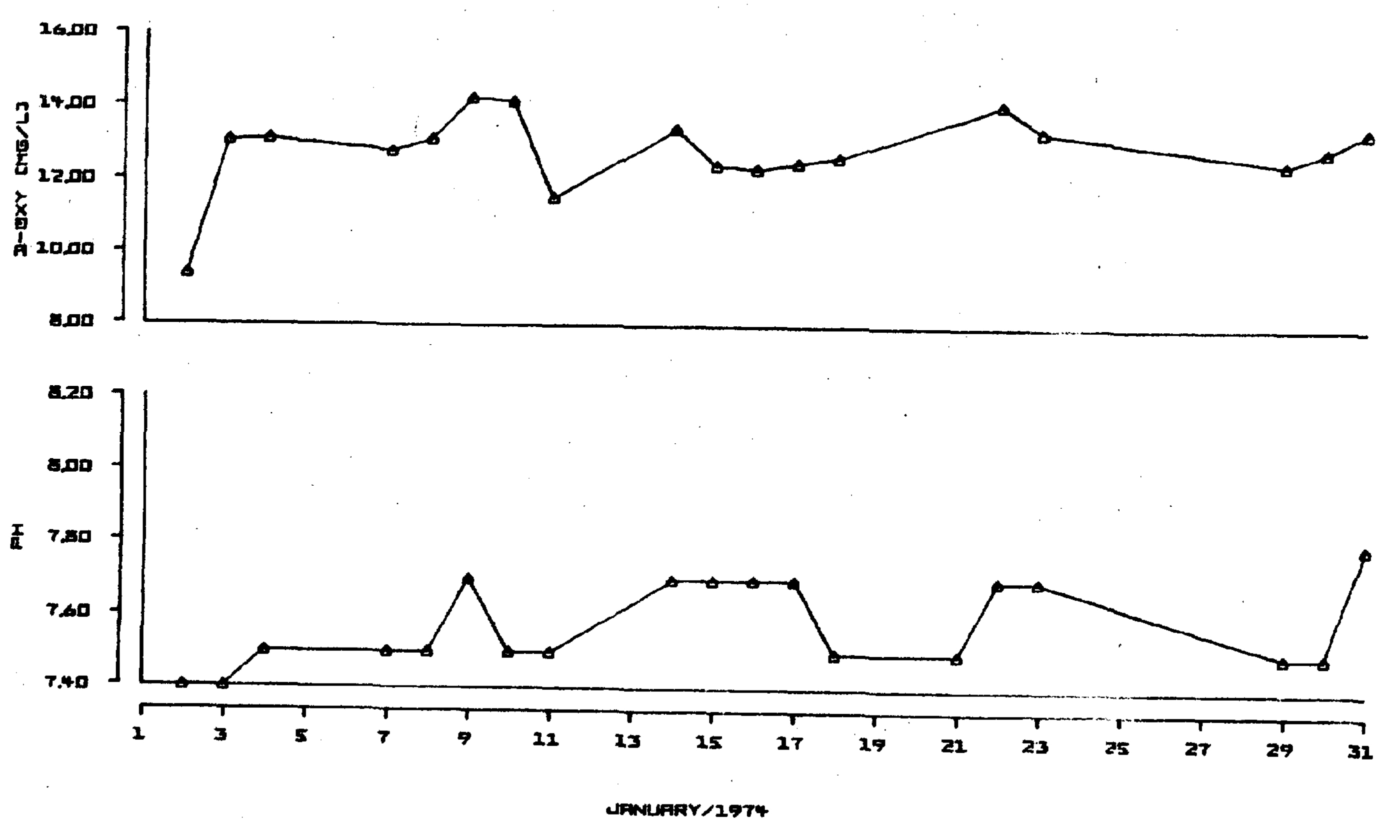
APPENDIX: Daily Water Quality Data at the Chesapeake Bay Bridge January 1974 - July 1975.

WESTINGHOUSE OCEAN RESEARCH

BAY BRIDGE, ANNAPOLIS





WESTINGHOUSE OCEAN RESEARCH

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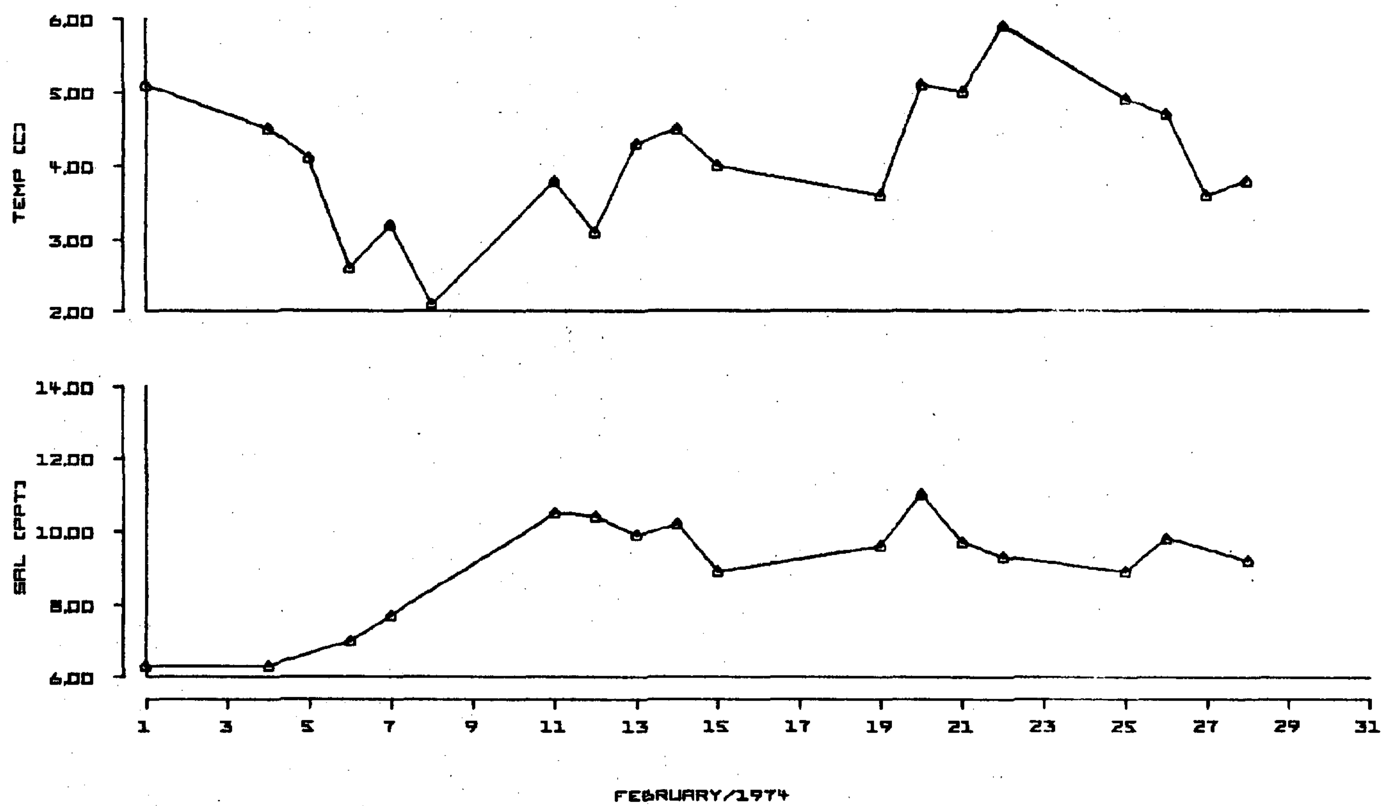

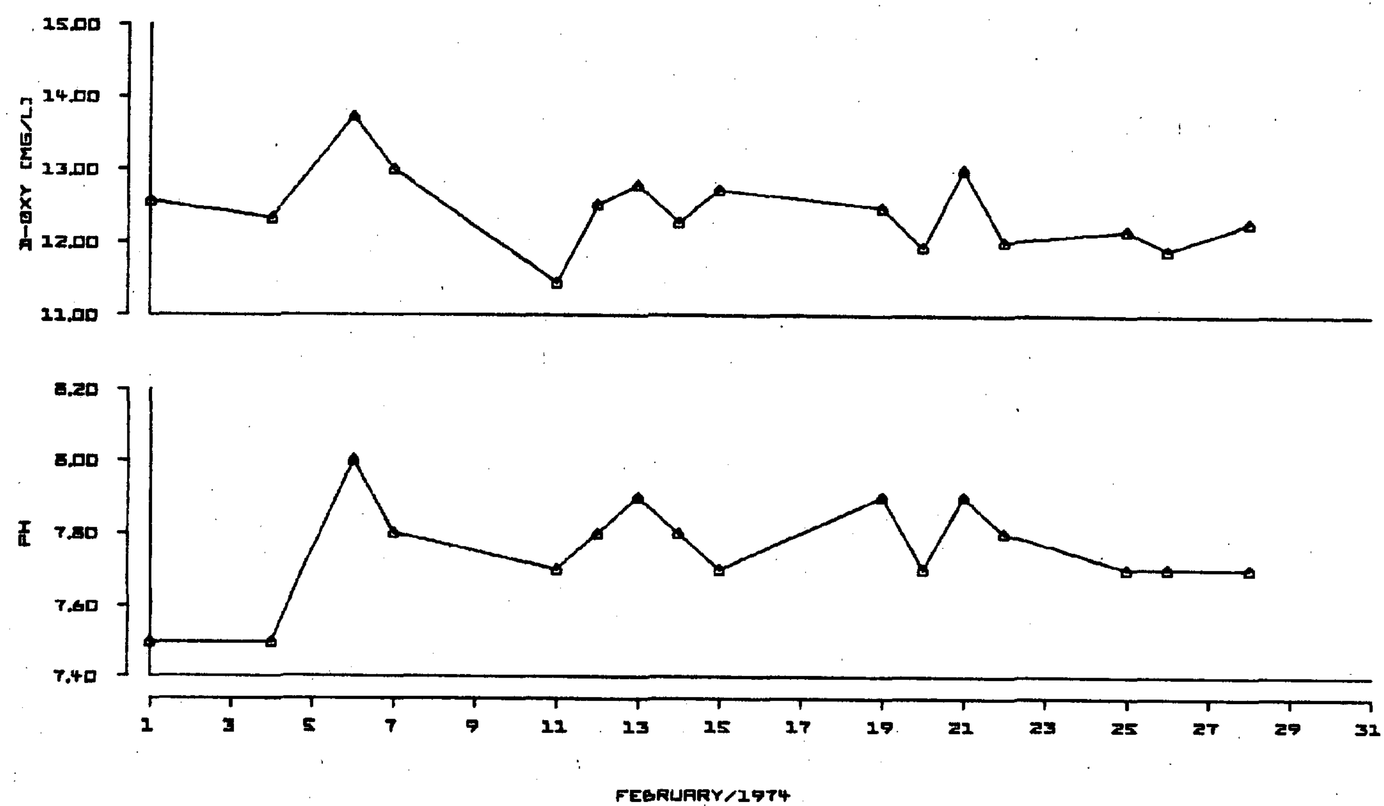

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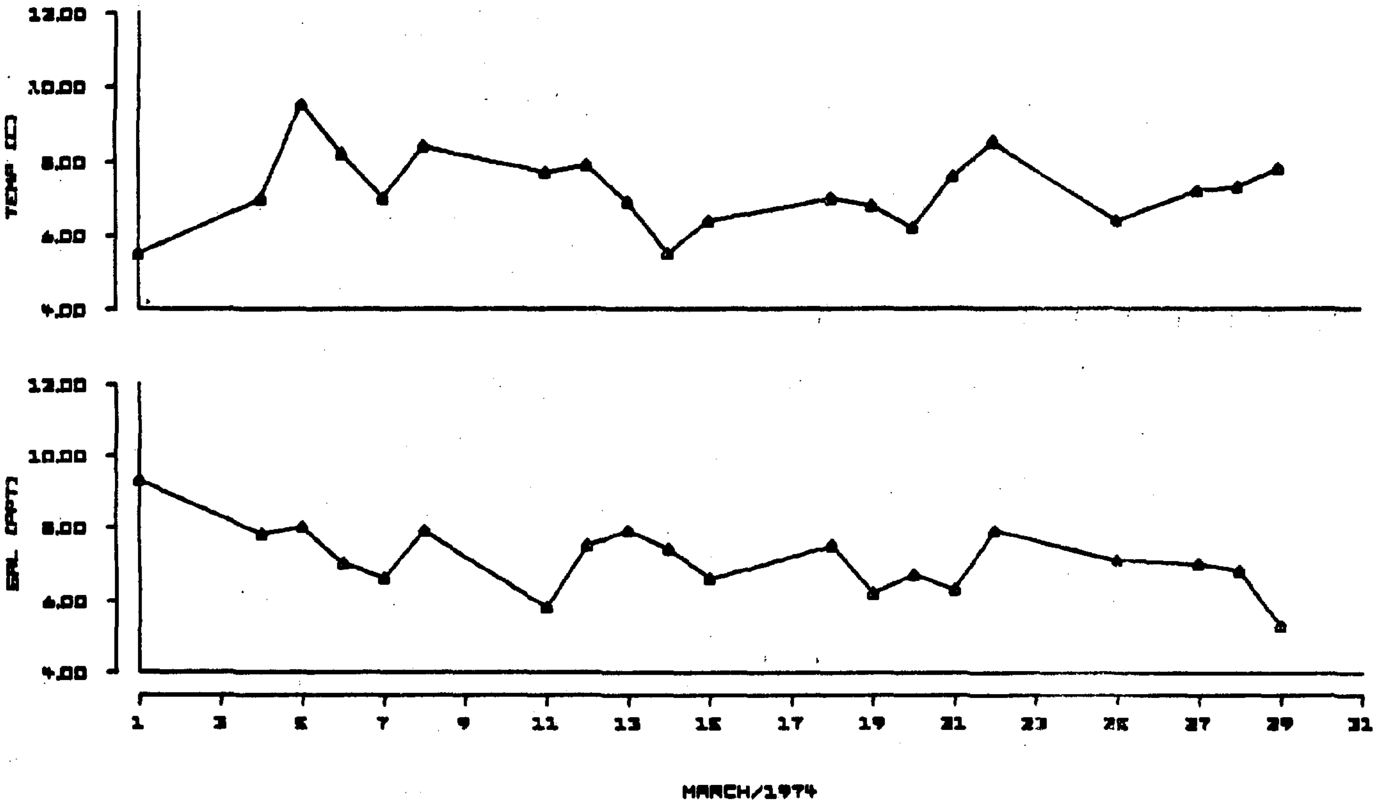

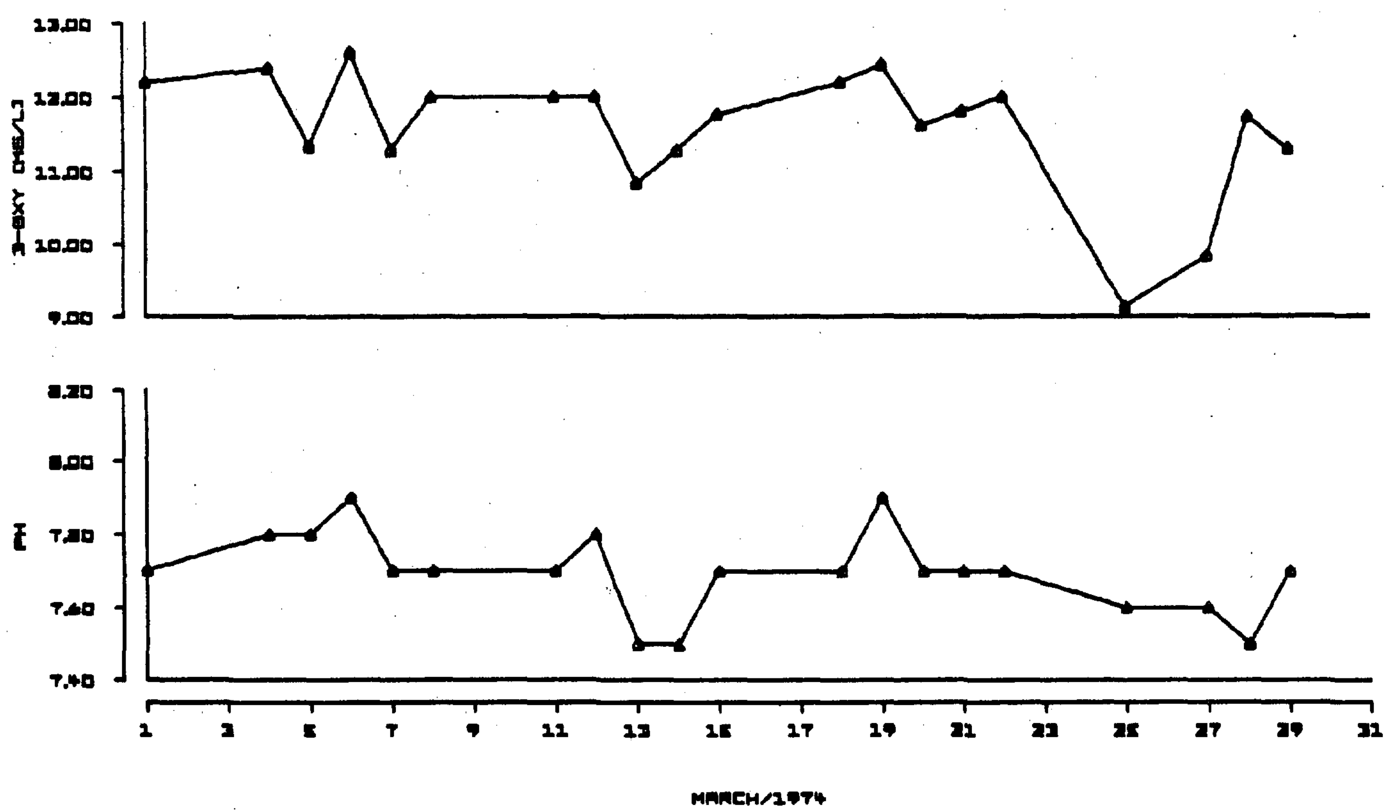

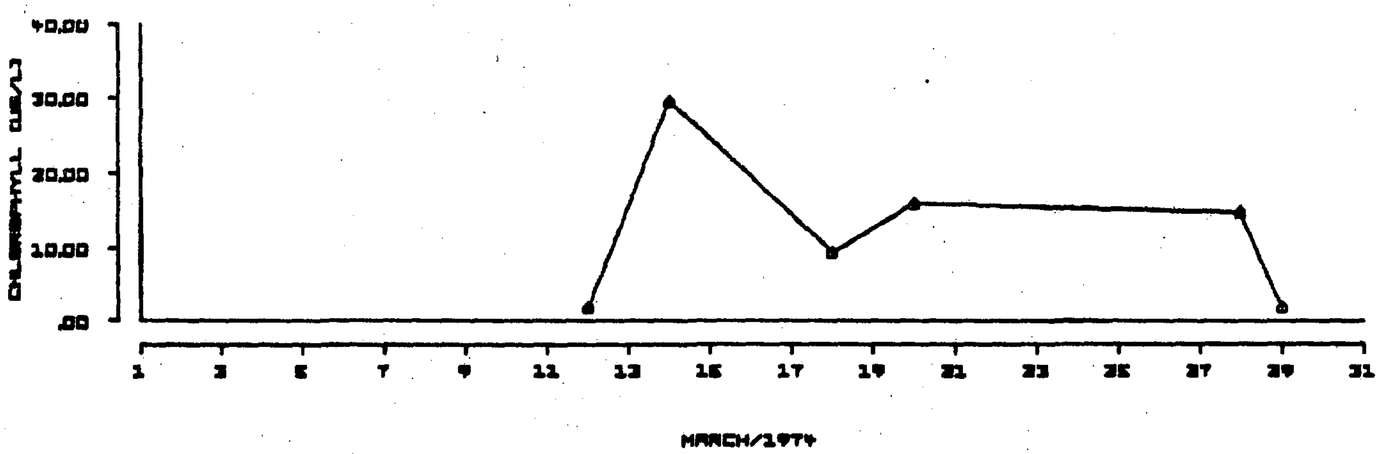
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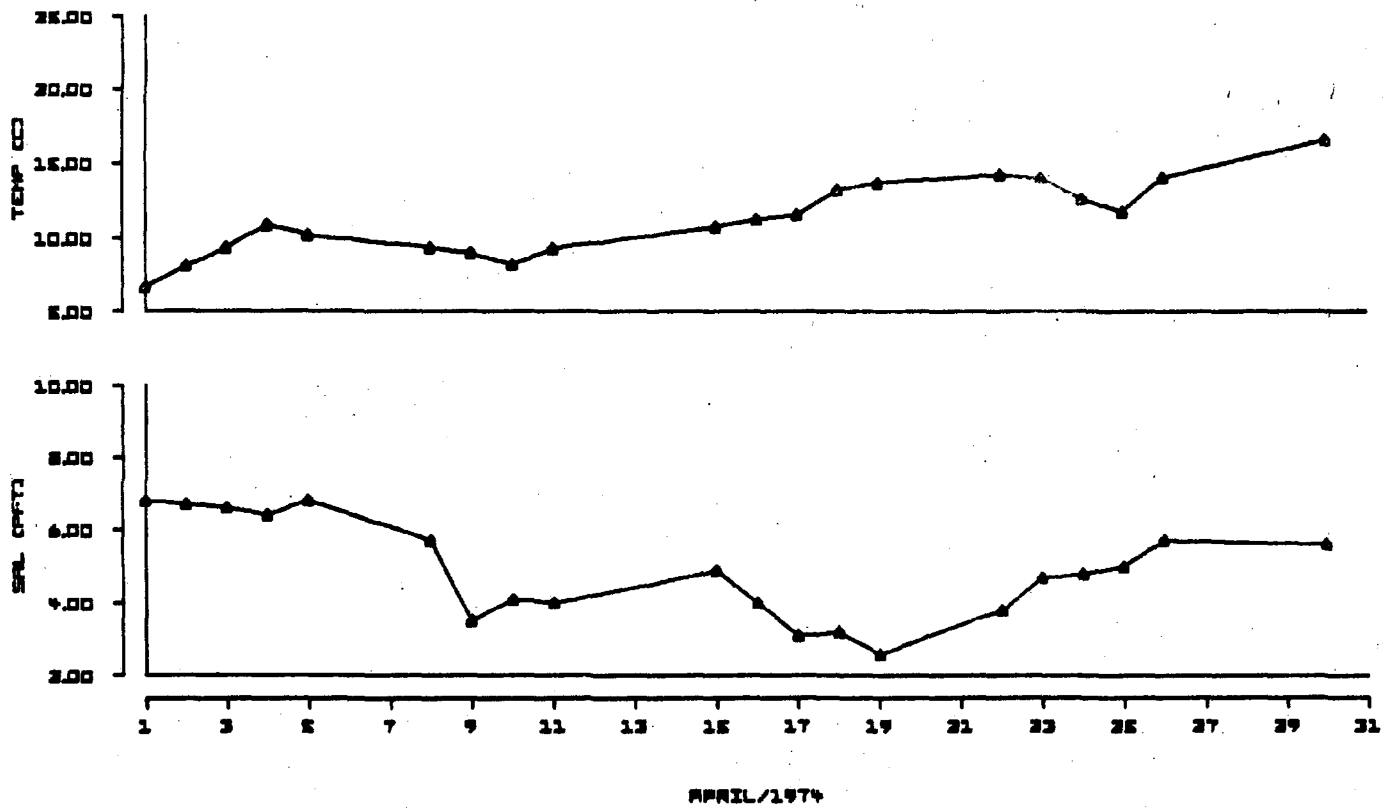

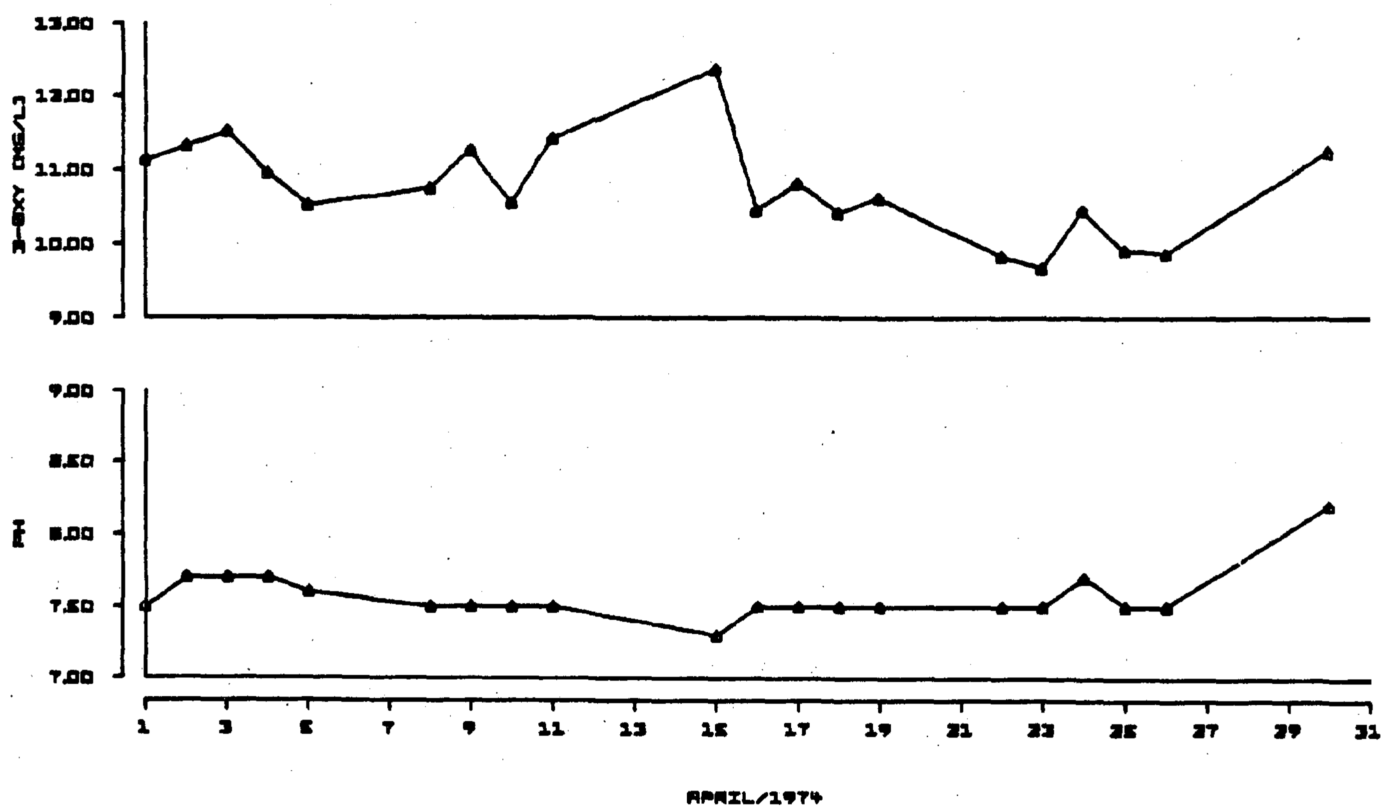

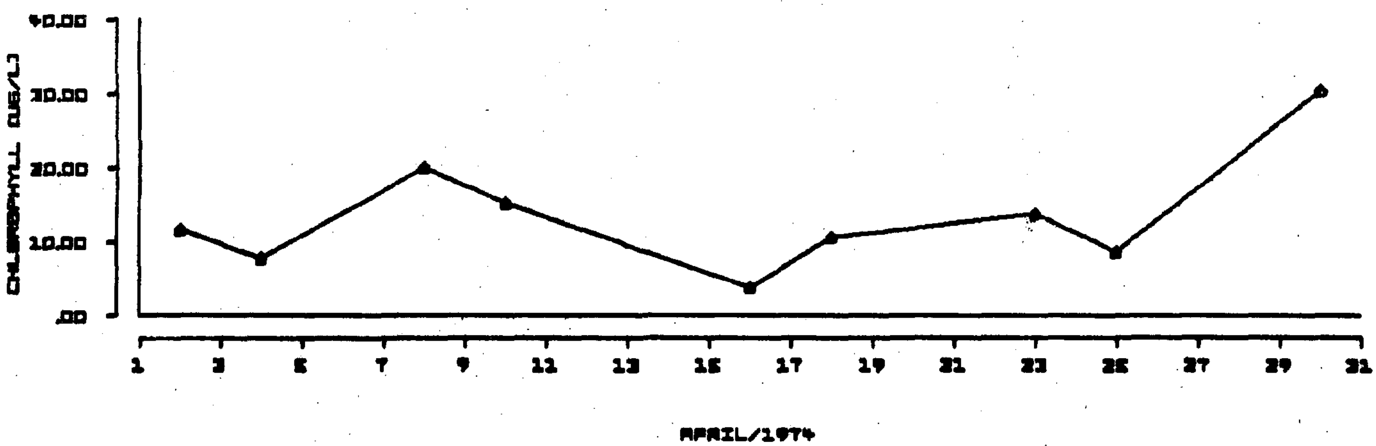
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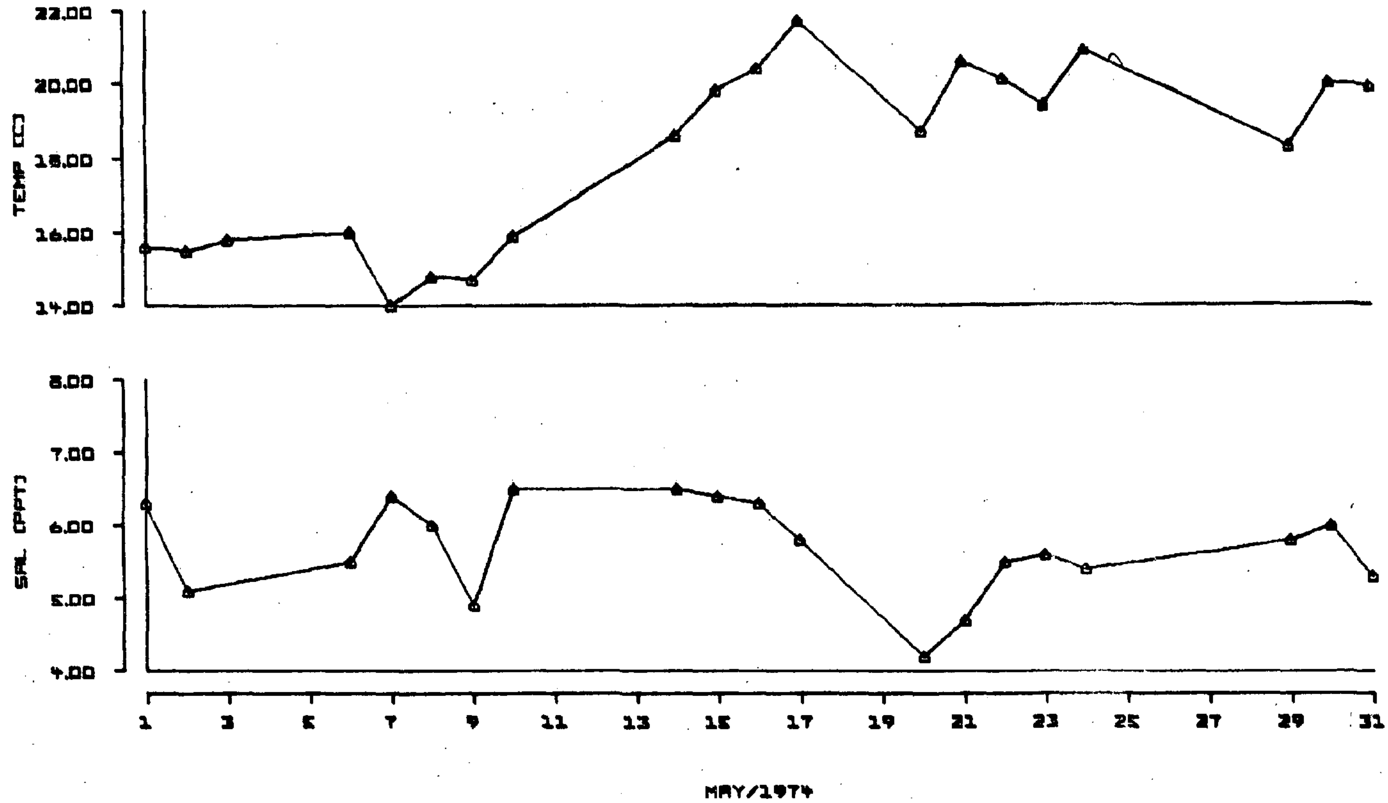

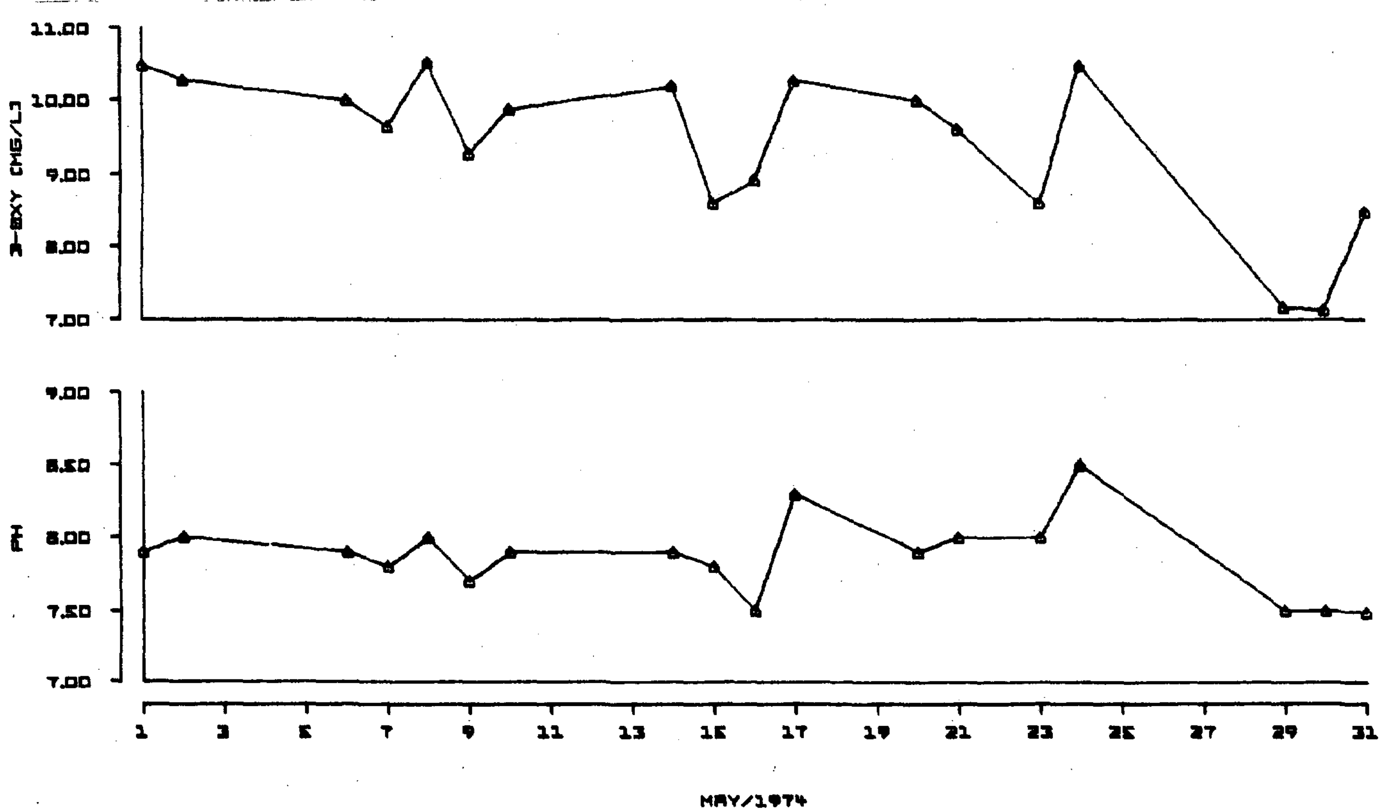

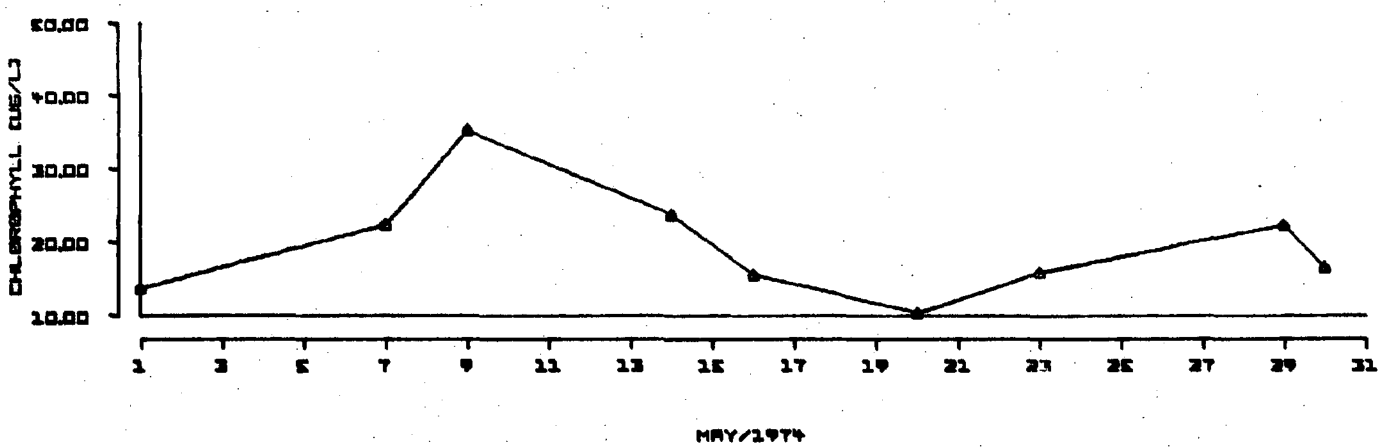
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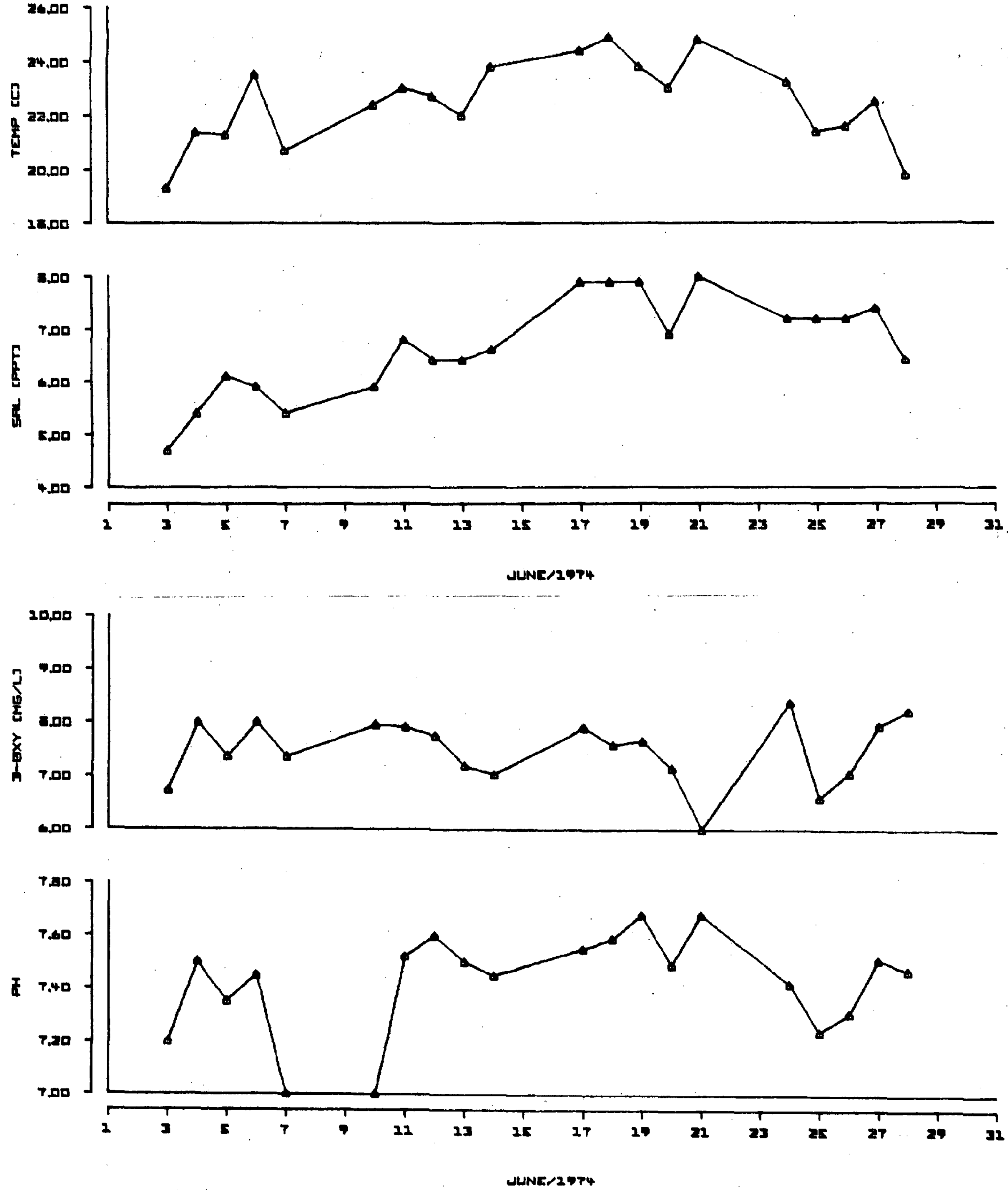

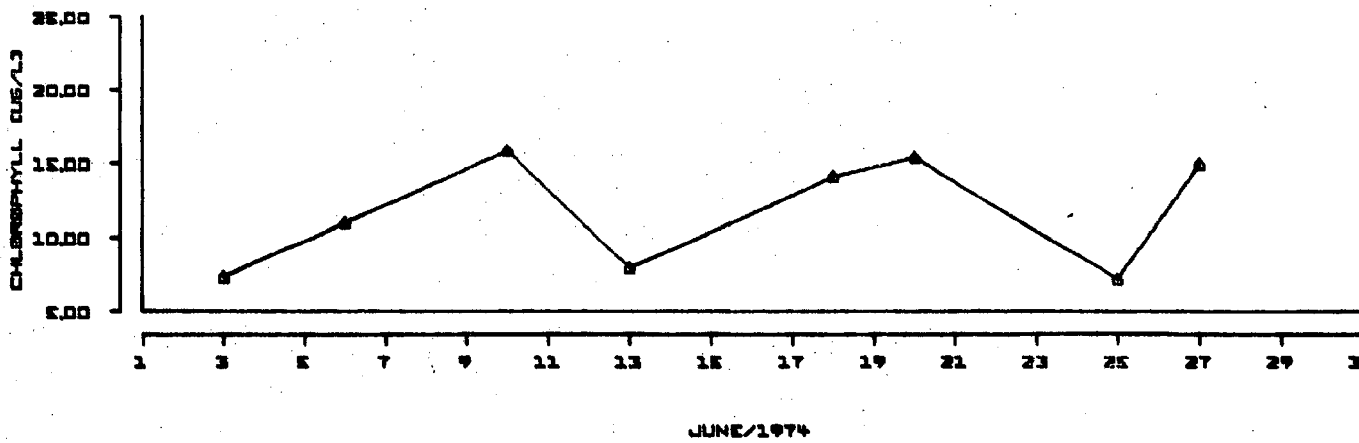
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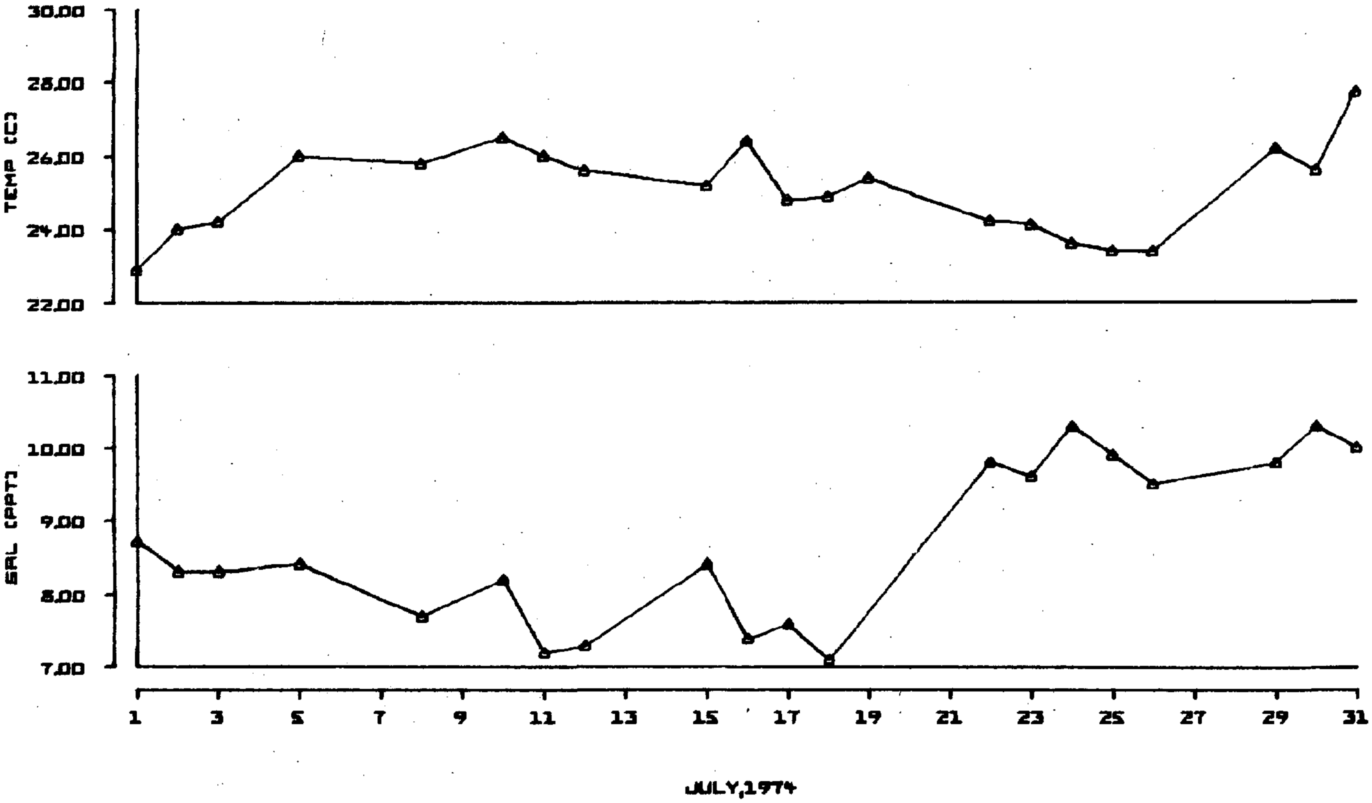

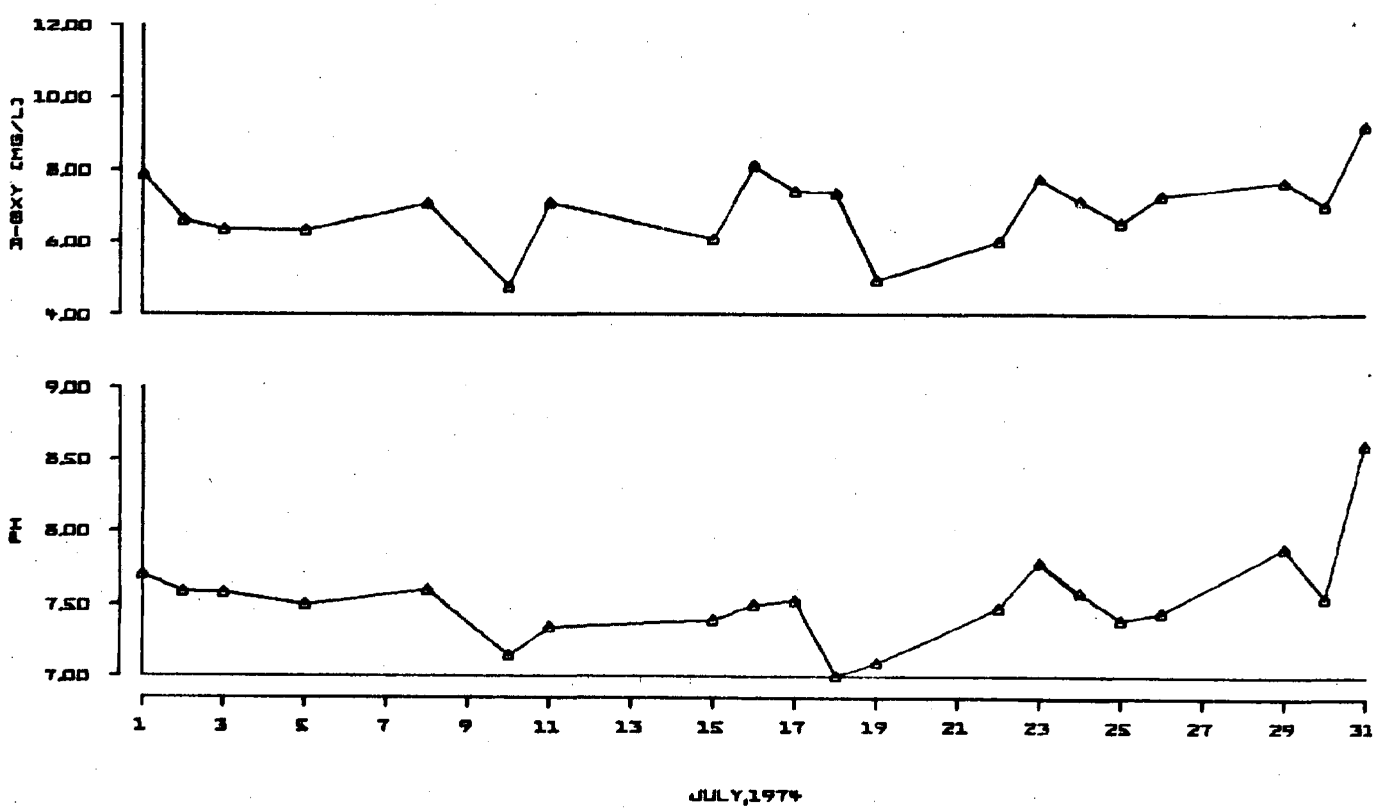

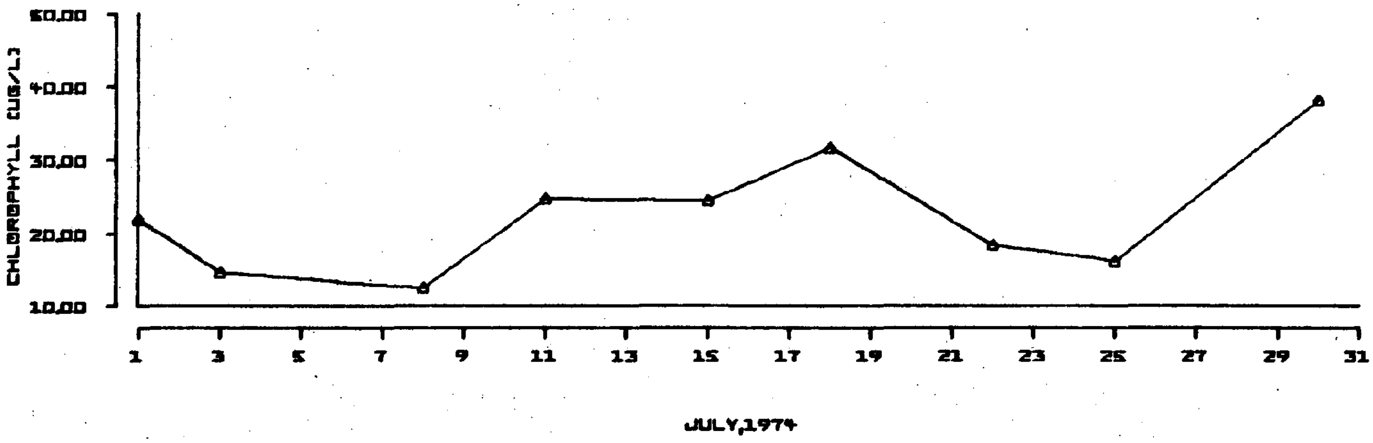
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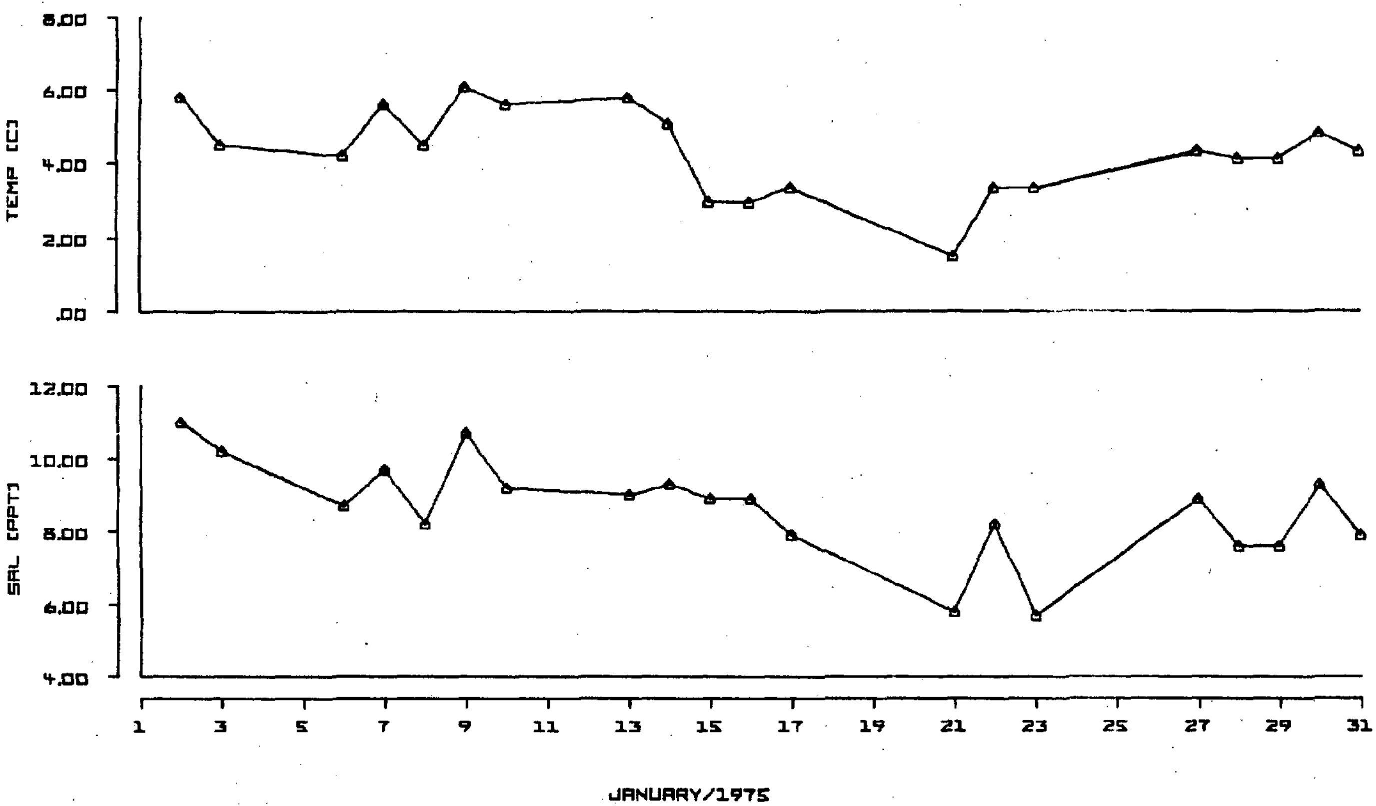

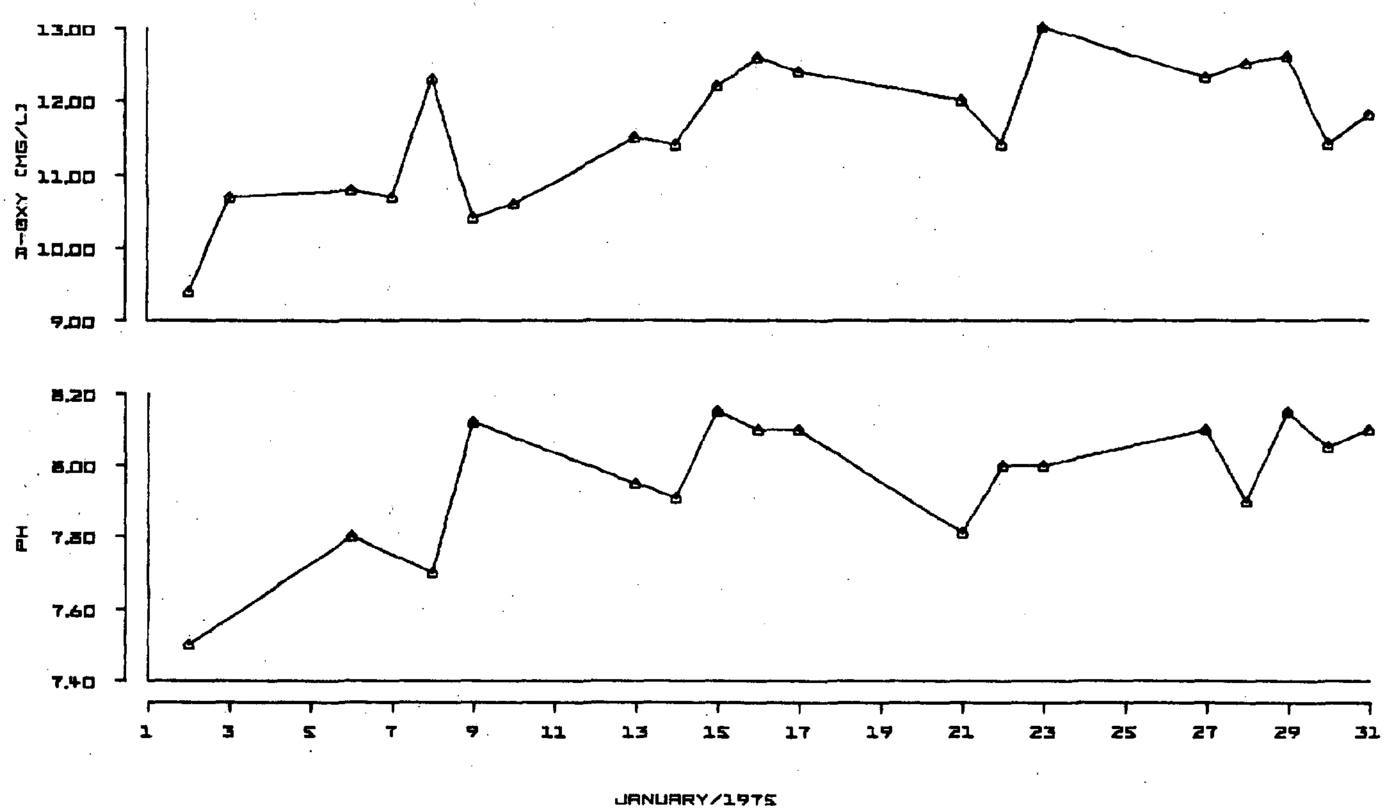

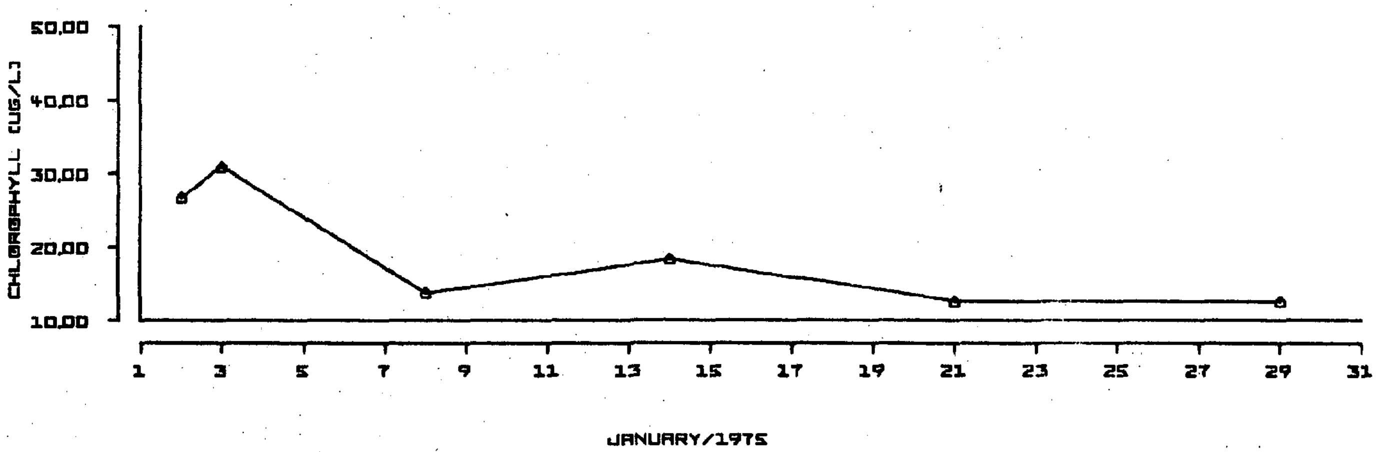
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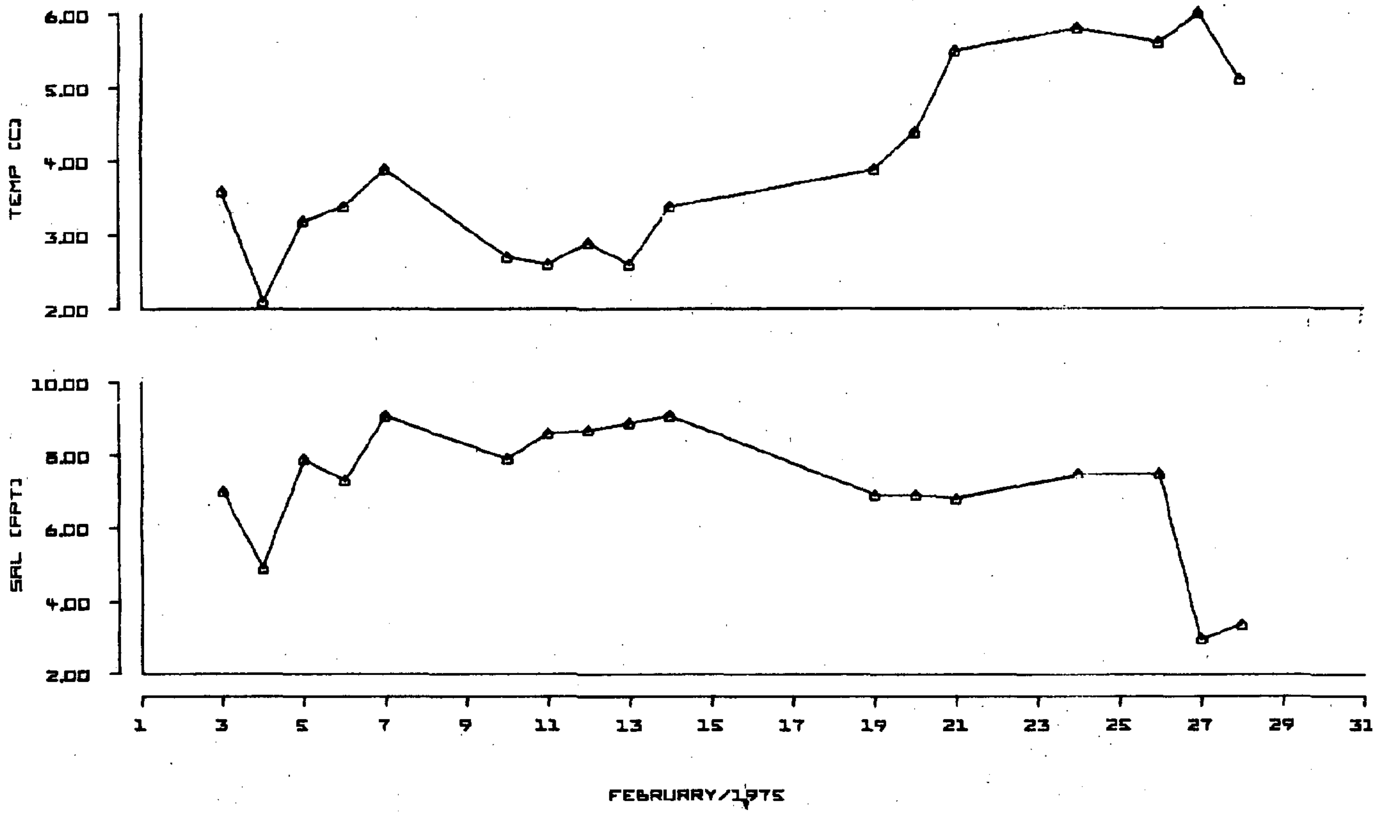

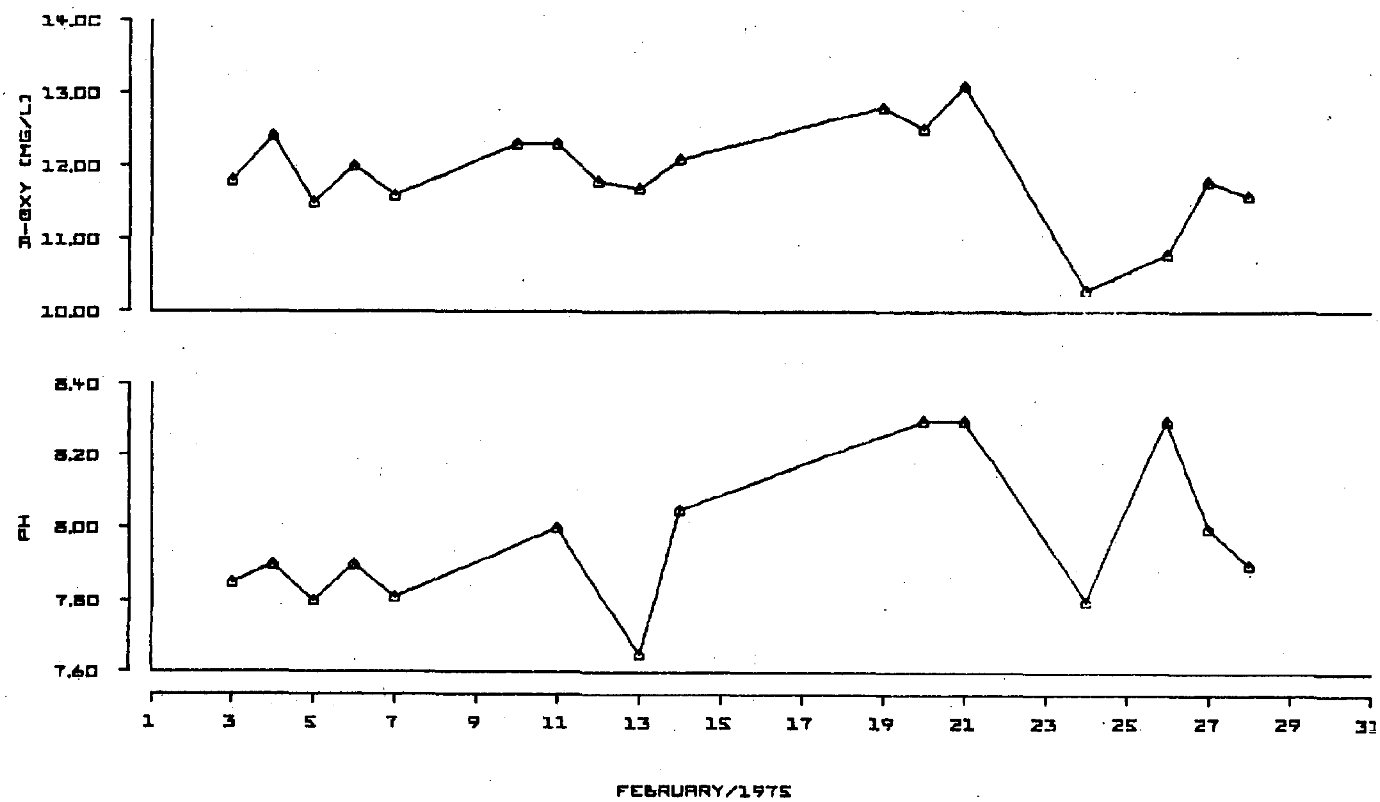

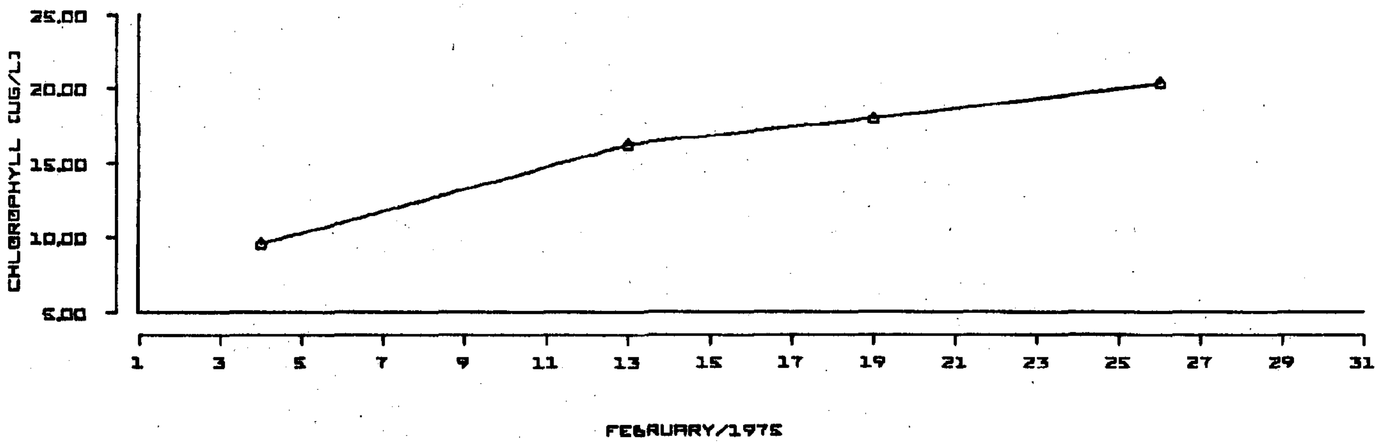
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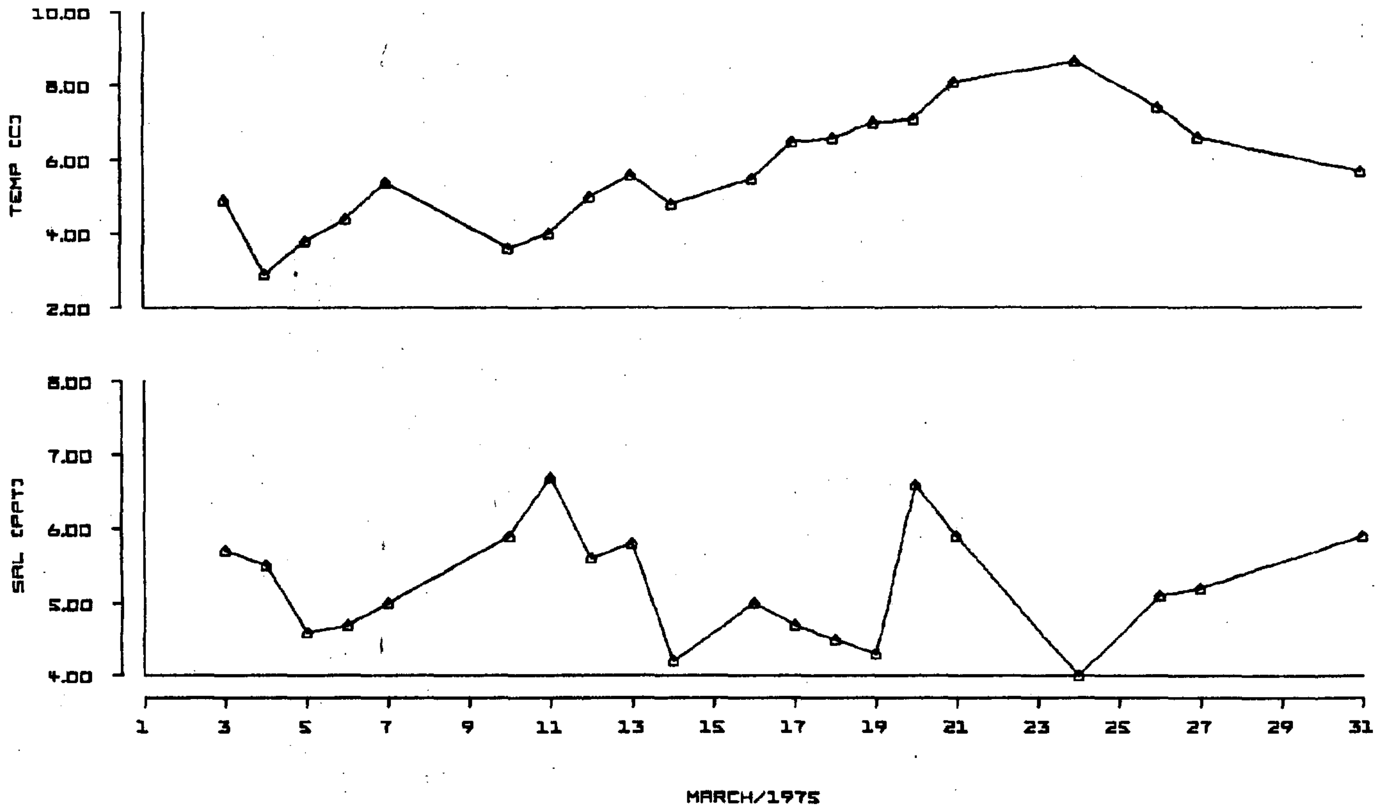

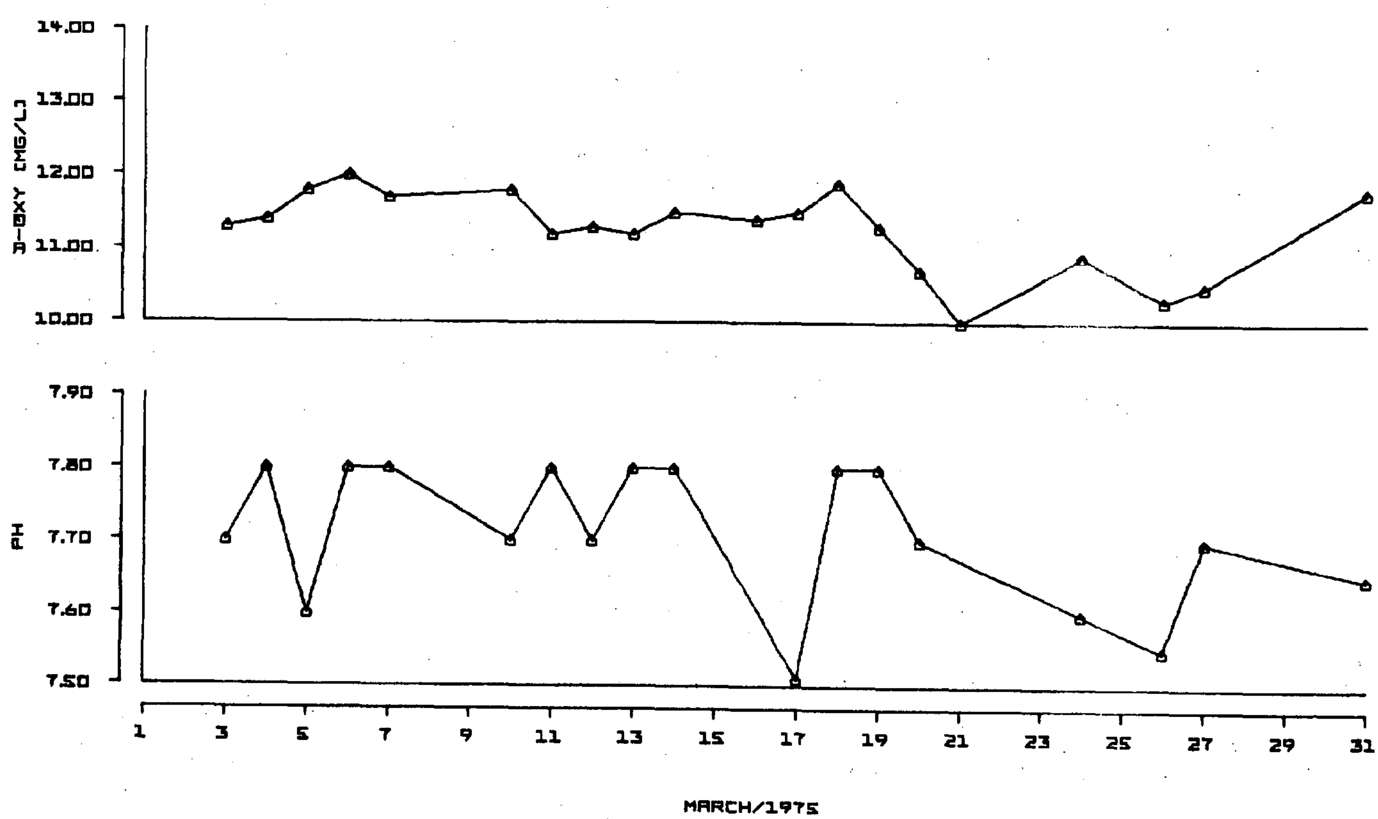

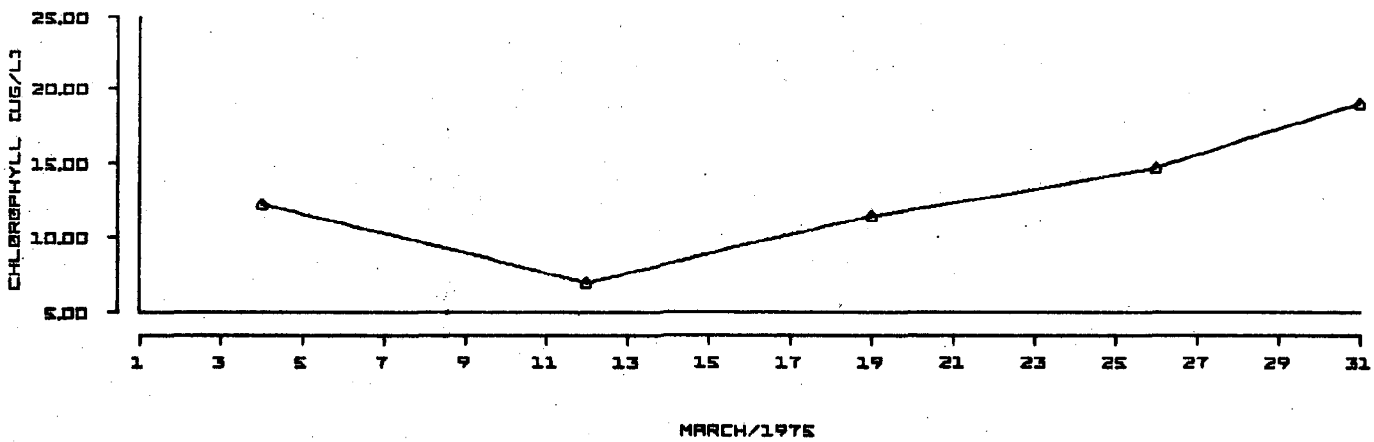
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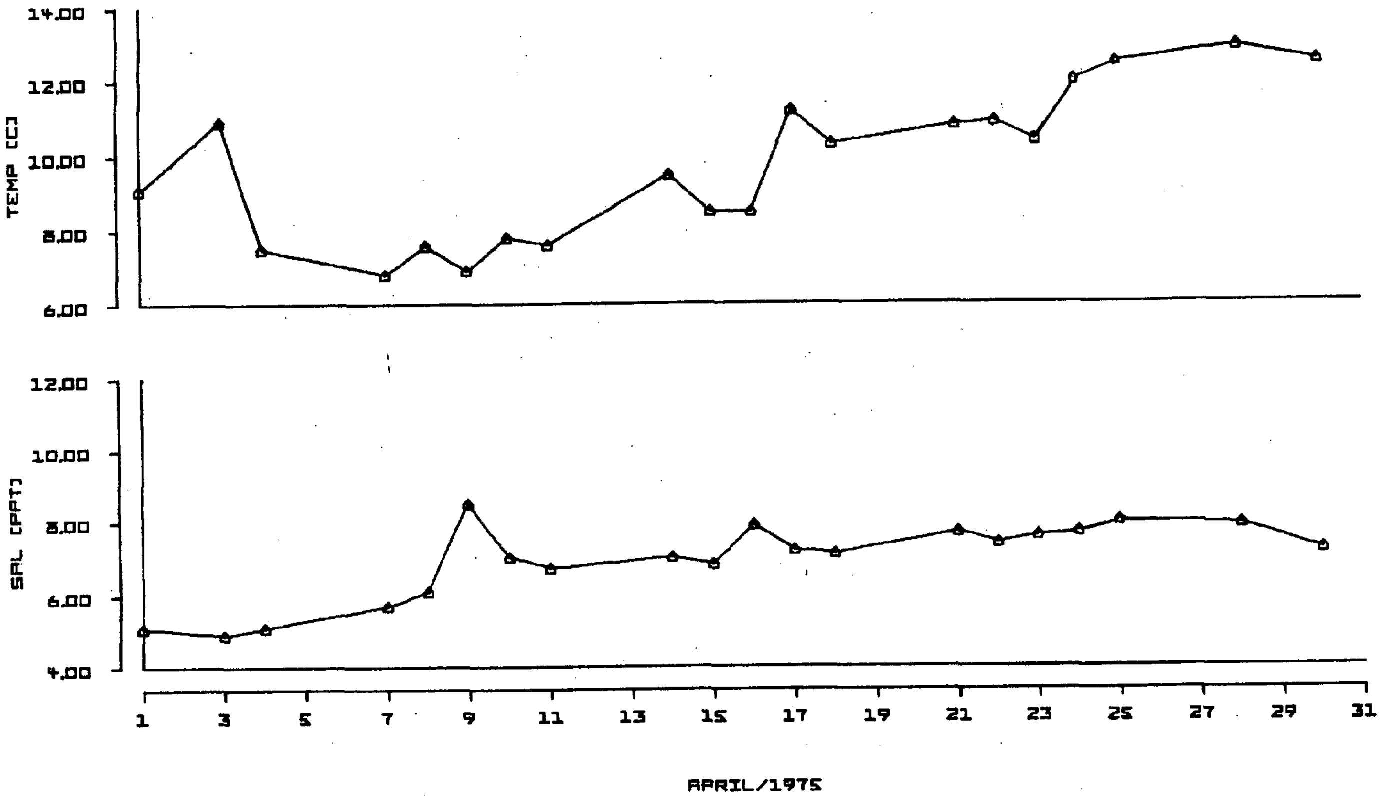

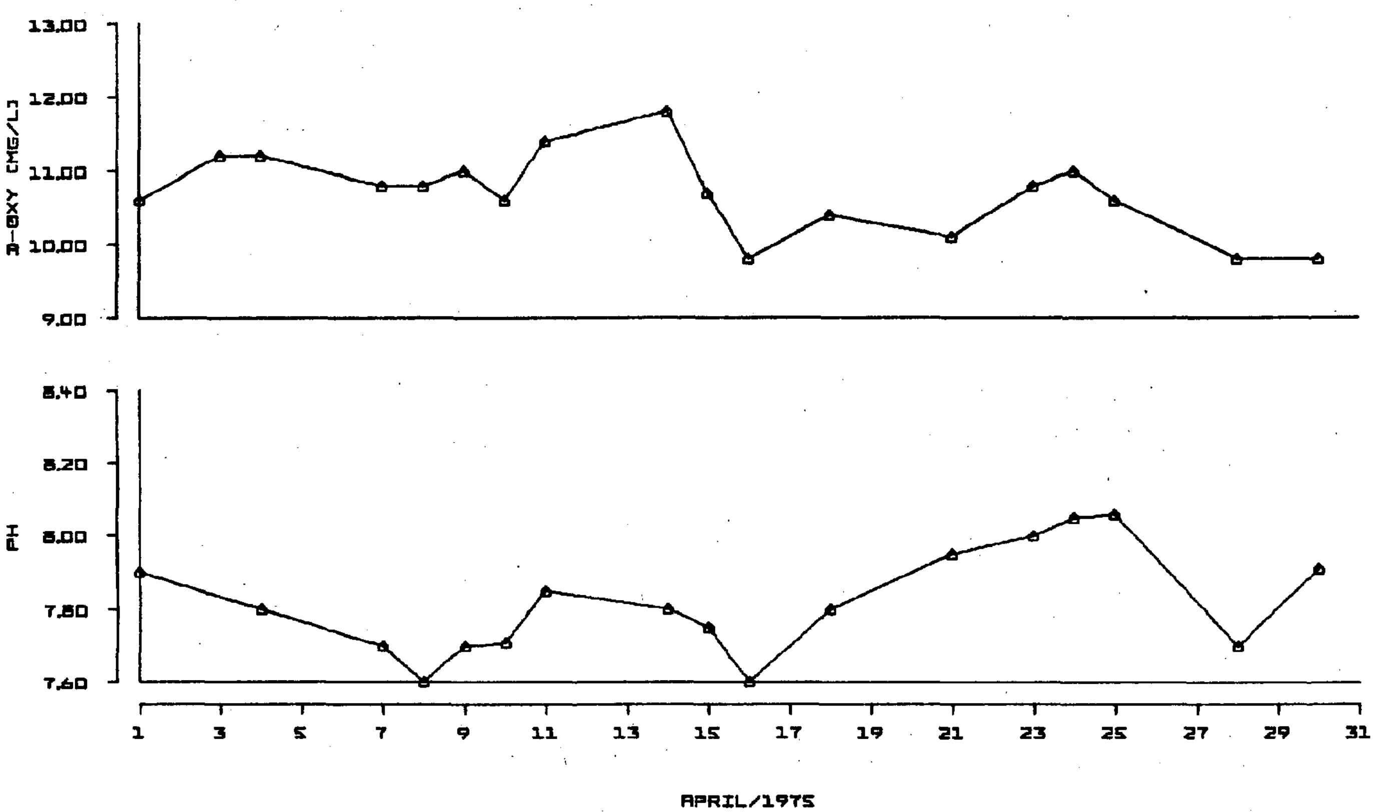

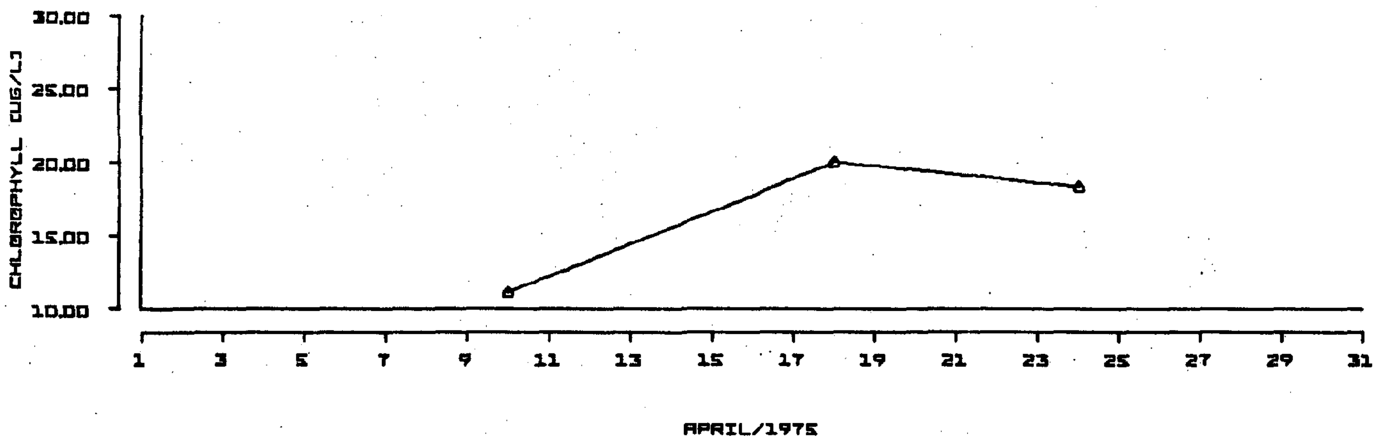

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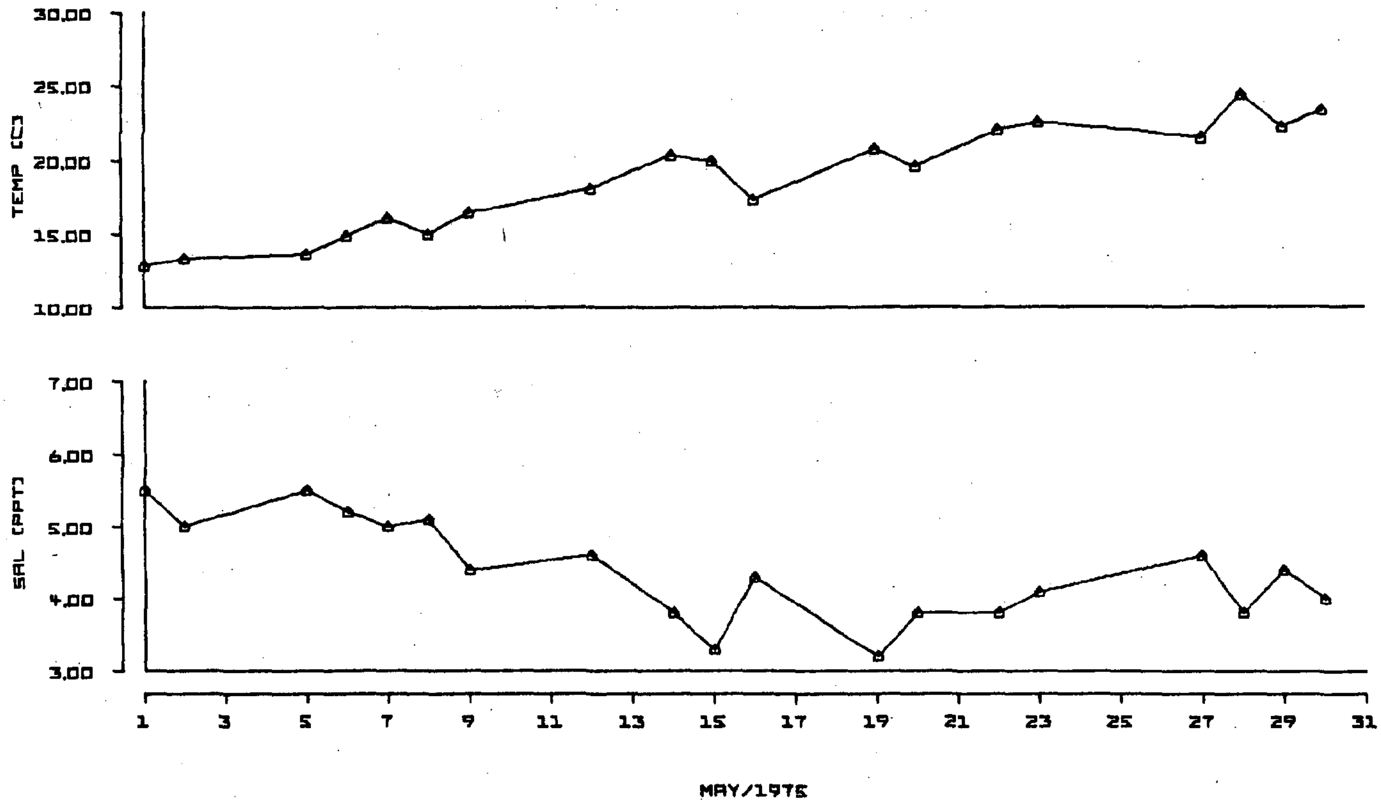

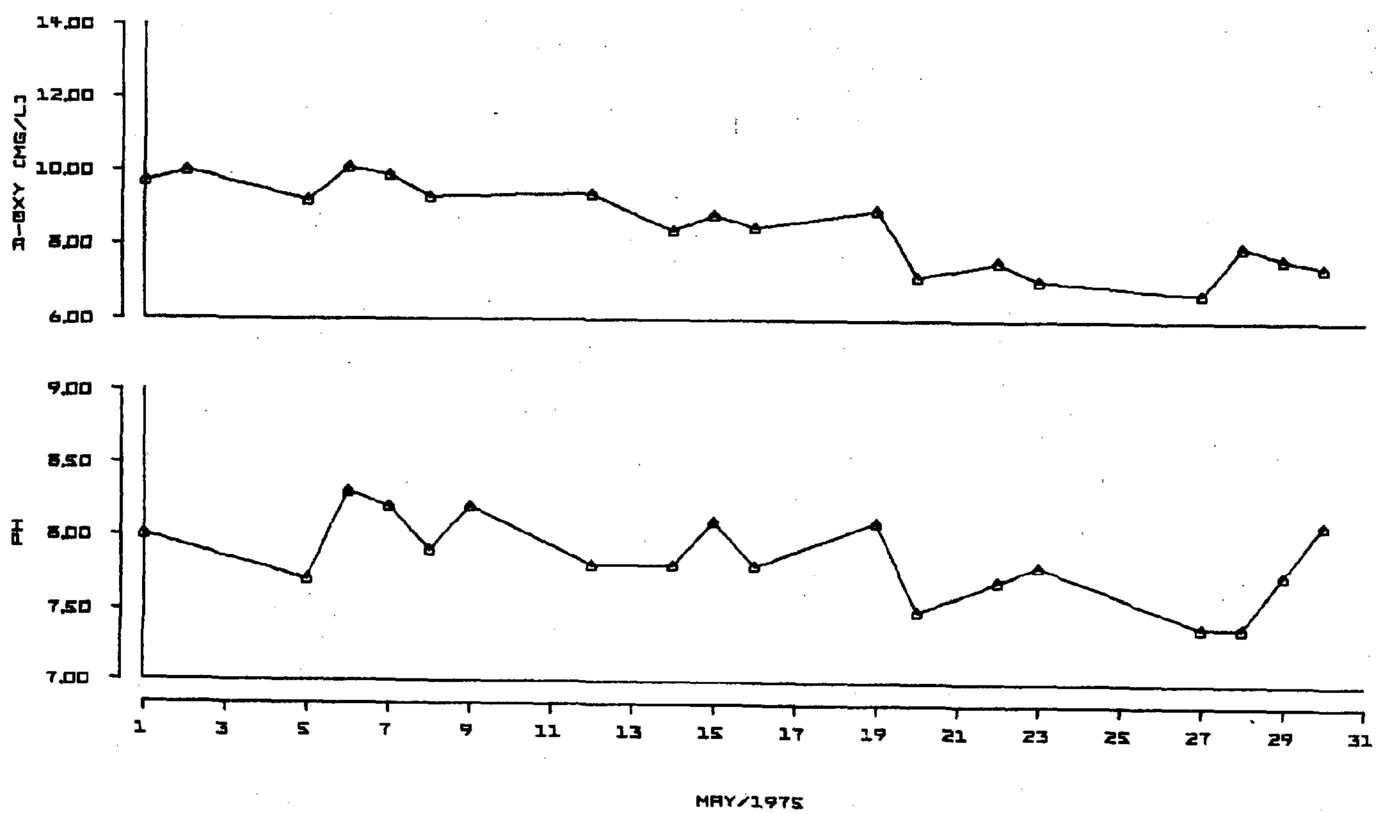

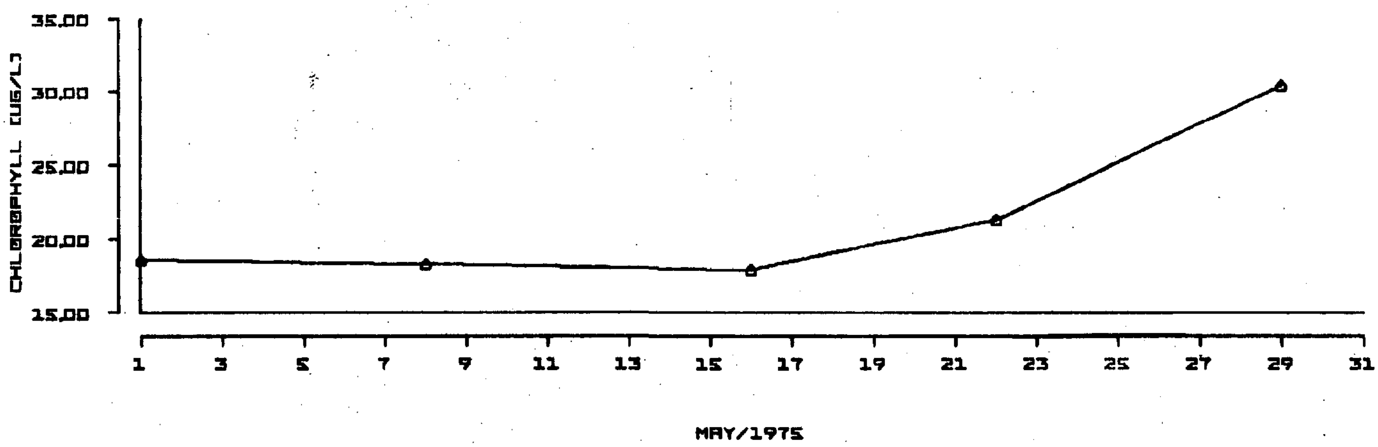
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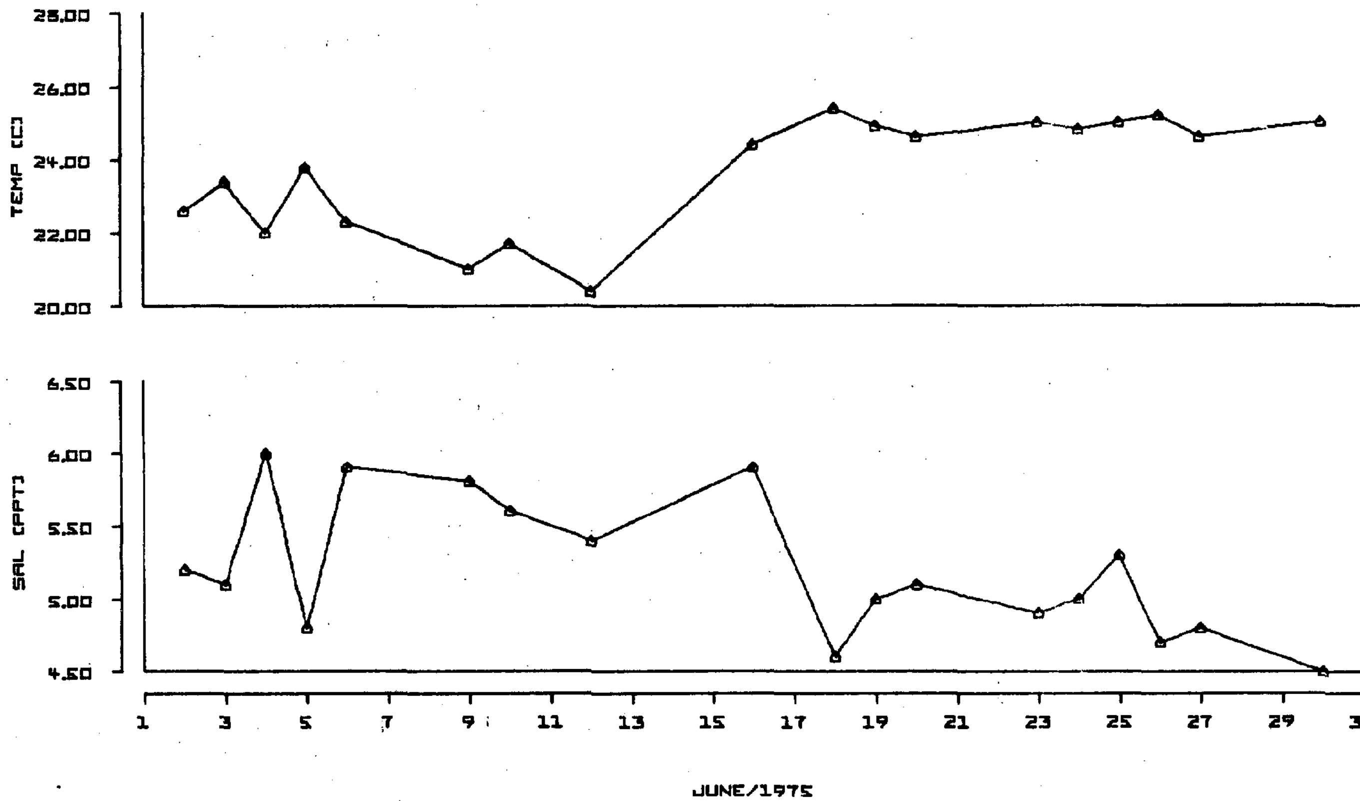

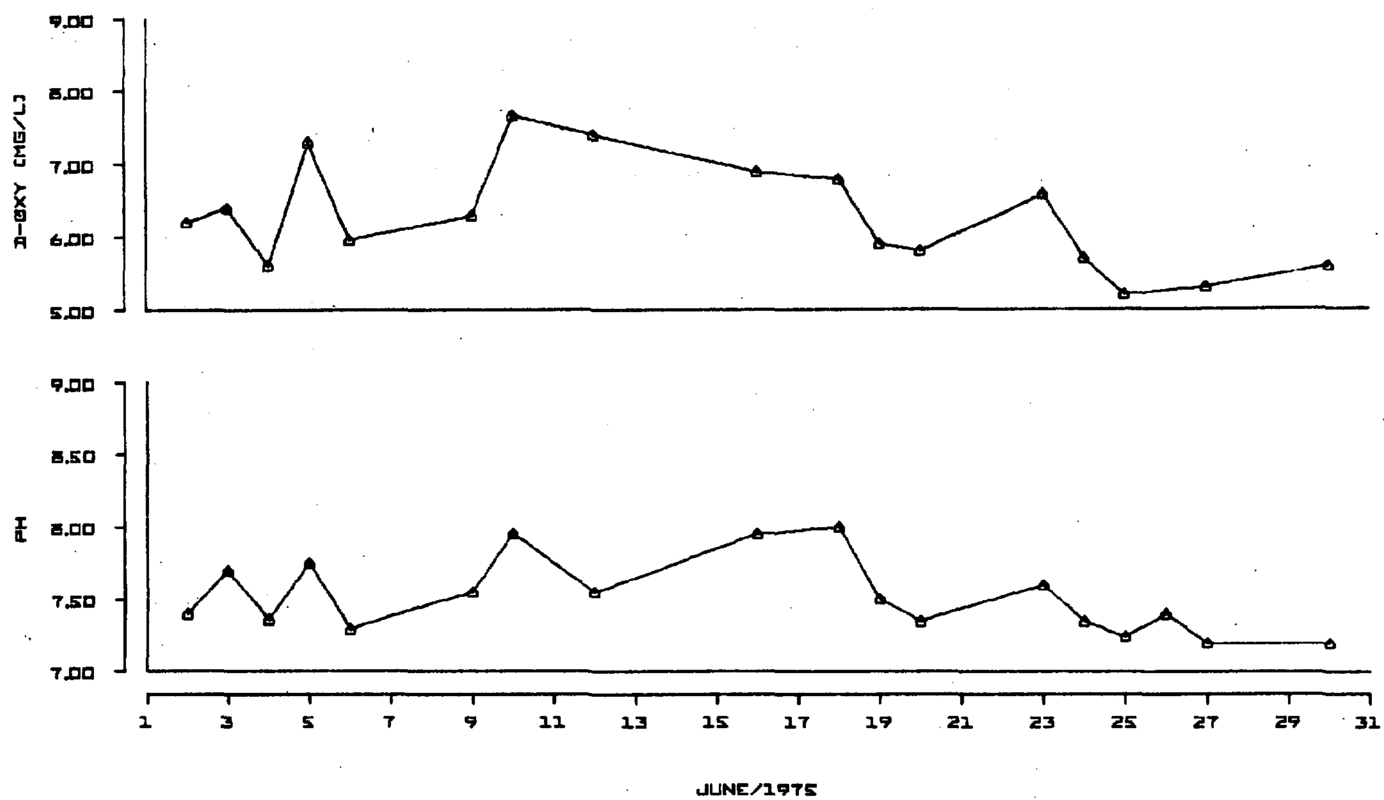

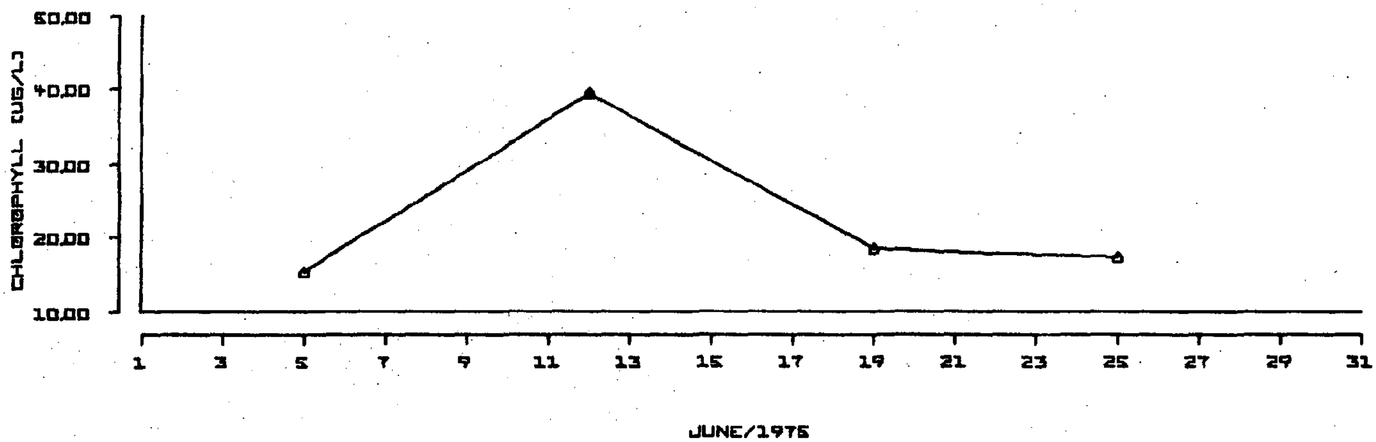
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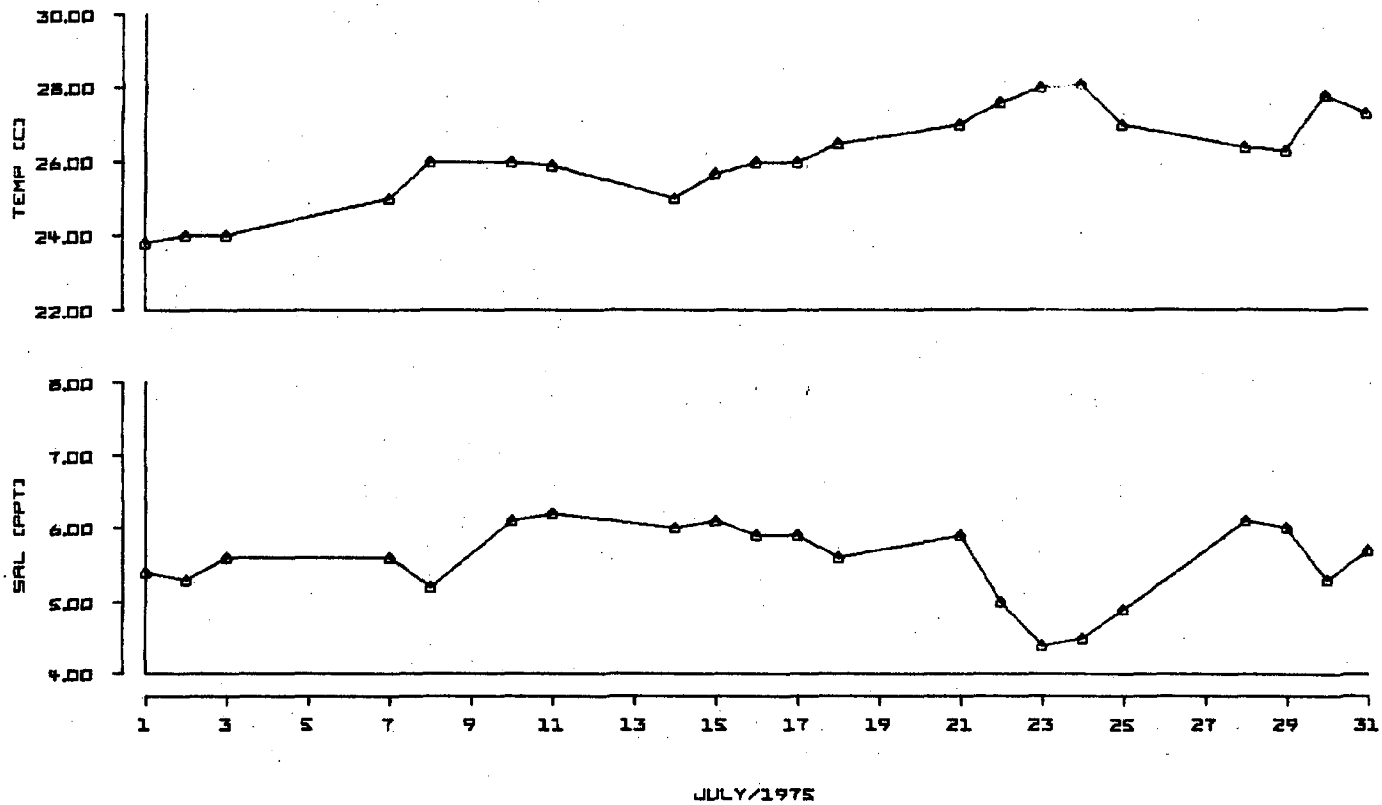

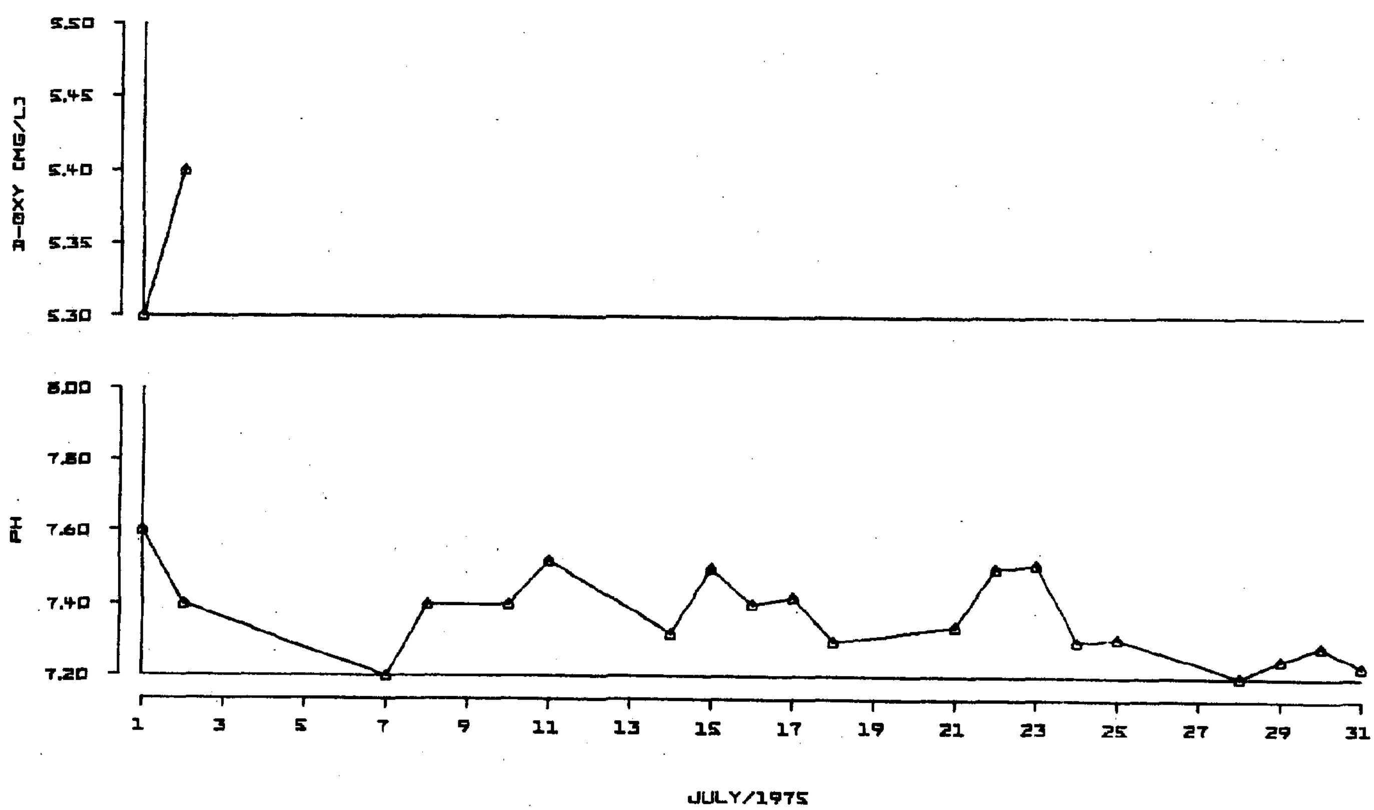

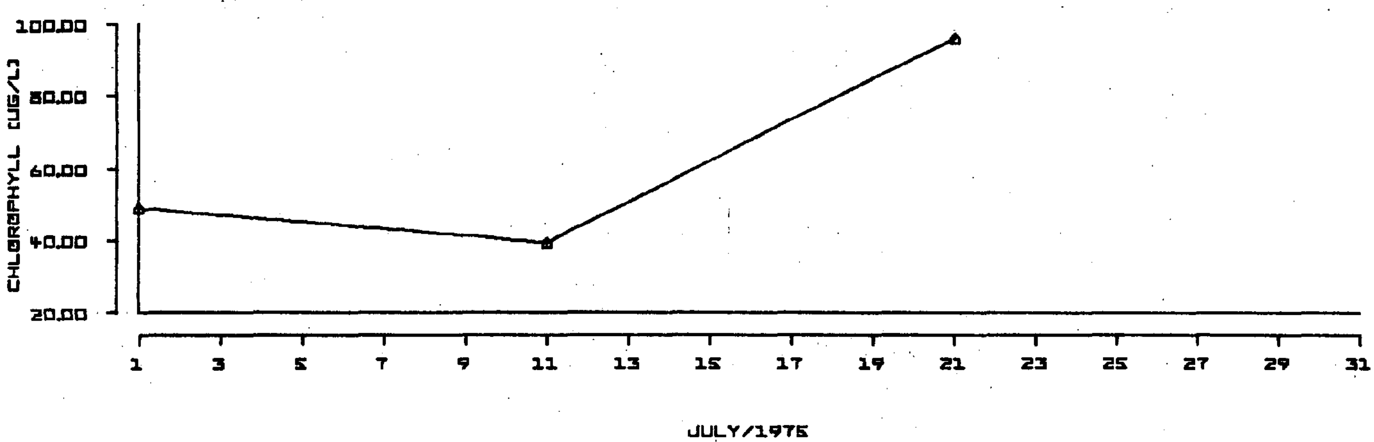
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SECTION FOUR:

IMPACT OF DREDGE SPOIL DISPOSAL OPERATIONS AT KENT ISLAND ON EXISTING STOCKS OF COMMERCIALLY IMPORTANT SHELLFISH AND PREDOMINATE BENTHIC ORGANISMS

DR. GEORGE E. KRANTZ
PRINCIPAL INVESTIGATOR

TECHNICAL ASSISTANCE

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David Boone
Phyllis Pulles
Martin O'Berry
William Keefe
Clellan Keffe
Michael Reusing

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INTRODUCTION

"Open-water" disposal of spoil materials from the approaches to the Baltimore Harbor on a new disposal site adjacent to Kent Island aroused the social and scientific curiosity of many sectors of our State community and agencies involved in the management of our natural resources. The potential dispersal of the spoil material from this site could have threatened the health and well being of commercially viable shellfish beds and the estuarine benthic community in adjacent waters. The scientific literature has only a few studies of open-water spoil disposal by hopper dredges which indicate that about 90-99% of the spoil material of high silt content will be deposited "on-site" where as the remainder will spread outward over an increased area delineated by about 30% of the site depth, (Gorden, 1974). Dispersal of turbidity discharged into surface waters is often more extensive. Biggs (1970) described increased turbidity from a point surface discharge which covered 1.5 to 1.9 square miles and a tide related plume that carried increased turbidity 3.1 miles from the disposal site.

The bottom topography, tides and wind-borne currents of every disposal site are different. Spoil materials suspended in the water column would be different for every dredged area. With all of these variables interacting, one would also expect variation in disposal patterns on a daily basis. Therefore, potential hazard of unknown and unpredictable magnitude threatened the natural resources of the

Chesapeake Bay during the Kent Island disposal operation. Three scientific research groups attempted to describe the problem by monitoring of dispersal of dredged spoils at this site and the impact of the disposal operation on experimentally exposed and natural stocks of shellfish. Even though the modest budget permitted only cursory evaluation of the existing situation instead of a comprehensive scientific approach which could have yielded results with predictive value, observations that were made confirmed that the 1975 spoil disposal operation at Kent Island had a minimal impact on the commercially important shellfish resources of the Chesapeake Bay.

Two concurrent investigations (CBI and Westinghouse) concentrated on dispersal of suspended sediments from the disposal site, the volume and location of deposited material, and the effect of the sediments upon laboratory conditioned animals exposed directly to the suspended materials as they were swept from the disposal site to the exposure stations. Exposure stations for shellfish were adjacent to the spoil disposal site and thought to be representative of natural shellfish beds. All groups hoped to measure subtle biological and physical modifications of the Bay bottom that could be used in the future as an index of impact of this type of disposal operation on the estuarine community.

The monitoring project contracted to UMCEES and reported in the following pages attempted: (1) to describe any increased level of turbidity on commercially important shellfish beds east of the disposal site as a result of the disposal operations and (2) to determine the health and "well-being" of shellfish and benthic organisms in areas adjacent to the disposal site.

Funds were not adequate to permit continuous monitoring during disposal operations nor were funds adequate to develop statistically valid analyses of changes in animal populations. The project did, however, provide an opportunity to use gross quantative and subjective observational techniques to assess the impact of the spoil disposal operation on local shellfish resources and the benthic community. These techniques were expected to detect any catastrophic environmental change by estimating population mortality, health of shellfish and benthic animals, pathobiology of these animals, and uptake of heavy metals by shellfish. Major changes in the health and/or density of estuarine animals are the primary factors which can provoke public criticism of the disposal project. The monitoring program as conducted was to detect gross changes in the benthic animals. An important part of the contract was the flexibility to fully investigate any unusual phenonemon, and even advise DNR to cease spoil disposal operations if necessary to protect both the public interest in the dredging operation and the Bay environment.

The project study area included the disposal site, Westinghouse exposure sites (East and West), benthic communities inshore of the disposal site, and commercial soft clam beds and oyster bars located from Swan Point (6 miles North from the disposal site) to Kentmoor Marina, 6.1 miles South of the site. Observations were made as outlined in the work statement which accompanied the project proposal (Attached, Appendix I). Adverse weather conditions during the study period caused only minor modifications to the plan of observations. "On-site" surveys by UMCEES personnel were conducted on:

Feb. 18-20	(before operations)
Feb. 27	(during operations)
March 4	(during operations)
March 14	(during operations)
March 19-21	(post-operations 1-3 days)
March 25	(State Health Department samples)
April 15	(post-operation; 30 days)
May 19 and 21	(post-operation; 60 days)
June 25	(post-operation; 90 days)
July 28	
August 21	
September 30	

TECHNIQUES AND OBSERVATIONS

The report of this project is conveniently divided by the types of observations used to monitor the changes in the water quality and in the health of the local benthic community as a result of the spoil disposal operation.

STUDY AREA

A recording fathometer and existing survey charts were used to locate and delineate the extent of shellfish beds and bottom types adjacent to the disposal site. The area studied extended from Swan Point to Kentmore Marina (Map 1). Samples of benthic biota were collected with a Van Veen grab, oyster dredge, and/or a hydraulic escalator soft clam dredge as appropriate for the type of bottom. Six oyster bars, 5 clam beds and 6 benthic community sites were selected for study (Map 1). An effort was made to place these stations in possible paths of spoil disposal from the discharge site. Most stations also corresponded to active commercial shellfish harvest areas and State Health Department water quality monitoring stations. A general description and location of these stations is found in Appendix II.

WATER QUALITY

Temperature and salinity were recorded at intervals throughout the water column at each site by use of a Beckman salinometer. Turbidity or more accurately suspended materials (silt, bacteria, phytoplankton, zooplankton), was determined gravimetrically following filtration of water by use of fiberglass filters. Some investigators (Biggs, 1970) refer to this as seston.

A submersible pump lowered to selected depths obtained water samples for analyses. A measured volume of the sample (250 ml under conditions of ambient turbidity) was vacuum filtered through pre-weighed fiberglass filter pads of 1 micron pore size. (Whatman GF/S; special order). Two filters containing suspended material from a sample from each depth at the stations were stored in separate petri dishes, dried in a silica gel dessicator at 28°C, and weighed to the nearest 0.1 milligram. Variation in weight of filters within each package should be documented since it represents some variation among stations and among different depths at a given station.

Standard deviations for fiberglass filters used in the study.

Date	S D
18-19 Feb	8.5
27 Feb	8.1
4 Mar	10.5
14 Mar	4.4
21 Mar	7.2
15 April	7.5
19 May	7.0

During each visit while disposal operations occurred, (27 Feb, 4 March, 14 March), an effort was made to sample the water column at the disposal site (BB-1) within an hour after the dredge discharged. Adjacent stations-North (BB-5), South (BB-6), and East (BB-2) of the discharge site were sampled at this time to determine what levels of turbidity were generated in various water masses so that observations of turbidity over commercially important shellfish beds could be related to this "maximum" condition.

Observations of temperature, salinity and quantity of suspended materials in the water column are given by station and date in

Appendix III. These data are also summarized on Maps 2 through 17. The maps indicate "turbidity" on the surface and bottom of the water column during each site visit.

OYSTER BARS

At stations where oyster bars were located, samples were obtained by a 4 minute dredge "haul". Enough shell and live oysters for a standard ½ bushel, bar-composition analysis were collected. Techniques for analysis of oysters and associated organisms were as currently used by the Department of Natural Resources. A bar composition yield sheet (Appendix IV) was completed for each station. Oyster condition, gross signs of health, presence of crystalline style and density of Polydora was determined on 5 oysters thought to represent market-size oysters on the sample. A representative sample of 25 oysters was processed for histopathology. A summary of oyster bar composition by station and date found in Appendix IV was prepared from the Field Data sheets.

SOFT CLAM BEDS

"Beds" of soft clams Mya arenaria, were located and examined by use of a local, commercial "clammer". A hydraulic escalator dredge of commercial design was used to dig the bottom in the usual manner. Several bushels of clams were collected at each site and counts were made on the number of weak or moribund clams per bushel harvested (Appendix II). Handling several hundred clams also presented the opportunity to observe the gross signs of health of the animals and provided animals for heavy metal and histopathological analyses. During surveys while disposal operations were being conducted, the clam beds were sampled by Van Veen grab and a modified hard clam dredge with long teeth and a small mesh bag.

BENTHIC COMMUNITY

At stations where the benthic community was monitored, (BB and CB series) duplicate samples of the bottom sediments were collected with a 0.1 meter Van Veen grab. The bottom material contained in the grab was placed on a 0.7 mm mesh opening screen and washed on board the research vessel. The residual material with specimens was flushed into plastic jars and fixed with 10% formalin. Approximately 3 days later the formalin was replaced with 70% ethyl alcohol. This material was further washed in the laboratory and the entire sample was examined for benthic organisms. After sorting, the specimens were placed in vials and preserved again in alcohol for future identification and enumeration. A summary of the number of all species found at each station during each particular sampling period is recorded in Table 1. Records of individual stations on various dates may be found in Appendix V.

TABLE I

Kent Island Spoil Disposal Monitoring

Benthic Species Diversity

<u>Total Number Individuals</u>

Number of Species

Station Code	Date 2/19/75	3/21/75	4/16/75	5/20/75
BB1	5840 / 14	30 / 3	5095 / 12	3560 / 14
BB2	1731 / 17	8090 / 16	3035 / 15	2365 / 11
BB3	5300 / 19	3035 / 13	13220 / 19	4810 / 18
BB4	4840 / 19	6512 / 16	3400 / 17	4840 / 16
BB5	5880 / 17	3795 / 14	3665 / 17	2775 / 13
BB6	2800 / 14	10265 / 20	1599 / 13	3450 / 15
CB-1	840 / 17	3430 / 18	1045 / 14	2770 / 16
CB-2	2000 / 15	2540 / 16	940 / 9	1825 / 16
CB-3	18045 / 14	3025 / 17	5925 / 22	18370 / 17

HEAVY METALS IN SHELLFISH

Oysters for determination of heavy metal levels in the tissue were taken from those in the bar composition analysis.

Quantitative analyses for the presence of heavy metals in shellfish were conducted by Mr. Dave Boon at the University of Maryland Seafood Technology Laboratory at Crisfield. The nitric acid digestion technique and subsequent analysis on a Perkin Elmer 290 atomic absorption spectrophotometer required the use of pooled samples to yield 100 grams (wet weight) of tissue. Details of lab procedures for sample preparation and analysis may be obtained from Boon, 1973. Assays were conducted to detect copper, zinc, iron, cadmium, manganese, lead, cobalt, nickel, chromium, and mercury. Levels of copper, zinc, iron and manganese in the shellfish fell within the range of accuracy of the techniques and procedures used. Levels of lead, cobalt, nickel, chromium, cadmium, and especially mercury fell below scientifically acceptable limits of accurate quantitative determination by the above techniques and equipment. The investigators chose not to apply concentration techniques to determine low levels of heavy metals since a voluminous literature exists to show that this approach may produce erratic and misleading results.

Since data on tissue levels of heavy metals were obtained from pools of several animals, wide range of variation was found among pools from the same station (Appendix V). Comparable levels of variation were noted among individual shellfish. Table 2 gives some measure of the amount of variation in metal concentrations

TABLE 2

HEAVY METAL CONCENTRATIONS

VARIATION IN 10 INDIVIDUAL ANIMALS

COLLECTED 20 FEBRUARY 1975

PRE-DISPOSAL CONCENTRATIONS IN ppm DRY WEIGHT

	Hi Conc	Lo Conc	Average Conc	S.D.
OYSTERS (OB3)				
Cd	22	11	16	11
Mn	29	7	12	20
Zn	12,000	1,740	9,200	10,000
Fe	230	130	160	90
Cu	650	90	425	540
OYSTERS (BB4)				
Cd	22	13	18	9
Mn	22	6	11	17
Zn	19,500	4,200	13,400	12,600
Fe	227	120	160	100
Cu	767	142	550	510
SOFT SHELL CLAM (BB3)				
Mn	1,900	250	1,140	1,420
Zn	187	95	146	103
Fe	1,700	800	1,300	1,000
Cu	61	38	47	20

among individual animals. Results of some of the analyses for heavy metal concentrations in oysters, soft clams, and Rangia clams collected before spoil disposal operation (20 February), immediately after the operation ceased (29 March), and after 30 and 60 days are summarized on a dry weight basis in Table 3 through 18 and details of each sample on a wet weight basis are shown in Appendix V. The standard deviation of metal concentrations equals or exceeds the mean of most of the metals found in oysters from the selected stations. Expression of heavy metal concentration on a wet weight basis increased variation among samples because of the added variable of individual variation in percent solid concentration interacting with animal size! To assist in interpretation of metal levels in shellfish from the Kent Island area, Tables 19-20 summarize some data on levels of metals found in oysters and shellfish throughout the coastal waters of the United States (Pringle, 1968).

TABLE 3

CONCENTRATIONS OF COPPER IN OYSTERS
(ppm wet weight) COLLECTED DURING
1975 KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19		AVERAGE
OB 1	48.3	45.2	55.9	36.4	———	46.5
OB 2	49.2	67.8	52.4	53.0	———	55.6
OB 3	46.6	54.6	42.8	52.3	———	49.1
OB 4	63.9	67.4	65.0	75.9	———	68.1
OB 5	40.3	55.4	69.3	75.1	———	60.0
OB 6	63.2	94.0	37.0	72.3	———	66.6
BB 4	74.6	66.7	-	-	———	70.7
AVERAGE	55.2	64.4	53.7	60.8	———	———

TABLE 4

CONCENTRATIONS OF ZINC IN OYSTERS
(ppm wet weight) COLLECTED DURING
1975 KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19		AVERAGE
OB 1	1230	940	1610	1060		1210
OB 2	1490	1720	1340	1360		1478
OB 3	1230	1270	1080	1400		1245
OB 4	1560	1470	1480	1390		1475
OB 5	1005	1230	1610	1730		1394
OB 6	1230	1510	720	1410		1218
BB 4	2090	1640	-	-		1865
AVERAGE	1405	1397	1307	1392		

TABLE 5

CONCENTRATIONS OF CADMIUM IN OYSTERS
(ppm wet weight) COLLECTED DURING
1975 KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19		AVERAGE
OB 1	1.9	1.7	2.3	1.8		1.9
OB 2	2.3	2.6	2.6	1.6		2.3
OB 3	2.8	2.0	1.6	2.9		2.3
OB 4	2.7	2.4	2.1	2.2		2.4
OB 5	2.9	2.9	3.3	3.0		3.0
OB 6	2.8	2.4	2.6	2.5		2.6
BB 4	3.3	2.5	-	-		2.9
AVERAGE	2.7	2.4	2.4	2.3		

TABLE 6

CONCENTRATIONS OF IRON IN OYSTERS
(ppm wet weight) COLLECTED DURING
1975 KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19		AVERAGE
OB 1	25.1	15.9	28.6	22.9		23.1
OB 2	18.8	24.0	22.1	22.5		21.9
OB 3	24.4	27.1	23.5	44.5		29.9
OB 4	27.7	24.7	46.0	121.3*		32.8
OB 5	18.6	22.2	18.9	27.9		21.9
OB 6	17.4	19.8	11.4	19.3		17.0
BB 4	18.4	25.8	-	-		22.1
AVERAGE	21.5	22.8	25.1	27.4		

* = Data not used in calculation of average

TABLE 7

CONCENTRATIONS OF MANGANESE IN OYSTERS
(ppm wet weight) COLLECTED DURING
1975 KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19		AVERAGE
OB 1	1.7	1.2	1.6	1.3		1.4
OB 2	2.9	1.4	1.7	1.7		1.9
OB 3	2.3	2.5	2.0	4.0		2.7
OB 4	2.9	2.3	3.7	9.6*		2.9
OB 5	1.5	2.0	1.3	2.8		1.9
OB 6	2.6	2.5	1.3	1.8		2.0
BB 4	1.5	2.2	-	-		1.8
AVERAGE	2.2	2.0	1.9	2.3		

* = Data not used in calculation of average

TABLE 8

CONCENTRATIONS OF HEAVY METALS IN OYSTERS
(ppm wet weight) THAT WERE BELOW LEVELS
FOR ACCURATE QUANTATIVE DETERMINATION

All samples were of similar concentration and below the levels shown

METAL	FEBRUARY 20	MARCH 28	APRIL 15	MAY 19
LEAD	7.3	3.5	3.9	3.6
COBALT	0.4	0.4	0.8	0.4
NICKEL	0.9	0.7	0.6	0.7
CHROMIUM	6.0	3.5	0.3	0.6
MERCURY	———	———	———	———

TABLE 9

CONCENTRATIONS OF COPPER IN SOFT-SHELLED CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 21	APRIL 18	MAY 21	AVERAGE
CB 1	No sample	9.8	11.2	10.5
CB 2	8.2	7.6	5.8	7.2
CB 3	6.1	8.3	5.1	6.5
CB 4	7.3	7.2	7.3	7.3
CB 5	7.4	7.8	--	7.6
BB 3	8.9	--	--	8.9
AVERAGE	7.6	8.1	7.4	

TABLE 10

CONCENTRATIONS OF ZINC IN SOFT-SHELLED CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 21	APRIL 18	MAY 21	AVERAGE
CB 1	No sample	30	77	54
CB 2	21	41	31	31
CB 3	38	40	38	39
CB 4	31	46	35	37
CB 5	38	45	--	42
BB 3	30	--	--	30
AVERAGE	32	40	45	

TABLE 11

CONCENTRATIONS OF IRON IN SOFT-SHELLED CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 21	APRIL 18	MAY 21	AVERAGE
CB 1	NO SAMPLE	175	422	298
CB 2	141	386	70	199
CB 3	210	194	55	153
CB 4	564	294	212	357
CB 5	742	600	--	671
BB 3	209	--	--	209
AVERAGE	373	330	190	

* = Data not used in calculation of average

TABLE 12

CONCENTRATIONS OF MANGANESE IN SOFT-SHELLED CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL STUDY

STATION CODE	FEBRUARY 21	APRIL 18	MAY 21	AVERAGE
CB 1	NO SAMPLE	42	241	142
CB 2	36	91	86	71
CB 3	108	88	111	102
CB 4	173	158	168	166
CB 5	145	171	--	158
BB 3	119	--	--	119
AVERAGE	116	110	152	

TABLE 13

CONCENTRATIONS OF HEAVY METALS IN SOFT-SHELLED CLAMS (ppm wet weight) THAT WERE BELOW LEVELS NECESSARY FOR ACCURATE QUANTATIVE DETERMINATION

All samples were below levels shown

METAL	FEBRUARY 21	APRIL 18	MAY 21
LEAD	6	6	4
COBALT	2	2	2
NICKEL	2	1	0.7
CHROMIUM	0.7	1	1
CADMIUM	0.5	0.7	0.5
MERCURY	___	___	___

TABLE 14

CONCENTRATIONS OF COPPER IN RANGIA CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL OPERATION

STATION CODE	FEBRUARY 20	APRIL 18	MAY 21
CB 1	--	--	2.0
CB 2	2.7	2.0	1.6
CB 4	--	--	2.0
BB 3	2.1	1.8	--
BB 4	9.8	--	1.5
AVERAGE	4.9	1.9	1.8

TABLE 15

CONCENTRATION OF ZINC IN RANGIA CLAMS
(ppm wet weight) COLLECTED DURING 1975
KENT ISLAND SPOIL DISPOSAL OPERATION

STATION CODE	FEBRUARY 20	APRIL 18	MAY 21
CB 1	--	--	16.5
CB 2	10	14.1	14.0
CB 4	--	--	16.4
BB 3	15	15.0	--
BB 4	67	--	12.0
AVERAGE	31	14.6	14.7

TABLE 16

CONCENTRATIONS OF IRON IN RANGIA CLAMS (ppm wet weight) COLLECTED DURING 1975 KENT ISLAND SPOIL DISPOSAL OPERATION

STATION CODE	FEBRUARY 20	APRIL 18	MAY 21
CB 1	--	--	46
CB 2	26	52	36
CB 4	--	--	86
BB 3	110	49	--
BB 4	188	--	43
AVERAGE	108	50	53

TABLE 17

CONCENTRATIONS OF MANGANESE IN RNAGIA CLAMS (ppm wet weight) COLLECTED DURING 1975 KENT ISLAND SPOIL DISPOSAL OPERATION

STATION CODE	FEBRUARY 20	APRIL 18	MAY 21
CB 1	--	--	5.7
CB 2	1.5	4.0	5.6
CB 4	--	--	7.5
BB 3	20	12	--
BB 4	28	--	4.9
AVERAGE	16	8	5.9

TABLE 18

CONCENTRATIONS OF HEAVY METALS IN RANGIA CLAMS (ppm wet weight) THAT WERE BELOW LEVELS FOR ACCURATE QUANTATIVE DETERMINATION

METALS	FEBRUARY 20	APRIL 18	MAY 21
LEAD	0	5.0	3.0
COBALT	1.1	0.7	0.7
NICKEL	1.0	3.0	2.0
CHROMIUM	0.5	0.7	0.7
CADMIUM	0.4	0.6	0.4
MERCURY	———	———	———

TABLE 19

AVERAGE TRACE METAL LEVELS IN SHELLFISH TAKEN FROM ATLANTIC COAST WATERS, IN PARTS PER MILLION OF WET WEIGHT *(FROM ENVIRONMENTAL PROTECTION AGENCY)

ELEMENT	EASTERN OYSTER	SOFT SHELL CLAM	NORTHERN QUAHAUG
ZINC	1,428	17	20.6
COPPER	91.50	5.80	2.6
MANGANESE	4.30	6.70	5.8
IRON	67.00	405	30
LEAD	0.47	0.70	0.52
COBALT	0.10	0.10	0.20
NICKEL	0,19	0.27	0.24
CHROMIUM	0.40	0.52	0.31
CADMIUM	3.10	0.27	0.19

* DRY WEIGHT APPROXIMATELY 10 to 15 TIMES THESE VALUES.

TABLE 20

RANGE OF TRACE METAL VALUES IN SHELLFISH HARVESTED FROM ATLANTIC AND PACIFIC WATERS, IN PARTS PER MILLION OF WET WEIGHT* (FROM ENVIRONMENTAL PROTECTION AGENCY)

ELEMENT	OYSTERS EAST COAST	OYSTERS WEST COAST	SHOFT SHELL CLAM	NORTHERN QUAHAUG
ZINC	180. - 4120.	86. - 344.	9.0 - 28.	11.50 - 40.20
COPPER	7.0 - 517	7.80 - 37.50	1.20 - 90.	1.0 - 16.50
MANGANESE	0.14 - 15.0	0.90 16.	0.10 - 29.90	0.7 - 29.70
IRON	31. - 238	15.30 - 91.40	49.70 - 1710	9.0 - 83.0
LEAD	0.10 - 2.30	0.10 4.50	0.10 - 10.20	0.10 - 7.50
CHROMIUM	0.04 - 3.40	0.10 - 0.30	0.10 - 5.0	0.19 - 5.80
NICKEL	0.08 - 1.80	0.10 - 0.20	0.10 - 2.30	0.10 - 2.40
COBALT	0.06 - 0.20	0.10 - 0.20	0.10 - 0.20	0.10 - 0.20
CADMIUM	0.10 - 7.80	0.20 - 2.10	0.10 - 0.90	0.10 - 0.73

*NOTE: DRY WEIGHT APPROXIMATELY 10 to 15 TIMES THESE VALUES

SHELLFISH PATHOBIOLOGY

Health of the shellfish and benthos was monitored during each site visit by visually inspecting the animals for gross signs of disease or weakness. In oysters these signs are firmness of shells, gapping, mantle response, meat condition and appearance, and presence of crystalline style; in soft clams and in *Rangia*, firmness of the siphon, ability to retract siphon, mantle response, meat condition and appearance. To confirm these subjective field evaluations, histopathologic analyses of oysters taken from each station on 19 March, 15 April, 19 May and September. Laboratory processing and initial histopathologic analyses were conducted at the Oxford Biological Laboratory by DNR personnel assigned to the 88-309 project - Pathobiology of Estuarine Animals. Many materials from this project are still being processed and studied.

Throughout the study, oysters from stations OB-3 North through OB-6 were in a weakened condition below acceptable levels for market use. These animals had many gross signs of fresh water stress and had a poor meat condition but a high percentage retained the crystalline style (see Bar Composition analysis summary). Histopathologic analysis of tissue and cellular changes suggest a combination of fresh water stress and "winter-kill" syndrome. Noteworthy syndromes observed in the March sample are:

(1) Expanded ducts in the diverticulum; (2) Eroded diverticulum; (3) Increased deposition of "yellow-waste" masses; (4) Reduced levels of food reserves.

Soft shelled clams at the 4 stations studied remained in good to excellent physical condition throughout the study. None of the stations showed any changes in the number of moribund or weak clams. The two commercially active clam beds CB-1 and CB-2 contained a few moribund clams as a result of commercial harvest activity.

Rangia clams were the most abundant animal throughout all study stations, especially on the soft clam beds. Estimates of abundance were not made but as the study progressed, mortality in *Rangia* increased. Estimates of percent mortality were made on samples obtained by Van Veen grab, hydraulic escalator dredge and modified hard clam dredge. As mortality became pronounced (25%), samples of *Rangia* populations in other areas of the Bay were collected and examined to determine the cause of the "die-off". These data will be an addendum to this report.

DISCUSSION AND CONCLUSIONS

WATER QUALITY

Water quality conditions (temperature, salinity and suspended material) at the Kent Island disposal site prior to disposal (19 February; Maps 2 and 3) were representative of winter conditions in the Upper Chesapeake Bay. Salinity was slightly higher than expected above the Chesapeake Bay Bridge. An unexplained but obvious increased amount of turbidity was observed in the deeper water masses over the dump site sample stations (Map 2; BB-1; BB-5; BB-6; BB-2; and Appendix III), before disposal operations began. The source and distribution of this turbid water mass is not known but a perceptable increase in turbidity was also found at Swan Point, OB-6, which suggests an Upper Bay origin. The same magnitude of increased turbidity (by comparison to surface waters at adjacent stations) was observed in deeper water over the dump site on all visits. In several instances this layer of increased turbidity existed prior to discharge of spoil from the hopper dredge. When water samples were taken within 1 to 2 hours after the discharge of spoil on the disposal site, turbidity increased over levels observed at the same water depth before disposal. Stations on Maps 2-5 with turbidity thought to originate solely from disposal operations are marked with an asterisk. These stations were BB-1 and BB-6 (Map 6); BB-1, BB-5, BB-6 (Map 8) and BB-1 and BB-6 (Map 10). Stations east of the disposal site and stations on commercially important shellfish beds were not observed to have any increase in suspended materials that could be directly attributed to the spoil disposal operation. Apparently the suspended material from the spoil disposal operation was restricted to the deeper waters (greater than 30 feet) in the immediate vicinity of the disposal site. Extensive measurements by other investigators of turbidity at the disposal site support this conclusion. Personal observation of surface waters and photographic records of the Dredge Essayons also support the research findings. During spoil discharge from the dredge, turbidity in surface waters was quickly lost in the relatively high background turbidity which persisted throughout the disposal operation.

Two natural phenomena contributed to high levels of turbidity throughout the Upper Bay region during the spoil disposal operation. Wind direction, velocity, and duration was such that large quantities of silt from inshore areas of the Upper Bay from the Susquehanna Flats were continuously resuspended in the water column. To help document the effect of wind, all of the summary maps of water quality observations show wind velocity and direction since turbidity over shellfish beds was increased by strong south-west or north-west winds which create strong wave action on the shallow areas of the Upper Bay. This phenomenon was very obvious from aerial overflights and even from the center of the Bay Bridge. The second phenomena was an extremely high discharge of turbid, cold, fresh water from the Susquehanna River. These two factors collectively created high levels of turbidity, high bacteria concentrations in the water, and an unusual temperature and salinity regime over the disposal site throughout the period the "Essayons" operated.

Data presented by the other investigators on the discharge and water quality from the Susquehanna River and the Maps 2-15 suggest the extent of the impact of the water mass on the ecology of the Upper Bay. Peak discharge at the Susquehanna Dam on 26-28 February approximated the 10-year maximum. This high-flow period was followed by a second significant discharge in late March. These cold fresh water masses which contained high levels of suspended sediments displaced the Bay water at all depths in the water column over the disposal site (Map 2). On February 27, a distinct line of demarkation could be seen on the surface between water of 4 ppt salinity and the fresher water. Stations CB-1; BB-3; BB-4; CB-3; OB-2)B-1, (Map 4) were covered with water of higher salinity with a lower silt load. These observations help to understand why marked changes on bacterial quality and health of shellfish have been observed in the vicinity of the Bay Bridge in the past.

By the next survey visit following the influx of water from the Susquehanna (4 March), the low salinity, highly turbid water mass covered all stations except Gum Thicket oyster bar, OB-1 (Maps 6-7). Gum Thicket-Kentmore Marina area has often been the dividing line for State Public Health closures of soft clam beds. Even though data collected by this study are sparce and superficial, they help explain some of the basic problems in the management of shellfish in the vicinity of Kent Island.

Elevated levels of turbidity in deeper waters over the disposal site were still detected about 30 days after disposal operations ceased (Map 14). These increased levels may have resulted from resuspended dredged spoils, but caution must be exercised in reaching this conclusion since elevated levels of suspended materials of approximately the same magnitude were detected at these stations (Map 2, February 19) prior to dredging operations. This conflict in observations shows the need for a greater understanding of sediment transport mechanisms in the Upper Bay so that the effect of open water spoil disposal on the total Bay environment may be clearly understood and any negative man-induced effect can be detected.

The physical characteristics of the water mass over the shellfish resources at Kent Island during February and March suggest that soft shelled clams, oysters, and perhaps the total benthic community suffered an insult that could have resulted in mass-mortality. Cold, fresh water of poor quality and high bacterial levels caused a decline in meat quality. Commercial harvest of shellfish could have been restricted! Without documentation by the contracted monitoring programs, the public would have blamed the spoil disposal operation for the loss of the natural resources. Fortunately, probably due to low water temperatures and the reduced activity of shellfish during the winter conditions, such a disaster did not occur. The effects of an inflow of fresh, turbid water from the Susquehanna River during summer months may have an entirely different effect on the health of shellfish. Monitoring programs designed to evaluate environment parameters and health of the Bay biota during spoil disposal operations can make a valuable contribution by separating natural environmental effects from the effects of the deposited spoil.

SHELLFISH

Because of an anticipated loss of shellfish and biota due to the influx of cold, fresh water, oyster bars and soft clam beds received thorough analyses to detect any mortality, assess the health of shellfish and document uptake of heavy metals. The standard oyster bar composition analysis used by DNR and other agencies provided "semi quantative" estimates of changes in the oyster population and associated benthos. During the predisposal survey an extensive effort was made to locate oyster bars representative of where commercial harvest occurs in the Kent Island area. Oysters, even on charted bars and previously planted areas, were at very low density. Throughout the Upper Bay and at 4 out of the 6 oyster sample areas, oysters were below densities that could support a commercial fishery. This observation is supported by the number of 4-minute dredge hauls needed to collect one-half of a bushel of shell (Appendix II). Most bars have been worked heavily and there has been virtually no recruitment for years. Few bars have any small oysters. Oysters north of the Chesapeake Bay Bridge have very poor meat condition and if harvested they would not have been accepted by processors. Organisms fouling oyster shell and the associated benthos in this area suggests that oysters on all bars except OB-1 have experienced periodic intrusions of low salinity water or some extreme environmental stress.

The oyster bar composition analyses summaries (Appendix IV) indicate that no oyster mortality occurred during and immediately after the spoil disposal operation. Presence of the crystalline style and a general increase in meat condition during late March and April throughout the study area, except for Swan Point (OB-6), substantiate the lack of damage to existing oyster bars. Oysters and mussels at Station OB-5 (Mouth of the Chester River) may have suffered some stress agent. This was suggested by the decrease in the number of oysters with crystalline styles and the observed dead barnicles (Balanus) on 15 April. This condition may have been related to prolonged exposure to the low salinity and highly turbid flow from the Upper Bay and the Chester River. A greater number of boxes were found at this station than at the other stations. However, other factors in the Chester River may have been responsible for these changes since oyster bars in all areas of the Chester River have experienced unusually high mortality during recent years. In fact, total mortality on oyster bars exists from Chestertown to the Mouth of the Corsica River. A decline in worms was also noted on Love Point Bar OB-4, which may receive some flow of water from the Chester River. A great difference was noted in the associated organisms on oyster bars above the Bay Bridge (OB-3,4,5,6) compared to OB-1. Organisms on OB-1 are probably continuously covered by a layer of high salinity water due to the morphology of the Bay bottom at OB-1 and rarely received any exposure to low salinity water.

To confirm field observations on oyster bars and gross signs of oyster health, histopathological techniques were employed to detect probable reasons for the problems found. In samples examined to date, oysters from all stations were in various states of reduced health. Oysters at the southern end of the study area, OB-1 and OB-2, showed lower levels of abnormal response. Cellular changes in oysters at Stations OB-4,5, and 6 indicated that the oysters had experienced several months exposure to fresh water. Many of the signs of pathology also may be interpreted as "winter-kill" syndrome or chronic exposure to pesticides or other toxic material. There were no obvious signs of prolonged exposure to suspended sediments, nor were any of the 800 oysters examined in a terminal physical condition.

Laboratory analysis for concentrations of heavy metals in oysters confirmed the histopathologic interpretation. No significant change in concentrations of heavy metals in natural shellfish populations could be demonstrated. Copper concentrations were about 10 percent higher in the 19 March samples. However, this change did not exceed the limits of variation in heavy metals among oysters and among the pooled samples. (Note the high standard deviation for copper concentrations Table 2). It is probable that the observed increase in copper may be sampling procedure and/or experimental error in techniques. Subsequent samples on 15 April and 19 May confirm the opinion that the elevated copper levels may have resulted from sampling procedures. Again this is an illustration of the value of prolonged and multiple monitoring times in producing reliable assessment of impact of spoil disposal on the environment composed of heterogenous individuals and species.

Our understanding of the flux of heavy metals in the Bay biota and the physical environment also suffers from the lack of baseline studies and laboratory proven uptake rates for metals from spoils under expected environmental conditions. Without laboratory data, any investigator would be hard pressed to prove beyond a doubt that heavy metals in levels in natural shellfish did, or did not change as a result of spoil disposal operations.

BENTHOS

The lack of diversity of benthos associated with the oyster bars in the Upper Bay indicate the stress of low salinity environment and some slight differences among samples were expected. However, if any major environmental change would have occurred as a result of spoil disposal operation, the benthic community associated with an oyster bar would have suffered severe losses since these organisms do not have the oysters' capacity to stop circulating water for long periods of time. Minor changes in health of the benthos could not be detected by semi-quantitative techniques employed in this study.

An attempt was made to quantitatively examine the benthic community at all stations other than oyster bars by use of Van Veen grab samples. Observations on the diversity of species and number of individuals at various stations showed no change during the disposal operation except on the disposal site station BB-1 immediately after the disposal operation (21 March). Within thirty days benthos had repopulated the spoil site and in sixty days the spoil contained a community and density identical to surrounding Bay bottom, which was covered by at least 10 feet of spoil. No other change in benthos of any significance was detected outside of the disposal area. Slight changes in numbers of individuals found in various samples is expected due to variations in sampling techniques. The relatively sparce benthic community at adjacent sites where water depth exceeded thirty feet, is representative of the Upper Bay estuarine benthic community. This "deep-water" community apparently experiences periodic intrusions of fresh water, periods of high silt deposition from the river systems and frequent anoxic conditions.

Analyses of uptake of heavy metals by several members of the benthos was prevented by the constraints of the budget and by the requirement to analyze 100 grams of tissue from a given species. Rangia clams occurred in abundance at all sample stations regardless of depth and therefore were selected to represent a component of the benthos. Analyses of heavy metal concentrations in Rangia collected from Kent Island monitoring stations, suggest that Rangia differs from Mya and oysters in metal uptake. Rangia does not appear to concentrate copper, as do oysters, or zinc, as do soft clams. However, Rangia has higher levels of iron relative to the other two shellfish. These observations suggest the need to analyze each species of the benthic biota for uptake of heavy metals since each species may have a different mechanism and physiological need for specific metals.

RANGIA MORTALITY

Throughout the monitoring study, weak Rangia were observed at all stations. The weakened condition of this species increased from about 5% to 10% of a given sample in February to 25% to 50% in the 15 April samples. During early May, 70% to 90% of the *Rangia* at various stations died. This weakened condition was most pronounced on clam beds, CB-1 and CB-2 which were heavily worked by clam dredges during the winter. Some of the mortality on the clam beds could have been due to mechanical damage by the hydraulic escalator dredges and by burial in the newly worked bottom. However, losses of *Rangia* increased at other stations where the bottom had not been disturbed. The area of mortality extended far beyond the spoil disposal area. On April 16, areas of the Upper Chester River were sampled with a lined oyster dredge and moribund and weak *Rangia* were found. Samples of *Rangia* collected at North Point (Baltimore Harbor) and at Hart-Miller Island on April 17, contained about 10% moribund clams with about 15% weak individuals. Department of Natural Resources fishery department personnel have also reported mortality of *Rangia* in the Chester and Gunpowder Rivers. Samples of several year classes (size groups) of *Rangia* from CB-2 and CB-3 were held in the laboratory to observe the nature of the losses and to determine the total levels of expected mortality in the field. An extensive field survey of all Bay examined and histopathologic examination of moribund *Rangia* is in progress to determine the cause for this mortality.

The *Rangia* clam is adapted to southern climates (south of the Cape Hatteras zoogeographic break.) In Maryland waters, *Rangia* is near its' northern limit of tolerance to cold water and probably suffers from lack of food due to low phytoplankton densities in the Chesapeake during the winter. The population as a whole is weakened during the winter and due to variation in resistance of individuals, we observed a partial mortality. However, State management agencies should be prepared to defend the allegation that spoil disposal may have killed the Rangia adjacent to Kent Island.

A comprehensive study on the life history population dynamics and histopathology of Rangia is badly needed to relate the observed level of mortality to natural environmental factors in the Chesapeake Bay. Extensive field and laboratory studies are needed to better understand this relatively new component of the Chesapeake Bay biota. Such a study is strongly justified since Rangia is the predominate shellfish in the many areas North of the Bay Bridge which may be subject to future dredging and spoil disposal operations.

SOFT CLAMS

The population density, size, composition, meat quality and gross signs of health of soft clams in various beds adjacent to Kent Island was determined by use of a commercial hydraulic escalator dredge before (18 February) and thirty days after (15 April) the spoil disposal operation. During the spoil disposal operation (27 February, 4 March, 19 March), cursory surveys of the soft clam beds was conducted by use of the Van Veen dredge and/or a lined clam dredge. Living clams were carefully observed for signs of distress and weakness symptomatic of any adverse condition. There was no detectable change in gross signs of health of the clams or in the percentage of moribund clams in a given population at the 4 stations.

Most of the moribund soft clams found suffered damage from the hydraulic dredge. Only 3 clams were found without obvious physical damage. Apparently, soft clams were able to survive the prolonged exposure to the low salinity, highly turbid water from the Susquehanna River. Survival may be related to low water temperatures since mortality due to fresh water influx during summer months has occurred previously at this site. Being a northern clam living at the southern extreme of its range, *Mya* probably has higher resistance to this type environmental change in the winter than in the summer.

Analyses for levels of heavy metals in soft clams failed to demonstrate any significant increase in heavy metals. Commercial clam harvest at CB-1 and CB-2 continued during spoil disposal operations and there were no reports of moribund clams from the watermen or reports of declining meat quality from the packing houses. Spoil disposal operations conducted during winter months when *Mya* has higher resistance to the stress and to low salinity water, avoids the chance of a concurrent natural clam mortality which may be blamed on spoil disposal and/or dredge operations. This is especially true for sites located in the Upper Bay.

Benthos associated with soft clams at Stations CB-1, CB-2, CB-3, and CB-4 are listed in Appendix V. There was little change in the species composition or number of species during spoil disposal operations. Slight differences did occur on commercially active clam beds (CB-1 and CB-2) as compared to inactive clam beds at CB-4 and CB-3.

DREDGE DISPOSAL OPERATIONS

Sonar bathymetery of the Bay bottom at spoil disposal site and of spoil falling from the dredge Esseyons was conducted on several occasions. These records were given to the Westinghouse personnel who were responsible for this phase of the operation. bathymetric profiles of the entire dredge site were taken on a north-south and east-west axis on three occasions.

As part of the UMCEES environmental program, motion pictures and color slides were taken of the Esseyons during spoil deposition on 27 February 1975. These visual references are being edited and prepared for use by interested scientific groups. These materials are available to DNR and will be shown at a future briefing.

SUMMARY OF PROJECT FINDINGS

1. Spoil disposal operations at Kent Island may have increased turbidity at water depths greater than 40 feet but only in an area immediately adjacent to the disposal site.
2. Increased levels of turbidity at the disposal site in deeper water (greater than 40 feet) were noted before and 2 months after the spoil disposal operations.
3. There was no evidence of sediment from spoil disposal operations impinging on commercially important shellfish beds.

4. There was no detectable mortality or change in health status in oysters, soft shell clams or other benthic organisms on commercially important shellfish beds that could be related to spoil disposal operations.
5. There was no significant increase in heavy metal concentration in oysters, soft clams and Rangia clams. Each species seems to concentrate a different metal from the environment.
6. Documentation of the influx of low salinity, highly turbid, and bacterially contaminated water from the Susquehanna River over commercially important shellfish beds in the Upper Bay provides an explanation of some of the problems of shellfish health and shellfish bacterial quality previously encountered by State agencies.
7. Rangia clams are experiencing a significant mortality throughout the Upper Bay which may be related to their environmental tolerance to northern winter conditions.
8. Changes in the benthic community at the dump site were transitory and the spoil was recolonized by benthic forms within thirty to sixty days.
9. Population levels of oysters in the upper bay are extremely low and no recruitment has occurred for years, while commercial harvest has continued with maximum effectiveness. Meat quality of oysters above the Chesapeake Bay bridge is very poor and histopathology suggests extreme stress from a toxic agent complicated by exposure to fresh water.

APPENDICES

APPENDIX I: WORK STATEMENT FOR C.B.L. PROJECT

IMPACT OF DREDGE SPOIL DISPOSAL OPERATIONS AT KENT ISLAND ON STOCKS OF COMMERCIALLY IMPORTANT SHELLFISH AND PREDOMINATE BENTHIC ORGANISMS

The following synopsis of work schedules for the project is offered to assist in planning and interpretation of projects by D.N.R. personnel.

C.B.L. vessels and personnel will be on the Kent Island disposal site at the following times:

Feb. 18-20	Before operation survey.
Feb. 25	Assessment of shellfish health and turbidity on commercially important beds during disposal.
Mar. 5	D O
Mar. 11-12	D O
Mar. 21	D O
Mar. 26-28	Post operation survey (+1-3 days)
Apr. 22	Post operation survey (+ 30 days)
May 20-21	Post operation survey (+ 60 days)
Oct. 18-20	Post operation survey (+240 days)

Details of activity during each visit:

Feb. 18-20 Before operation survey;

1. Location of sample stations and bottom characteristics.
   Range of study areas - Kentmore Marina to Swan Point, east of shipping channel.
2. Oyster bars (6 sites).
   a. Bar composition (age, size, meat quality, mortality rate, density)
   b. Associated Benthos quantity and species),
   c. Turbidity, temperature, salinity in water column,
   d. Heavy metal levels.
3. Benthos at selected sites other than oyster bars.
   a. 7 locations Spoil area, adjacent flats, (Note: Benthos at exposure sites)
   b. Quantitative description of species and density,
   c. Heavy metals in Rangia,
   d. Turbidity, temperature and salinity in water column,

4. Clam bed survey (5 locations).
   a. Population density, size, composition and general health,
   b. Frequency and cause of moribund clams,
   c. Heavy metal samples,
   d. Turbidity, temperature and salinity in water column,
   e. Associated Benthos - quality and health.

5. Coordinated and complimentary effort.
   a. Analysis of oyster-clam exposure sites (2) turbidity, temperature, Benthos, heavy metal uptake in clams, bar composition and heavy metals on adjacent oyster bars.
   b. Oyster bar and clam bed sites correspond to State Health Department water test sites, all data under 2 above (oyster bars) available.
   c. Benthic community in spoil to be moved, spoil disposal site (2 locations), old disposal site.

Feb. 25; Mar. 5,11-12, 21

Assessment of shellfish health and turbidity on commercially important beds during disposal:

1. 6 oyster bar sites, 5 clam bed sites, 2 test exposure sites,
   a. Turbidity, temperature and salinity in water column,
   b. Qualitative study of health and diversity of benthos,
   c. Sonar Bathemetery of dump site to determine accumulation rate.

2. Coordinated and complimentary effort:
   a. Analysis of oyster-clam exposure sites,
   b. Analysis of oyster bar and clam bed sites, coordinated with weekly State Health Department studies,
   c. Monitoring of turbidity in water column,
   d. Monitoring of spoil deposition during operation,
3. Immediate assessment of any unusual phenomenon.

Mar. 26-28

Post operation survey (repeat of Feb. 18-20)

1. Analysis of oyster bars (6 sites):
   a. Bar composition,
   b. Associated Benthos,
   c. Turbidity, temperature and salinity in water column,
   d. Heavy metals,
   e. Histopathologic analysis of sample,
2. Benthos at selected sites:
   a. 7 locations adjacent to disposal area,
   b. Quantitative description by species and density

c. Heavy metals in Rangia
d. Temperature, turbidity and salinity,
3. Clam bed survey (5 locations):
a. Population density, size, composition and health,
b. Frequency and cause of moribund clams,
c. Heavy metal sample,
d. Turbidity, temperature and salinity in water column,
e. Associated Benthos quantity and health.
4. Coordinated and complimentary effort:
a. Analysis of oyster-clam exposure sites(see Feb. 18)
b. Oyster bar sites correspond with Health Department water test sites,
c. Pathobiology of oysters at site (with D.N.R.) 88-309 project - spoil disposal induced pathology),
d. Sonar Bathemetery of dump site.

April 22 — Post operation survey (30 days)
1. 6 oyster bars; 5 clam beds; 2 test exposure sites.
2. Turbidity, temperature, salinity.
3. Qualitative study of health and diversity of Benthos.
4. Sonar Bathemetery of dump site.

May 20-21 — Post operation survey (60 days)
1. Analysis of oyster bars (6 sites):
a. Bar composition,
b. Associated Benthos,
c. Turbidity, temperature and salinity,
d. Heavy metals,
e. Histopathologic analysis.
2. Benthos at 7 sites:
a. Quantitative descriptive of species and densities
b. Heavy metals Rangia,
c. Temperature, turbidity and salinity.
3. Clam bed survey - 5 locations:
a. Population density, size composition and health,
b. Frequency and cause of moribund clams,
c. Heavy metals,
d. Turbidity, temperature and salinity in water column,
e. Associated Benthos quantity and health.
4. Coordinated and complimentary effort:
a. Analysis of oyster and clam exposure sites,
b. Sonar Bathemetery of dump sites,
c. Pathobiology of oysters.

Oct. 18-20 — Post operation survey (240 days)
(Note: one growing season for adverse effects to show survey is repeat of Pre operation survey of Feb. 18-20)
1. Oyster bar (6 sites):
a. Bar composition,
b. Associated Benthos - quantity and species,
c. Turbidity, temperature and salinity in water column,

d. Heavy metals,
e. Pathobiology of oysters.

2. Benthos at 7 selected sites;
   a. Quantitative description of species and densites,
   b. Heavy metals in Rangia,
   c. Turbidity, temperature, and salinity in water column,
3. Clam bed survey - 5 locations:
   a. Population density, size, composition and health,
   b. Frequency and cause of moribund clams,
   c. Heavy metal levels,
   d. Turbidity, temperature and salinity in water column,
   e. Associated Benthos - quantity and health.
4. Coordinated and complimentary efforts;
   a. Oyster bar and clam bed sites correspond to State Health Department water test sites,
   b. Pathobiology of oysters.

APPENDIX II: DESCRIPTION OF STUDY SITES

OYSTER BARS

Gum Thicket Bar: Code ØB-1

38° 54' 00" 76° 22' 52" 20 ft. deep.

Commercially active bar off Kentmore Marina 6.1 miles from the disposal site. Location corresponds to the State Health Department sampling station KIM-1. Small "lumps" of shell on base of silt-clays. Oyster density on "lumps" fair. 0.5 bushel sample of oysters and shell required 1 to 3 - 4 minute dredge hauls.

Brickhouse Bar: Code OB-2

38° 55' 58" 76° 22' 44" 15 ft. deep.

Commercially active bar near the North Mile Market. three and one-half miles from disposal site. Location corresponds to the State Health Department sampling station KIM-2. Narrow band of old shell on drop-off from 12 ft. to 22 ft.. Bottom of silt, clay and sand. 0.5 bushel sample of oyster and shell required 2 to 3 - 4 minute dredge hauls. Soft clam dredging appears to have reduced oyster bar to deep area. Very few if any oysters are found inshore on oyster bar described on DNR map.

Broad Creek Bar: Code OB-3 20 ft. deep.

38° 59' 22" 76° 21' 103"

Bar only worked by Skipjack dredges in area near Bay Bridge. Closest oyster bar to disposal site, 1.1 miles 0.5 bushel sample required 3 to 4 - 4 minute dredge hauls. Oysters are dispersed over the area. Containing large rock, silt, and sand. Location corresponds to State Health Department sampling site KIM-

Love Point Bar: Code OB-4 18 ft. deep.

39° 02' 36" 76° 20' 18"

Located 2.4 miles from the disposal site. Old oysters widely scattered through large rock on hard clay and sand. This could never be considered a workable bar. 0.5 bushel sample required 4 to 5 - 4 minute dredge hauls. Station is located slightly south of original State Health Department sampling station KIM # 8. Health Department station shifted to this location.

Chester River (Mouth): Code OB-5 16 ft. deep.

Located 3 miles from disposal site. Oyster scattered over well defined hump near 2 wrecks at mouth of Chester River. Large rock on hard clay bottom could not be considered a workable oyster bar. 0.5 bushel sample required 4 to 5 - 4 minute dredge hauls on a very specific location. State Health Department station KIM # 9 is located on sample station.

Swan Point Bar: Code OB-6 15 ft. deep.

Located 6 miles from disposal site. Site contains "shell plants" and old oysters on shell covered hard bottom. Density of oysters is great enough for commercial harvest over an area of about 1 acre. Meat quality and shell shape is poor and may be the reason oysters are not harvested. 0.5 bushel sample on this spot required 1 to 2 dredge hauls. At all other locations on Swan Point only 2 to 10 living oysters were found per 4 minute dredge hauls. State Health Department sample station K 12 is located on this "lump" and station KIM # 11 was 2.5 miles east southeast of this station but was moved to this location.

CLAM BEDS

Broad Creek Bed: Code CB-1 11 ft. deep.

39° 01' 03" 76° 19' 56"

Located 1.1 miles from disposal site. Silt with some sand on heavily worked bottom. Small market clams predominate (65%) with dense Rangia, population (3 year classes). Mortality level before spoil disposal was 1 - 2 moribund clams per bushel, . Clam meat condition good. Corresponds to State Health Department sample station KIM-7

Brickhouse Clam Bed: Code CB-2 10 ft. deep

38° 56' 19" 76° 22' 28"

Located 3.5 miles from disposal site. Oyster shell, sand, rock on clay and sand. Heavily worked but 70% market clams present. 10% Ragia clams per bushel of soft clams. Clam meat condition very good. Mortality level ranged from 1 to 11 moribund clams per bushel.

Pier 1 Clam Bed: Code CB-3 16 ft. deep on steep slope.

38° 58' 18" 76° 21' 37"

Located 1.5 miles from disposal site. Clay bank with rock, coal, and clam shell and oyster shell. Not worked commercially. 90% market clams with large Rangia. No detectable mortality. Clams large 4 - 5.5 inches and in excellent condition. Location corresponds to State Health Department sample station KIM-3

Love Point Clam Bed: Code CB-4 17 ft. deep.

39° 01' 25" 76° 20' 01"

Located 1.15 miles Northeast of dump site. Sand and oyster shell on hard clay. Not worked commercially in winter due to tide-wind problem. Narrow bed with 95% market clams 4.5 to 6 inches with large Rangia in excellent condition. No mortality in any samples. State Health Department sample station KIM-7

Clam Bed near BB-4: Code BB-4 16 ft. deep.

39° 00' 03" 76° 20' 18"
Located 1.15 miles east of disposal site on edge of drop-off from 12 feet to 22 feet. Sand and shell over clay. Commercial quantities present with 75% marketable soft clams. Rangia of 3 year classes present. 1-2 dead soft clams per bushel indicate some commercial harvest. Located close to State Health Department sample station KIM-4

Spoil Disposal Site: Code BB-1

38° 00' 47" 76° 21' 22" 61 ft. deep
Located between Coast Guard bouys E and F at the center of the discharge site. Bottom of black silt and sand with sparce benthic community representative of deep, bay environment that occassionally experiences anaerobic conditions and receives periodic deposits of sediment.

East of Dump Site (old site) Code BB-2

39° 00' 42" 76° 21' 02" 45 ft. deep
Located in center of old spoil disposal site about 0.3 of a mile from the edge of new discharge site. Bottom similar to BB-1.

East of Dump Site (Inshore) Code BB-3

39° 00' 21" 76° 20' 15" 22 ft. deep
About 0.9 of a miles east of spoil disposal site on junction of deep bay environment and producation shellfish beds. Silt and sand with deep benthic community dominated by Mya and Rangia

East Exposure Site Code: BB-4

39° 00' 03" 76° 20' 18" 18 ft. deep
Located on edge of clam bed, oyster bar and on shelf dropping into deeper water. 1.17 miles to edge of disposal site. Westinghouse exposure site located here since it is close to probable inshore drift of spoil and represent commercially important shellfish havitat. Oyster density very low in mixed rock and old shell. Inshore clam bed described alone. Corresponds to State Health Department sample station KIM-4

West Exposure Site BB-5

39° 01' 15" 76° 21' 54" 59 ft. deep
Westinghouse exposure site located here on bottom and benthic communities similar to spoil disposal site. State Health Department sample station KIM-6

South Dump Site BB-6

38° 59' 56" 76° 22' 01" 69 ft. deep

Located in ~~south~~ end of disposal site near core sample location #10. Corresponds to State Health Department sample station KIM-5. Bottom and benthic community similar to BB-1

APPENDIX III: WATER QUALITY OBSERVATIONS DURING MONITORING OF KENT ISLAND DISPOSAL OPERATIONS

Station Code: BB-1 Station: Dump Site

Date: Feb. 18, 75 Time: 1100 Wind: 0 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.0	8.7	181
10	3.0	8.7	177
20	3.9	8.3	180
30	4.6	8.3	114
40	4.7	8.3	272
50	4.8	8.3	312
60	4.8	8.3	292

Station Code: BB-2 Station: East of Dump Site (old site)

Date: Feb. 18, 75 Time: 13:22 Wind: 0 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.3	10.0	114
10	3.1	10.0	230
20	4.5	9.7	148
30	4.7	9.6	218
40	4.8	9.6	238

Station Code: BB-3 Station: East of Dump (Inshore)

Date: Feb. 18, 75 Time: 15:55 Wind: 0 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.1	9.5	180
10	4.0	9.4	182
15	4.9	9.4	186

Station Code: BB-4 Station: East Exposure Site

Date: Feb. 18, 75 Time: 15:55 Wind: SW5 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.5	11.0	172
5	3.3	11.0	---
10	3.9	10.8	142
15	3.9	10,8	168

Station Code: BB-5 Station: West Exposure Site

Date: Feb. 18, 75	Time: 16:45	Wind: SW8	Tide:
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.1	8.9	134
10	3.2	8.9	186
20	3.2	8.9	142
30	4.3	8.6	188
40	4.5	8.6	248
50	4.6	8.6	276
60	4.6	8.5	328

Station Code: BB-6 Station: South Dump Area

Date: Feb. 19, 75	Time:	Wind:	Tide
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.7	9.8	146
10	3.5	9.0	222
20	3.5	9.0	132
30	3.9	9.0	242
40	4.5	8.8	221
50	4.7	8.8	---
60	4.7	8.7	210

Station Code: OB-1 Station Gum Thicket Bar

Date: Feb. 19, 75	Time; 09:20	Wind: 0	Tide: Flood
Depth (ft.)	Temp (C°)	Salinity (PPT)	Turbidity (PPM)
0	10.1	3.3	130
10	10.1	3.3	160
20	9.9	3.8	160

Station Code: OB-2 Station: Brickhouse Bar

Date: Feb. 19, 75	Time: 08:10	Wind: 0	Tide:
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	10.4	162
10	3.4	10.4	---
15	3.4	10.4	174

Station Code OB-3

Station: Broad Creek Bar

Date Feb. 19, 1975 Depth (ft.)	Time Temp (C°)	Wind Salinity (PPT)	Tide Turbidity (PPM)
0	3.7	9.0	133
10	3.7	9.0	170
20	3.7	8.9	110

Station Code OB-4

Station: Love Point Bar

Date Feb. 19, 1975 Depth. (ft.)	Time Temp (C°)	Wind Salinity (PPT)	Tide Turbidity (PPM)
0	3.6	8.8	142
10	3.6	8.8	---
15	3.6	8.8	166

Station Code: OB-5 Station: Chester River (Mouth)

Date: Feb. 19, 75	Time:	Wind:	Tide:
Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	3.6	9.8	162
10	3.5	9.7	---
15	3.6	9.7	182

Station Code: OB-6 Station: Swan Point Bar

Date: Feb. 19, 75	Time:	Wind:	Tide:
Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	3.7	8.4	192
10	3.5	8.4	---
15	3.4	8.4	220

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Feb. 18, 75	Time: 15:10	Wind: 0	Tide: EBB
Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	3.2	9.9	224
5	3.7	9.7	172
10	3.7	9.7	156

Station Code: CB-2 Station Brickhouse Clam Bed

Date: Feb. 19, 75	Time: 08:15	Wind: 0	Tide: Flood
Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	3.3	10.3	188
5	3.5	10.2	---
10	3.5	10.2	152

Station Code: BB-1 Station: Dump Site

Date: Feb. 27, 75 Time: 10:50 Wind: W 6 Tide: Ebb

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.4	2.8	300
10	5.1	2.8	312
20	5.3	2.8	306
30	5.2	2.85	---
40	5.0	2.85	240
50	5.0	2.8	251
60	4.9	2.8	292

Station Code: BB-2 Station: East of Dump Site (Old Site)

Date: Feb. 27, 75 Time: 11:15 Wind: W 6 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.3	2.8	376
10	5.2	2.8	224
20	5.2	2.8	270
30	5.2	2.8	253
40	5.2	2.9	304

Station Code: BB-3 Station: East of Dump Site (Inshore)

Date: Feb. 27, 75 Time: Wind: SW 6 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.8	4.2	199
10	5.7	4.2	203
20	5.3	4.2	220

Station Code: BB-4 Station: East Exposure Site

Date: Feb. 27, 75 Time: 12:20 Wind: S W 6 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.8	3.5	194
10	5.2	3.5	---
15	5.2	3.5	206

Station Code: BB-5 Station: West Exposure Site

Date: Feb. 27, 75 Time: 12:00 Wind: W 8 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.4	2.9	324
10	5.2	2.9	---
20	5.2	2.9	276
30	5.2	2.9	---
40	5.2	2.9	256
50	5.2	2.9	292
60	5.1	2.9	---

Station Code: BB-6 Station: South Dump Area

Date: Feb. 27, 75 Time: 09:25 Wind: W 6 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	4.7	2.25	290
10	5.0	2.2	---
20	5.1	2.2	160
30	5.1	2.2	---
40	5.0	2.2	245
50	4.8	2.2	---
60	4.7	2.2	---

Station Code: BB-6 Station: South Dump Area (1 hr. post dump)

Date: Feb. 27, 75 Time: 11:40 Wind: W 8 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.4	2.9	300
10	5.1	2.9	241
20	5.2	2.9	255
30	5.2	2.9	---
40	5.2	2.9	226
50	5.2	2.9	296
60	5.1	2.9	---

Station Code: OB-2 Station: Brickhouse Bar

Date: Feb. 27, 75 Time: 17:20 Wind: SW 10 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.9	5.3	222
10	5.6	5.3	---
15	5.5	5.3	250

Station Code: OB-3 Station: Broad Creek Bar

Date: Feb. 27, 75	Time: 13:50	Wind: SSW 6	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.5	2.8	232
10	5.3	2.9	---
15	5.2	2.9	200

Station Code: OB-4 Station: Love Point Bar

Date: Feb. 27, 75	Time: 15:30	Wind: SW 8	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.8	1.9	370
10	5.7	1.9	---
15	5.5	1.9	240

Station Code: OB-5 Station: Chester River Mouth

Date: Feb. 27, 75	Time: 1600	Wind: SW 10	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.9	3.0	306
10	5.7	3.0	---
15	5.5	3.0	301

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Feb. 27, 75	Time: 15:05	Wind:	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.7	5.1	194
5	5.3	5.1	---
10	5.4	5.1	302

Station Code: CB-2 Station: Brickhouse Clam Bed

Date: Feb. 27, 75	Time: 17:05	Wind: SW 10	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.9	5.7	191
10	5.8	5.7	187

Station Code: CB-3 Station: Pier 1 Clam Bed

Date: Feb. 27, 75	Time: 13:40	Wind: SW 6	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.5	4.4	254
5	5.5	4.4	---
10	5.2	4.4	230

Station Code: CB-4 Station: Love Point Clam Bed

Date: Feb. 27, 75	Time: 16:40	Wind: SW 8	Tide: Flood
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.7	2.8	242
10	5.7	2.8	---
15	5.3	2.8	268

Station Code: BB-1 Station: Dump Site

Date: March 4, 75	Time: 16:50	Wind: NW 18	Tide: Ebb
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.9	4.7	318
10	3.9	4.7	---
20	4.6	4.7	313
30	4.9	4.7	---
40	4.8	4.6	302
50	4.8	4.6	346
60	4.8	4.6	---

Station Code: BB-4 Station: East Exposure Site

Date: Mar. 4, 75	Time: 12:20	Wind: NW 20	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.3	4.7	244
10	3.3	4.6	---
15	4.4	4.5	293

Station Code: BB-6 Station: South Dump Area

Date: Mar. 4, 75 Time: 16:20 Wind: NW 22 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.9	4.6	334
10	3.9	4.6	---
20	3.9	4.5	282
30	4.8	4.5	---
40	4.9	4.5	292
50	4.7	4.5	379
60	4.7	4.5	---

Station Code: OB-1 Station: Gum Thicket Bar

Date: Mar. 4, 75 Time: 14:45 Wind: NW 22 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.8	5.7	238
10	3.8	5.7	---
15	4.3	5.7	248

Station Code: OB-2 Station: Brickhouse Bar

Date: Mar. 4, 75 Time: 14:05 Wind: NW 15 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.8	4.9	286
10	3.8	5.0	---
15	4.7	4.9	277

Station Code: OB-3 Station: Broad Creek Bar

Date: Mar. 4, 75 Time: 12:40 Wind: NW 24 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	4.4	294
10	3.4	4.5	---
15	3.4	4.5	305
20	3.4	4.6	312

Station Code: OB-4 Station: Love Point Bar

Date: Mar. 4, 75	Time: 11:40	Wind: NW 20	Tide: Flood
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.3	4.7	264
10	3.3	4.7	---
15	4.3	4.6	272

Station Code: OB-5 Station: Chester River (Mouth)

Date: Mar. 4, 75	Time: 11:20	Wind: NW 18	Tide: Flood
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	3.9	228
10	3.5	3.9	---
15	3.5	3.9	200

Station Code: OB-6 Station: Swan Point Bar

Date: Mar. 4, 75	Time: 10:20	Wind: NW 18	Tide: Flood
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.0	2.2	385
10	3.0	2.1	---
15	3.0	2.1	379

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Mar. 4, 75	Time: 12:10	Wind: NW 22	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	4.5	354
10	3.4	4.5	397

Station Code: CB-2 Station: Brickhouse Clam Bed

Date: Mar. 4, 75	Time:	Wind:	Tide:
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	4.1	278
10	3.4	4.1	292

Station Code: CB-3 Station Pier 1 Clam Bed

Date: Mar. 4, 75	Time: 12:50	Wind: NW 15	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.2	4.8	300
10	3.2	4.8	---
15	4.6	4.8	289

Station Code: CB-4 Station: Love Point Clam Bed

Date: Mar. 4, 75	Time: 13:30	Wind: NW 15	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.3	4.7	275
10	3.4	4.7	---
15	3.4	4.8	292

Station Code: BB-1 Station: Dump Site

Date: Mar. 14, 75	Time: 08120	Wind: NE 18	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.5	6.9	270
10	3.5	6.9	---
20	3.4	6.9	268
30	3.7	8.7	---
40	3.7	8.8	307
50	5.9	8.7	403
60	5.9	8.9	---

Station Code: BB-1 Station: Dump Site 1 hr. after dump

Date: Mar. 14, 75	Time: 16:30	Wind:	Tide: Slack
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.6	8.2	236
10	3.6	8.1	---
20	3.6	8.1	229
30	3.6	8.2	---
40	3.8	8.2	522
50	3.9	8.1	495
60	4.2	8.1	---

Station Code: BB-2 Station: East of Dump Site

Date: Mar. 14, 75 Depth (ft.)	Time: 17:40 Temp. (C°)	Wind: NE 16 Salinity (PPT)	Tide: Flood Turbidity (PPM)
0	3.8	9.4	276
10	3.7	9.4	---
20	3.7	9.4	260
30	3.8	9.4	---
40	4.1	9.3	268

Station Code: BB-3 Station: East of Dump Site (Inshore)

Date: Mar. 14, 75 Depth (ft.)	Time: 08:35 Temp. (C°)	Wind: NE 15 Salinity (PPT)	Tide: Slack Turbidity (PPM)
0	3.6	9.1	252
10	3.6	9.0	230
20	3.6	9.0	276

Station Code: BB-5 Station: West Exposure Site

Date: Mar. 14. 75 Depth (ft.)	Time: 17:05 Temp. (C°)	Wind: NE 20 Salinity (PPT)	Tide: Slack Turbidity (PPM)
0	3.4	6.9	230
10	3.4	6.9	---
20	3.4	6.9	304
30	3.6	6.9	---
40	3.8	6.8	435
50	4.0	6.8	538
60	4.0	6.8	---

Station Code: BB-6 Station: South Dump Area

Date: Mar. 14, 75 Depth (ft.)	Time: 16:25 Temp. (C°)	Wind: NE 15 Salinity (PPT)	Tide: Slack Turbidity (PPM)
0	3.5	7.5	197
10	3.5	7.4	---
20	3.7	7.4	241
30	3.7	7.5	---
40	3.8	7.5	334
50	3.9	7.4	---
60	3.9	7.4	383

Station Code: OB-1 — Station: Grim Thicket Bar

Date: Mar. 14, 75 — Time: 13:40 — Wind: NE 16 — Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.6	9.5	229
10	3.6	9.5	240
20	3.7	9.6	223

Station Code: OB-2 — Station: Brickhouse Bar

Date: Mar. 14, 75 — Time: 14:20 — Wind: NE 15 — Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.6	9.5	271
10	3.6	9.4	222
15	3.8	9.4	268

Station Code: OB-3 — Station: Broad Creek Bar

Date: Mar. 14, 75 — Time: 1600 — Wind: NE 15 — Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.75	9.7	229
10	3.7	9.7	257
20	3.9	9.7	234

Station Code: OB-4 — Station: Love Point Bar

Date: Mar. 14, 75 — Time: 11:20 — Wind: NE 18 — Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.5	8.1	185
10	3.5	8.1	---
15	3.6	8.1	233

Station Code: OB-5 — Station: Chester River (Mouth)

Date: Mar. 14, 75 — Time: 11:10 — Wind: NE 18 — Tide:

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	7.8	226
10	3.4	7.9	187

Station Code: OB-6 Station: Swan Point Bar

Date: Mar. 14, 75 Time: 10:05 Wind: NE 20 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.4	7.5	208
10	3.4	7.5	236

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Mar. 14, 75 Time: 1800 Wind: NE 15 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.7	10.3	220
10	3.7	10.4	232

Station Code: CB-2 Station: Brickhouse Clam Bed

Date: Mar. 14, 75 Time: 18:30 Wind: NE 15 Tide:Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.7	10.1	238
10	3.7	10.2	249

Station Code: CB-3 Station: Pier 1 Clam Bed

Date: Mar. 14, 75 Time: 15:40 Wind: NE 14 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	3.7	9.7	242
10	3.9	9.7	---
15	3.9	9.7	258

Station Code: BB-3 Station: East of Dump Site (Inshore)

Date: Mar. 19, 75 Time: 15:05 Wind: SW 30 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.6	8.5	192
10	5.5	8.4	191
15	5.4	9.4	290

Station Code: BB-4 Station: East Exposure Site

Date: Mar. 19, 75 Time: 14:15 Wind: SW 4 Tide: Slack

Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	5.7	9.3	230
10	5.6	9.3	199
15	5.5	9.3	158

Station Code: OB-1 Station: Grim Thicket Bar

Date: Mar. 19, 75 Time: 11:40 Wind: SW 25 Tide: EBB

Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	6.3	10.1	178
10	6.2	10.1	---
15	6.1	10.2	177
20	6.2	10.1	---

Station Code: OB-2 Station: Brickhouse Bar

Date: Mar. 19, 75 Time: 1200 Wind: SW 22 Tide: EBB

Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	5.6	9.6	198
10	5.7	9.7	---
15	5.5	9.7	208
20	5.5	9.8	---

Station Code: BB-1 Station: Dump Site

Date: Mar. 21, 75 Time: 1000 Wind: NW 5 Tide: Slack

Depth (ft.)	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	5.8	6.7	206
10	5.7	6.6	---
20	5.7	7.6	204
30	5.5	9.1	---
40	5.2	10.3	260
50	5.1	13.6	258
60	5.0	14.4	264

Station Code: BB-2 Station: East of Dump Site (old site)

Date: Mar. 21, 75 Time: 09:30 Wind: NW 3 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.9	6.8	212
10	5.8	7.5	---
20	5.6	9.6	281
30	5.1	12.4	---
40	5.1	14.1	181
50	5.2	14.2	212

Station Code: BB-3 Station: East of Dump Site (Inshore)

Date: Mar. 21, 75 Time: 09:15 Wind: NW 3-5 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.8	7.8	160
10	5.6	7.8	136
15	5.6	9.7	167

Station Code: BB-4 Station: East Exposure Site

Date: Mar. 21, 75 Time: 11:25 Wind: NW 7 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	6.5	7.4	186
10	6.3	7.6	170
15	6.0	7.8	137

Station Code: BB-5 Station: West Exposure Site

Date: Mar. 21, 75 Time: 10:20 Wind: NW 8 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.9	6.7	224
10	5.9	7.5	216
20	5.9	8.1	140
30	5.6	10.4	---
40	5.0	13.3	234
50	5.1	14.4	248

Station Code: BB-6 **Station: South Dump Area**

Date: Mar. 21, 75 **Time: 10:45** **Wind: NW 7** **Tide: Flood**

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	6.2	7.2	212
10	6.0	7.2	237
20	6.0	8.1	208
30	5.6	10.3	---
40	5.2	12.6	223
50	5.2	14.2	236
60	5.4	14.6	219

Station Code: OB-1 **Station: Grim Thicket Bar**

Date: Mar. 21, 75 **Time: 13:40** **Wind: NW 2** **Tide: Flood**

Depth (ft)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.1	8.0	179
10	6.3	8.9	---
15	6.0	10.3	177
20	6.2	10.3	---

Station Code: OB-2 Station: Brickhouse Bar

Date: Mar. 21, 75 Time: 12:20 Wind: NW 2 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	8.1	7.2	206
10	8.5	6.7	---
15	8.8	6.4	218

Station Code: OB-3 Station: Broad Creek Bar

Date: Mar. 21, 75 Time: 1200 Wind: NW 3-5 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	6.5	7.5	130
10	6.2	8.9	116
20	5.6	10.7	137

Station Code: OB-4 Station: Love Point Bar

Date: Mar. 21, 75 Time: 08:45 Wind: NW 3-5 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.6	6.5	224
10	5.9	7.0	---
15	5.8	8.2	209
20	5.2	12.2	230

Station Code: OB-5 Station: Chester River (Mouth)

Date: Mar. 21, 75 Time: 08:05 Wind: NW 3-5 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.6	6.9	129
10	6.4	8.7	164

Station Code: OB-6 Station: Swan Point Bar

Date: Mar. 21, 75 Time: 07:20 Wind: NW 2 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.6	4.2	223
10	5.8	5.1	---
15	5.8	7.1	323

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Mar. 21, 75 Time: 09:00 Wind: NW 3-5 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	5.8	7.2	237
10	5.6	8.2	---
15	5.6	8.8	228

Station Code: CB-2 Station: Brickhouse Clam Bed

Date: Mar. 21, 75 Time: 12:20 Wind: NW 2 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.2	8.1	126
10	6.7	8.5	---
15	6.4	8.8	130

Station Code: CB-3 Station: Pier 1 Clam Bed

Date: Mar. 21, 75 Time: 12:10 Wind: NW 5 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	6.5	7.5	155
10	6.2	7.8	---
15	5.6	8.9	169

Station Code: CB-4 Station: Love Point Clam Bed

Date: Mar. 21, 75 Time: 11:45 Wind: NW 3 Tide:

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	6.0	6.5	198
10	6.0	7.1	---
15	5.9	7.1	202

Station Code: BB-1 Station: Dump Site

Date: Apr. 15, 75 Time: 10:40 Wind: NE 10 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.7	6.7	71
10	7.8	6.7	87
20	7.3	6.7	70
30	7.2	6.8	78
40	7.2	6.8	128
50	7.2	6.8	146
60	7.2	6.8	152

Station Code: BB-2 Station: East of Dump Site (old site)

Date: April 15, 75 Time: 11:10 Wind: NE 12-15 Tide: Slack

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.8	6.7	73
10	7.8	6.7	---
20	7.7	6.7	81
30	7.2	6.8	--
40	7.1	6.8	79
45	7.0	6.8	81

Station Code: BB-3 Station: East of Dump Site (Inshore)

Date: Apr. 15, 75	Time: 11:50	Wind: NE 18	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	7.3	59
10	7.9	7.3	--
15	8.0	7.3	--
20	8.0	7.3	78

Station Code: BB-4 Station: East Exposure Site

Date: Apr. 15, 75	Time: 12:20	Wind: NE 10	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	7.2	68
10	7.9	7.2	60
15	7.7	7.2	44

Station Code: BB-5 Station: West Exposure Site

Date: Apr. 15, 75	Time: 10:20	Wind: NE 10	Tide: Flood
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.8	6.6	83
10	7.8	6.6	---
20	7.6	6.6	77
30	7.1	6.7	---
40	7.2	6.7	80
50	7.2	6.7	57

Station Code: BB-6 Station: South Dump Area

Date: Apr. 15	Time: 11:30	Wind: NE 15	Tide: EBB
Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.8	7.0	76
10	7.8	7.0	---
20	7.3	7.1	76
30	7.1	7.1	---
40	7.2	7.1	71
50	7.2	7.2	---
60	7.2	7.2	106

Station Code: OB-1 Station: Grim Thicket Bar

Date: Apr. 15 Time: 14:30 Wind: NNE 12 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.8	7.7	67
10	7.3	7.8	---
20	7.3	7.8	84

Station Code: OB-2 Station: Brickhouse Bar

Date: Apr. 15, 75 Time: 15:20 Wind: NW 15 Tide: Ebb

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.6	8.2	54
10	7.6	7.0	---
15	7.6	7.0	73

Station Code: OB-3 Station: Broad Creek Bar

Date: Apr. 15, 75 Time: 13:45 Wind: NE 15 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	8.0	7.2	57
10	7.8	7.2	56
20	7.5	7.3	62

Station Code: OB-4 Station: Love Point Bar

Date: Apr. 15, 75 Time: 1000 Wind: NE 10 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.7	6.2	66
10	7.9	6.3	--
20	7.3	6.3	89

Station Code: OB-5 Station: Chester River (Mouth)

Date: Apr. 15, 75 Time: 09:30 Wind: E 8-10 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	5.5	72
10	7.9	5.5	--
15	7.8	6.6	60

Station Code: OB-6 Station: Swan Point Bar

Date: Apr. 15, 75 Time: 08:45 Wind: E 8-10 Tide: Flood

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	5.3	65
10	8.1	5.5	--
15	8.1	5.5	67

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: Apr. 15, 75 Time: 12:05 Wind: NWE 15 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	6.7	63
10	7.7	6.8	--
15	7.7	6.8	83

Station Code: CB-2 Station: Brickhouse Clam Bed

Date: Apr. 15, 75 Time: 15:25 Wind: NW 15 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.7	8.5	79
10	7.7	8.5	92

Station Code: CB-3 Station: Pier 1 Clam Bed

Date: Apr. 15, 75 Time: 15:45 Wind: NW 18 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.8	7.7	75
10	7.7	7.7	--
20	7.2	7.8	91

Station Code: CB-4 Station: Love Point Clam Bed

Date: Apr. 15 Time: 16:30 Wind: NW 15 Tide: EBB

Depth (ft.)	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	7.9	6.3	78
10	7.8	6.3	--
15	7.8	6.3	86

Station Code: BB-5 Station: West Exposure Site

Date: 19 May 75 Time: 12:45 Wind: 0 Tide: Flood

Depth	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	20.6	-	88
10	17.5	-	-
20	13.4	-	143
30	11.9	-	-
40	11.5	-	151
50	11.4	-	-
65	11.2	-	190

Station Code: BB-6 Station: South Dump Area

Date: 19 May 75 Tide: 14:40 Wind: SW4 Tide: Flood

Depth	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	19.9	-	63
10	17.42	-	-
20	13.9	-	135
30	11.28	-	-
40	10.88	-	101
50	11.02	-	-
60	11.02	-	161

Station Code: OB-1 Station: Gum Thicket Bar

Date: 19 May 75 Time: 08:20 Wind: NE 3-5 Tide: EBB

Depth	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	17.8	6.4	63
10	14.9	6.8	-
15	14.2	6.8	-
20	13.8	7.0	82

Station Code: OB-2 Station: Brickhouse Bar

Date: 19 May 75 Time: 09:30 Wind: NE3 Tide: EBB

Depth	Temp. (C^o)	Salinity (PPT)	Turbidity (PPM)
0	17.8	5.2	76
10	17.3	5.2	-
15	15.4	5.3	-
20	14.5	5.5	138

Station Code: BB-1 — Station: Dump Site

Date: 19 May 75 — Time: 13:45 — Wind: 0 — Tide: Flood

Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.0	-	73
10	17.26	-	-
20	13.88	-	105
30	11.32	-	-
40	10.92	-	168
50	110.82	-	173
53	10.78	-	-

Station Code: BB-2 — Station: East Dump Site (old site)

Date: 19 May 75 — Time: 14:10 — Wind: 0 — Tide: Flood

Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.2	-	80
10	17.14	-	-
20	14.04	-	98
30	11.60	-	-
40	10.82	-	143
50	10.62	-	176
53	10.80	-	-

Station Code: BB-3 — Station: East of Dump (Inshore)

Date: 19 May 75 — Time: 1500 — Wind: SW4 — Tide: Flood

Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.4	-	68
10	16.22	-	68
15	15.78	-	77

Station Code: BB-4 — Station: East Exposure Site

Date: 19 Ma7 75 — Time: 15:20 — Wind: SW5 — Tide: Flood

Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.34	-	71
10	16.78	-	-
15	15.22	-	76
20	15.22	-	106

Station Code: OB-3 Station: Broad Creek Bar

Date: 19 May 75	Time: 10:20	Wind: NE3	Tide: EBB
Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.0	5.2	112
10	17.9	5.3	-
15	17.2	5.3	113

Station Code: OB-4 Station: Love Point Bar

Date: 19 May 75	Time: 1200	Wind: 0	Tide: Flood
Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.2	-	63
10	17.7	-	-
15	13.3	-	-
20	12.8	-	120

Station Code: OB-5 Station: Chester River (Mouth)

Date: 19 May 75	Time: 11:40	Wind: NE1	Tide: Flood
Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	19.7	3.4	93
10	18.9	3.4	-
15	17.2	3.5	118

Station Code: OB-6 Station: Swan Point Bar

Date: 19 May 75	Time: 11:05	Wind: NE1	Tide: Slack
Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	18.6	3.8	96
10	18.3	3.8	-
15	17.3	3.8	110

Station Code: CB-1 Station: Broad Creek Clam Bed

Date: 19 May 75	Time:	Wind: 0	Tide: Flood
Depth	Temp. (C°)	Salinity (PPT)	Turbidity (PPM)
0	21.0	3.8	129
10	19.1	4.8	-
13	19.5	5.0	145

Station Code CB-2

Station Brickhouse Clam Bed

Date: 19 May 75 Depth	Time: 15:45 Temp. (C°)	Wind: SW5-8 Salinity (PPT)	Tide: Flood Turbidity (PPM)
0	20.0	-	100
10	18.5	-	-
15	18.5	-	105

Station Code CB-3

Station Pier 1 Clam Bed

Date: 19 May 75 Depth	Time: 15:30 Temp. (C°)	Wind: SW5 Salinity (PPT)	Tide: Flood Turbidity (PPM)
00	19.4	-	80
10	19.4	-	-
15	18,2	-	78

APPENDIX IV: BAR COMPOSITION YIELD SHEET USED BY D.N.R. FISHERIES ADMINISTRATION AND U.M.C.E.E.S.

OYSTER BAR COMPOSITION ANALYSIS

DEPARTMENT OF CHESAPEAKE BAY AFFAIRS

SAMPLE NO. ______

Date ______ Bar ______

Location ______

	TEMP.	SALINITY	0/00
Top			
Bottom			

Bottom ______ Size Sample ______

Depth ______ Gear Used ______

Type Bar ______ No. of Licks ______

PLANTING INFORMATION

Type of Planting: Seed ______ Bus.; Source ______; Fresh Shells ______ Bus.;
Dredged Shells ______ Bus.; Reef Shells ______; Clam Shells ______ Bus.;
Slag ______ Bus.; Other Materials ______ Bus.; No Material Planted, A Natural Bar ______
Date Planted ______; Size of Planting ______ acres; Number of bushels per acre ______

ASSOCIATED ORGANISMS: (SCORE: 0 absent, 1 few, 2 moderate, 3 numerous, 4 very abundant)

Barnacle ______	*Anemones* ______	*Small Clams* ______	*Sabellaria* ______	*Crepidula* ______	Algae ______
Mussels ______	M. Snails ______	Boring Spng. ______	Serpulids ______	Mud Crabs ______	Grass ______
Bryozoa ______	Bor. Clam ______	Encrus. Spng. ______	Polynices ______	Hydroids ______	Venus ______
Molgula ______	Mud Tubes ______	Mytilopsis ______	Stylochus ______	Anomia ______	Mya ______

DISTRIBUTION AND COMPOSITION OF BAR MATERIAL
(Cull out stones before taking sample)

	TALLY SPACE Number of oysters in Sample	(Use for spat count if needed)	NO. PER BUSHEL	PER CENT
Market Oysters				
Small Oysters (under 3 inches)				
SPAT ON SHELL				
SPAT ON CINDER				
SPAT ON MARKETS				
SPAT ON SMALL				
SPAT ON OTHER				

Est. the size range of the spat   Est. the average size of the spat   TOTAL SPAT

BOXES	Cause Unknown	With Ulcer	Drilled		
Spat Boxes					
Old Oyster Boxes					
Recent Oyster Boxes					
Gapers					
DRILLS Urosalpinx					
Urosalpinx Egg Clutches					
Eupleura					
Eupleura Egg Clutches					

Average Size of Market Oysters

Very Large over 6" ______ Large 5"-6" ______ Medium 4"-5" ______ Small 3"-4" ______ All Sizes evenly mixed ______

Typical Shape and Character

Deep Cup ______ Thick Shell ______ Roundish ______ Regular ______ Single ______
Flat ______ Thin Shell ______ Long ______ Irregular ______ Clustered ______

Shell Growth and Condition of Oysters

Average Growth of Bill: (Check One) Excellent (over 3/4") ______ Good (1/2 - 3/4") ______
Average (1/4 - 1/2") ______ Poor (0 - 1/4") ______

Rate Each Individual, From 0 - 5

Condition of Oysters: Fat as Criteria										
Polydora: Actual Number Counted										

BLANK SHELLS	
CINDER	
DEBRIS (MAKE NOTE OF KIND)	
TOTAL	

Estimate the Size range these oysters

SMALL OYSTERS (those oysters under 3 inches)
Average Growth of Bill: (Check One) Excellent (over 3/4") ______ Good (1/2 - 3/4") ______
Average (1/4 - 1/2") ______ Poor (0 - 1/4") ______

REMARKS:

OYSTER BAR COMPOSITION ANALYSIS

The standard D.N.R. field sheet and procedures for analysis of oyster bars were used with ½ bushel samples of shell and living oysters. Number of 4 minute dredge hauls varied due to bar condition and bottom type and number used per bar were given in bar description. The following summary of field data sheets reflects field observations. Five market oysters were examined for condition, presence of crystaline style and polydora.

OB1 Gum Thicket Bar February 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	50	65
Small oysters	1	--
Spat	1	--
Boxes	1	--
Blank shell	-	35

Market oysters
- Size: Large — Style (5) present
- Condition: (5) 2+
- Polydora: (5) <2 per shell

Associated Orangisms

Barnacle	Numerous
Mussels	Numerous
Bryozoa	Moderate
Anemones	Numerous
Worms	Few

OB2 Brickhouse Bar FEBRUARY 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oyster	67	60
Small oysters	6	6
Spat	0	0
Boxes	4	4
Shell	-	30

Market oysters
- Size: Medium
- Condition: (5) 3+
- Style: (5) present in 4
- Polydora: (5) 2+ per shell

OB2 Brickhouse Bar FEBRUARY 19-20, 1975 continued

Associated organisms

Barnacle	Moderate
Mussels	Moderate
Bryozoa	Few
Anemones	Moderate
Worms	Absent

OB3 Broad Creek Bar FEBRUARY 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	83	80
Small oysters	2	1
Spat	0	0
Boxes	2	1
Shell	-	18

Market oysters

Size	Medium
Condition	(5) <2
Style	(5) Present
Polydora	(5) 3 per shell

Associated organisms

Barnacle	Moderate
Mussels	Moderate
Bryozoa	Few
Anemones	Moderate
Worms	Few

OB4 Love Point Bar FEBRUARY 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	57	60
Small oysters	6	6
Spat	0	0
Boxes	2	4
Shell	-	30

Market oysters

Size	Medium
Condition	(5) < 3 green body
Style	(5) present
Polydora	(5) 4 per shell

Associated organisms

Barnacle	Moderate
Mussels	Moderate
Bryozoa	Few
Anemones	Few
Worms	Moderate

OB5 Chester River Mouth FEBRUARY 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	54	45
Small oysters	28	20
Spat	0	--
Boxes	10	5
Shell	--	30

Market oysters
- Size: Small
- Condition: (5) 2
- Style: (5) 4 present
- Polydora: None

Associated Organisms
- Barnacle: Few
- Mussels: Moderate
- Bryozoa: Absent
- Worms: Absent
- Anemones: Absent

OB6 Swan Point Bar FEBRUARY 19-20, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	45	47
Small oysters	15	6
Spat	0	-
Boxes	6	2
Shell	-	47

Market oysters
- Size: Medium
- Condition: < 2 not marketable
- Style: (5) present in 4
- Polydora: None

Associated organisms
- Barnacle: Numerous
- Mussels: Moderate
- Bryozoa: Absent
- Anemones: Few
- Worms: Few

OB1 Gum Thicket Bar — MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	78	70
Small oysters	1	--
Spat	0	--
Boxes	5	5
Blank Shell	-	25

Market oysters		
Size	Large	
Condition	(5)	2
Style	(5)	present
Polydora	(5)	2 per shell

Associated organisms	
Barnacles	Moderate
Mussels	Numerous
Bryozoa	Few
Anemones	Moderate
Worms	Moderate

OB2 Brickhouse Bar — MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	60	50
Small oysters	5	5
Spat	0	
Boxes	4	5
Shell		40

Market oysters		
Size	Medium	
Condition	(5)	2+
Style	5/5	
Polydora	(5) 1+/shell	per shell

Associated organisms	
Barnacles	Numerous
Mussels	Moderate
Bryozoa	Few
Anemones	Moderate
Worms	Absent

OB3 Broad Creek Bar — MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	77	80
Small oysters	3	2
Spat	0	-
Boxes	1	2
Shell	-	16

OB3 Broad Creek Bar continued — MARCH 19, 1975

Market oysters	
Size	Medium
Condition	(5) < 2
Style	(5) 3/5 present
Polydora	2 per shell

Associated organisms	
Barnacles	Numerous
Mussels	Moderate
Bryozoa	Few
Anemones	Few
Worms	Few

OB4 Love Point Bar — MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	113	80
Small oysters	16	5
Spat	0	-
Boxes	2	
Shell	-	15

Market oysters	
Size	Small
Condition	(5) 2 +
Style	(5) 5/5
Polydora	(5) 2 per shell

Associated organisms	
Barnacles	Moderate
Mussels	Moderate
Bryozoa	Few
Anemones	Few
Worms	Few

OB5 Chester River Mouth — MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	66	30
Small oysters	55	18
Spat	0	--
Boxes	19	6
Shell	--	50

OB5 Chester River Mouth continued MARCH 19, 1975

Market oysters		
Size	Small	
Conditions	(5)	2
Style	(5)	3/5
Polydora	None	

Associated organisms	
Barnacles	Few
Mussels	Few
Bryozoa	Absent
Anemones	Absent
Worms	Few

OB6 Swan Point Bar MARCH 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	66	30
Small oysters	55	25
Spat	0	
Boxes	19 (old dredge)	5
Shell		40

Market oysters		
Size	Small	
Condition		<2
Style	(5)	3/5
Polydora	None	

Associated organisms	
Barnacles	Moderate
Mussels	Moderate
Bryozoa	Absent
Anemones	Absent
Worms	Absent

OB1 Gum Thicket Bar — APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	69	75
Small oysters	2	5
Spat	1	--
Boxes	3	5
Shell	-	15

Market oysters	
Size	Medium
Condition	<2
Style	Present
Polydora	3

Associated organisms	
Barnacles	Moderate
Mussels	Numerous
Bryozoa	Few
Anemones	Numerous
Worms	Moderate

OB2 Brick house Bar — APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	109	60
Small oysters	21	10
Spat	0	
Boxes	4	2
Shell		28

Market oysters	
Size	Medium
Condition	(5) 3+
Style	(5) 5/5
Polydora	1+/shell

Associated organisms	
Barnacles	Moderate
Mussels	Moderate
Bryozoa	Moderate
Anemones	Few
Worms	Absent

OB3 Broad Creek Bar — APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	81	70
Small oysters	1	1
Spat	1	1
Boxes	3	3
Shell	-	25

OB3 Broad Creek Bar continued APRIL 15, 1975

Market oysters	
Size	Medium
Condition	3+
Style	4/5
Polydora	3+ per shell
Associated organisms	
Barnacles	Numerous
Mussels	Moderate
Bryozoa	Moderate
Anemones	Moderate
Worms	Few

OB4 Love Point Bar APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	115	85
Small oysters	5	2
Spat	0	
Boxes	5	3
Shell	-	10

Market oysters	
Size	Small
Condition	(5) 1 poor
Style	(5) 3/5
Polydora	(5) 3 per shell
Associated organisms	
Barnacles	Numerous
Mussels	Moderate
Bryozoa	Few
Anemones	Few
Worms	Absent

OB5 Chester River Mouth APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	84	45
Small oysters	4	5
Spat	0	--
Boxes	4	5
Shell	-	45

OB5 Chester River Mouth continued APRIL 15, 1975

Market oysters

Size	Medium
Condition	(5) 2
Style	(5) 3/5
Polydora	None

Associated organisms

Barnacles	Few (dead)
Mussels	Moderate
Bryozoa	Few
Anemones	Absent
Worms	Few

OB6 Swan Point Bar APRIL 15, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	68	70
Small oysters	2	15
Spat	0	0
Boxes	0	0
Shell	-	15

Market oysters

Size	Medium
Condition	< 2
Style	(5) 3/5
Polydora	None

Associated organisms

Barnacles	Moderate
Mussels	Moderate
Bryozoa	Absent
Anemones	Absent
Worms	Absent

OB1 Gum Thicket Bar — May 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	30	50
Small oysters	0	--
Spat	1	--
Boxes	0	--
Blank shell	---	50

Market oysters

Size	Large	Style (5) present
Condition	(5) 3	
Polydora	(5) per shell	

Associateddorganisms

Barnacle	Numerous
Mussels	Moderate
Bryozoa	Moderate
Anemones	Numerous
Worms	Few
Hydroids	Few

OB2 Brickhouse Bar — May 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oyster	80	85
Small oysters	0	6
Spat	0	0
Boxes	5	5
Shell	-	10

Markey oysters

Size	Medium
Condition	(5) 2+
Style	(5) present in 5
Polydora	(5) 2+ per shell

Associated organisms

Barnacle	Moderate
Mussels	Moderate
Bryozoa	Moderate
Anemones	Moderate
Worms	Present
Hydroid	Moderate

OB3 Broad Creek Bar May 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	80	70
Small oysters	3	2
Spat	0	0
Boxes	3	3
Shell	--	25

Market oysters
- Size: Medium
- Condition: (5) 2
- Style: (5) Present
- Polydora: (5) 3-5 per shell

Associated organisms
- Barnacle: Moderate
- Mussels: Abundant
- Bryozoa: Few
- Anemones: Moderate
- Worms: Moderate
- Hydroids: Few

OB4 Love Point Bar

	NUMBER	PERCENT COMPOSITION
Market oysters	103	92
Small oysters	1	1
Spat	0	--
Boxes	2	1
Shell	-	6

Market oysters
- Size: Medium
- Condition: (5) 1+(green)
- Style: (5) present
- Polydora: (5) 5 per shell

Associated organisms
- Barnacle: Abundant
- Mussels: Moderate
- Bryozoa: Few
- Anemones: Few
- Worms: Moderate

OB5 Chester River Mouth May 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	101	69
Small oysters	1	.5
Spat	0	--
Boxes	1	.5
Shell	--	30

Market oysters	
Size	Medium
Condition	(5)2(green color)
Style	(5) 5 present
Polydora	None

Associated Organisms	
Barnacle	Absent
Mussels	Moderate
Bryozoa	Absent
Worms	Few
Anemones	Absent
Mud Crab	Few

OB5 Swan Point Bar May 19, 1975

	NUMBER	PERCENT COMPOSITION
Market oysters	38	28
Small oysters	3	2
Spat	1	-
Boxes	9	10
Shell	-	60

Market oysters	
Size	medium to small
Condition	1+not marketable
Style	(5) present in 4
Polydora	2 per shell

Associated organisms	
Barnacle	Numerous
Mussels	Moderate
Bryozoa	Absent
Anemones	Few
Worms	Few
Mud Crab	Few
Rangia	Moderate

APPENDIX V: NUMBERS OF INDIVIDUAL BENTHIC SPECIES PER SQUARE METER

KENT ISLAND SPOIL DISPOSAL MONITORING DISTRIBUTION, AND NUMBERS OF BENTHIC SPECIES

SAMPLE DATE: 2-19-75

	SAMPLE STATION CODE								
	BB-1	BB-2	BB-3	BB-4	BB-5	BB-6	CB-1	CB-2	CB-3
COELENTERATES									
Diadumene leucolena		55	40	10	125		10		
CRUSTACEANS									
Balanus balanoides				5	5			5	
Callinectes sapidus									
Chiridotea coeca									
Cyathura polita					5	55	5		
Edotea triloba			95	5		15	5	10	
Corophium lacustre	5	5	70	75		5	60	10	
Leptocheirus plumulosus	115	15	70	40	25	1995	10	5	15
Monoculoides edwardsi	25	30			5		5	25	5
Parahaustorius holmsi									
Neomysis americanus							15		
Cumacean		5							
Gammerus sp.									
Melita nitida									
Rhithropahopeus harrisi									
POLYCHAETES									
Eteone heteropoda	10		25	10	100				195
Glycinde solitaria	50	80	15	10	135	5			40
Heteromastus filiformis	15	15	290	150	55	325	75		40
Nereis succinea	115	530	245	130	565	180	80	110	110
Pectinaria gouldii		15							
Polydora sp.		5	10						
Prionospio pinnate	565	491	50	40	3930	5	5		535
Scolecolepides viridis	95		925	1070	255	20	295	1410	1805
Scolplos fragilis	5								
Scoloplos robusta		5			55				20
Oligo chaetae									
FLATWORMS									
Stylochus ellipticus			15	5		5	5	5	
NEMERTEANS									
Micrura leidyi		45	25	50	10	70	35	115	20
MOLLUSCS									
Brachiodontes recurvus	5	10	10	15					
Crassostrea virginica		5			10			5	
Duridella obscura									
Macoma balthica			260	75		65	15	10	10
Macoma phenax			65	30			5	30	
Mulinia lateralis	4760	440	40	135	575				15215
Mya arenaria	25	25	3015	2965	25	10	135		35
Tagelus plebius			35	20		45	80	45	
Rangia cuneata									
TOTAL INDIVIDUAL	5840	1786	5300	4840	5880	2800	840	2000	18045
TOTAL SPECIES	14	17	19	19	17	14	17	15	14

SAMPLE DATE: 3-21-75

	SAMPLE STATION CODE								
	BB-1	BB-2	BB-3	BB-4	BB-5	BB-6	CB-1	CB-2	CB-3S
COELENTERATES									
Diadumene leucolena					105	10	90		10
CRUSTACEANS									
Balanus balanoides				5			85		30
Callinectes sapidus									
Chiridotea coeca			5						
Cyathura polita								5	
Edotea triloba							5		5
Corophium lacustre			30	10		10	180	5	
Leptocheirus plumulosus		45	55	80	20	20	40	5	25
Monoculoides edwardsi	5	10	40	15	5	5	15	45	5
Parahaustorius holmsi			60	140			10	210	140
Neomysis americanus	5	5				15			
Cumacean									
Gammerus sp.									
Melita nitida									
Rhithropahopeus harrisi									
POLYCHAETES									
Eteone heteropoda		60			55	145		25	5
Glycinde solitaria		125			65	25	5		
Heteromastus filiformis		25	40	25	20	30	85	290	40
Nereis succinea		480	60	20	560	465	200	65	30
Pectinaria gouldii					30	120			
Polydora sp.						5			
Prionospio pinnate		3170		25	1525	1360			
Scolecolepides viridis	20	3875	730	4725	1195	1150	1460	850	235
Scolplos fragilis									
Scoloplos robusta		5		75	80	110		10	10
Oligo chaetae									
FLATWORMS									
Stylochus ellipticus									
NEMERTEANS									
Micrura leidyi		40	5	25	40	65	15	120	30
MOLLUSCS									
Brachiodontes recurvus					5		30		
Crassostrea virginica									
Duridella obscura						10			
Macoma balthica		15		5		15	5	5	
Macoma phenax			25	15		6690		10	5
Mulinia lateralis		275	5		90	15			15
Mya arenaria		15	1850	1355			1155	875	2375
Tagelus plebius									
Rangia cuneata			130	90			50	20	65
TOTAL INDIVIDUAL	30	8090	3035	6640	3795	10265	3430	2540	3040
TOTAL SPECIES	3	16	13	16	14	20	18	16	17

SAMPLE DATE: 4-16-75

	SAMPLE STATION CODE								
	BB-1	BB-2	BB-3	BB-4	BB-5	BB-6	CB-1	CB-2	CB-3
COELENTERATES									
Diadumene leucolena			30	35	40				5
CRUSTACEANS									
Balanus balanoides		25	5	40					
Callinectes sapidus			5						
Chiridotea coeca									
Cyathura polita			5				5		5
Edotea triloba			40	5	5				55
Corophium lacustre	5	5	140	105		10	5	15	95
Leptocheirus plumulosus	5	5	115	25	5	5	15		50
Monoculoides edwardsi			5		5		10		5
Parahaustorius holmsi							5	40	
Neomysis americanus									
Cumacean									
Gammerus sp.					5				
Melita nitida			10	10		5			5
Rhithropahopeus harrisi									
POLYCHAETES									
Eteone heteropoda	150	25	40		30	100			285
Glycinde solitaria	15	45			5				10
Heteromastus filiformis	10	35	285	70	35		155	240	150
Nereis succinea	200	215	955	135	765	300	30		1250
Pectinaria gouldii	5	25				10			20
Polydora sp.						10			
Prionospio pinnate	140	1220		50	120		5		
Scolecolepides viridis	3485	665	8295	2055	1415		640	345	2895
Scolplos fragilis									
Scoloplos robusta	10	80			35	5		20	15
Oligochaetae							5		5
FLATWORMS									
Stylochus ellipticus									25
NEMERTEANS									
Micrura leidyi		45	25	15	5		70	115	110
MOLLUSCS									
Brachiodontes recurvus			5	25					5
Crassostrea virginica									
Duridella obscura									
Macoma balthica	15	25	430	25	15	20	10	10	630
Macoma phenax				5			15		45
Mulinia lateralis	905	605	35	10	1175	1115		5	260
Mya arenaria		15	2750	759	5	15	75	150	1890
Tagelus plebius									
Rangia cuneata			45	40					
TOTAL INDIVIDUAL	5095	3035	13220	3400	3665	1595	1045	940	5925
TOTAL SPECIES	12	15	19	17	17	13	14	9	22

SAMPLE DATE: 5-20-75

	SAMPLE STATION CODE								
	BB-1	BB-2	BB-3	BB-4	BB-5	BB-6	CB-1	CB-2	CB-3
COELENTERATES									
Diadumene leucolena	5			30	115	5		5	
CRUSTACEANS									
Balanus balanoides				65				175	
Callinectes sapidus									
Chiridotea coeca									
Cyathura polita							5	15	5
Edotea triloba			10						15
Corophium lacustre		5	195	145	10	15	25	30	115
Leptocheirus plumulosus		60	95	20	5	10	25		170
Monoculoides edwardsi	5		60	10			70	35	60
Parahaustorius holmsi	10						35	30	
Neomysis americanus									10
Cumacean									
Gammerus mucronatus			25				20		
Melita nitida			105	20				15	55
Rhithropahopeus harrisi			5						
POLYCHAETES									
Eteone heteropoda	25	45	10		25	25			35
Glycinde solitaria	15	10			35	15	5		10
Heteromastus filiformis	5	10	290	45	25	20	175	270	370
Nereis succinea	100	330	195	270	615	255	15	210	385
Pectinaria gouldii	5					25			
Polydora sp.									
Prionospio pinnate	280	575		10	915	665	10		
Scolecolepides viridis	215	775	1715	2930	945	560	2270	685	14170
Scolplos fragilis							15		
Scoloplos robusta	15				30	10			
Oligo chaetae								5	
FLATWORMS									
Stylochus ellipticus									
NEMERTEANS									
Micrura leidyi			85	40	10	50	60	60	165
MOLLUSCS									
Brachiodontes recurvus			5	45				110	
Crassostrea virginica									
Doridella obscura									
Macoma balthica	30	10	185	130	25	190	5	15	320
Macoma phenax			25						10
Mulinia lateralis	2840	545	45	10	20	1595	15		10
Mya arenaria	10		1735	1020		10	20	155	2465
Tagelus plebius									
Rangia cuneata			25	50			10		
TOTAL INDIVIDUAL	3560	2365	4810	4840	2775	3450	2770	1825	18370
TOTAL SPECIES	14	11	18	16	13	15	16	16	17

APPENDIX VI

CONCENTRATIONS OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 20 FEB. 1975

POOLED SAMPLES

Station Code	Cu	Zn	Fe	Cd	Mn
OB1	333	8,500	173	13	12
OB2	324	9,800	124	15	19
OB3	385	10,200	202	23	19
OB4	586	14,300	254	25	27
OB5	301	7,500	139	22	11
OB6	559	10,900	154	25	23
BB4Small	544	11,800	175	25	17
Big 1	504	14,100	124	22	10
Big 2	490	13,400	95	21	10
Big 3	505	13,000	112	21	7

Note: FOLLOWINGS METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Pb	<60
Co	<3
Ni	≤ 8
Cr	<50

CONCENTRATIONS OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 28 MARCH 1975

(POOLED SAMPLES)

Station Code	Cu	Zn	Fe	Cd	Mn
OB1	435	9,000	153	16	12
OB2	474	12,000	168	18	10
OB3	541	12,600	268	20	25
OB4	636	13,900	233	23	22
OB5	420	9,300	168	22	15
OB6	832	13,400	175	21	22
BB4 #1	451	11,100	174	17	15
BB4 #2	448	11,100	163	18	12
BB4 #3	433	11,000	181	18	12
S.D	540	10,000	90	11	20

CONCENTRATION OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 28 MARCH 1975

(POOLED SAMPLES)

Pb	< 30
Co	< 3
Ni	± 6
Cr	< 30

CONCENTRATIONS OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 15 April 1975

(POOLED SAMPLES)

Station Code	Cu	Zn	Fe	Cd	Mn
OB1	430	12,400	220	18	12
OB2	380	9,700	160	19	12
OB3	400	10,100	220	15	19
OB4	650	14,800	460	21	37
OB5	550	12,800	150	26	10
OB6	420	8,200	130	30	15

CONCENTRATION OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 28 MARCH 1975

(POOLED SAMPLES

Pb	< 35
Co	< 7
Ni	± 5
Cr	< 3

CONCENTRATIONS OF HEAVY METALS IN OYSTERS (ppm DRY WEIGHT) COLLECTED 19 MAY 1975

(POOLED SAMPLES)

	Cu	Zn	Fe	Cd	Mn
OB-1	289	8400	182	14	10
OB-2	461	11800	196	14	15
OB-3	344	9200	293	19	26
OB-4	825	15100	1319	24	104
OB-5	582	13400	216	23	22
OB-6	629	12300	168	22	16
SD	540	10000	90	11	20

Following metals were at concentrations below levels necessary for accurate detection.

Pb $<$ 30

Co $<$ 3

Ni $\pm$ 6

Cr $<$ 5

CONCENTRATIONS OF HEAVY METALS IN SOFT SHELL CLAMS (ppm DRY WEIGHT) COLLECTED 20 FEBRUARY 1975

POOLED SAMPLES

Station Code	Cu	Zn	Fe	Mn
CB2	54	138	930	240
CB3	40	253	1,380	710
CB4	45	192	3,480	1,070
CB5	44	225	4,390	860
BB3	52	174	1,210	690

NOTE: FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co	< 12
Ni	< 12
Cr	< 4
Pb	< 35
Cd	< 3

CONCENTRATIONS OF HEAVY METALS IN *Rangia* CLAMS (ppm DRY WEIGHT) COLLECTED 20 FEBRUARY 1975.

POOLED SAMPLES

Station Code	Cu	Zn	Fe	Mn
CB2	20	71	182	11
BB4	71	482	1,360	203
BB3	22	150	1,130	210

Note: FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co	< 8
Ni	± 12
Cr	< 4
Cd	< 3
Pb	< 35

CONCENTRATIONS OF HEAVY METALS IN SOFT SHELL CLAMS (ppm DRY WEIGHT)

COLLECTED 18 April 1975

POOLED SAMPLES

Station Code	Cu	Zn	Fe	Mn
CB1	56	170	1000	240
CB2	45	244	2300	540
CB3	47	225	1100	500
CB4	43	274	1750	940
CB5	46	268	3550	1010

NOTE: FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co	< 10
Ni	± 6
Cr	< 5
Pb	< 35
Cd	< 4

CONCENTRATIONS OF HEAVY METALS IN SOFT SHELL CLAMS (ppm DRY WEIGHT)

COLLECTED 21 MAY 1975

(POOLED SAMPLES)

	Cu	Zn	Fe	Mn
CB-1	39	268	1470	840
CB-2	42	229	510	624
CB-3	40	296	430	864
CB-4	47	225	1360	1080

FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co	< 10
Ni	± 4
Cr	< 6
Pb	< 20
Cd	< 3

CONCENTRATIONS OF HEAVY METALS IN Rangia CLAMS (ppm DRY WEIGHT) COLLECTED 18 April 1975.

POOLED SAMPLES

Station Code	Cu	Zn	Fe	Mn
CB2	13	93	360	26
BB3	13	105	340	83

Note: FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co	< 5
Ni	± 18
Cr	<5
Cd	<4
Pb	<35

CONCENTRATIONS OF HEAVY METALS IN RANGIA CLAMS (ppm DRY WEIGHT) COLLECTED 21 MAY 1975

(POOLED SAMPLES)

	Cu	Zn	Fe	Mn
CB-1	14	114	317	39
CB-2	12	108	280	43
CB-4	15	125	660	57
BB-4	13	104	370	43

FOLLOWING METALS WERE AT CONCENTRATIONS BELOW LEVELS NECESSARY FOR ACCURATE DETECTION

Co < 5

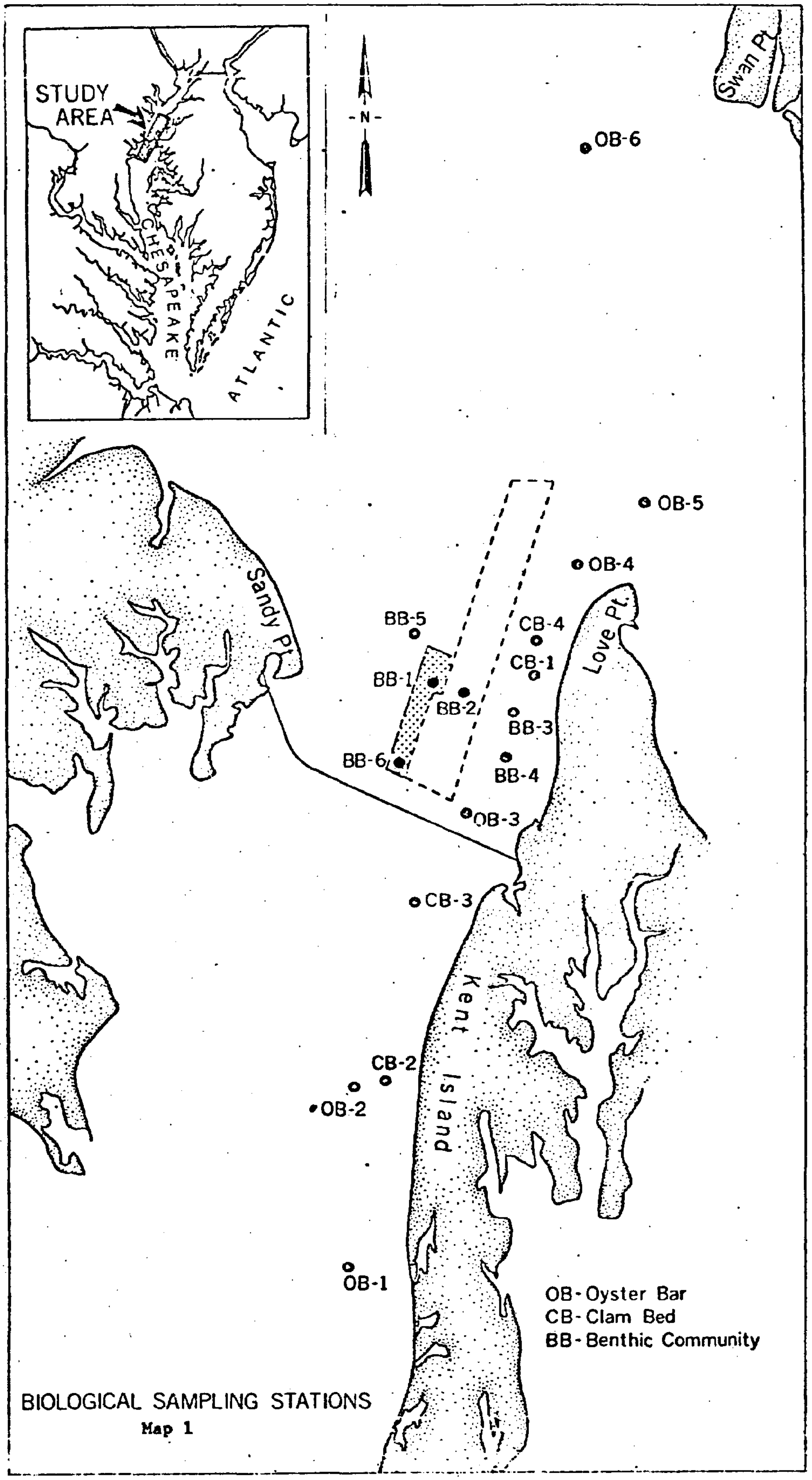
Ni ± 12

Cr < 5

Cd < 3

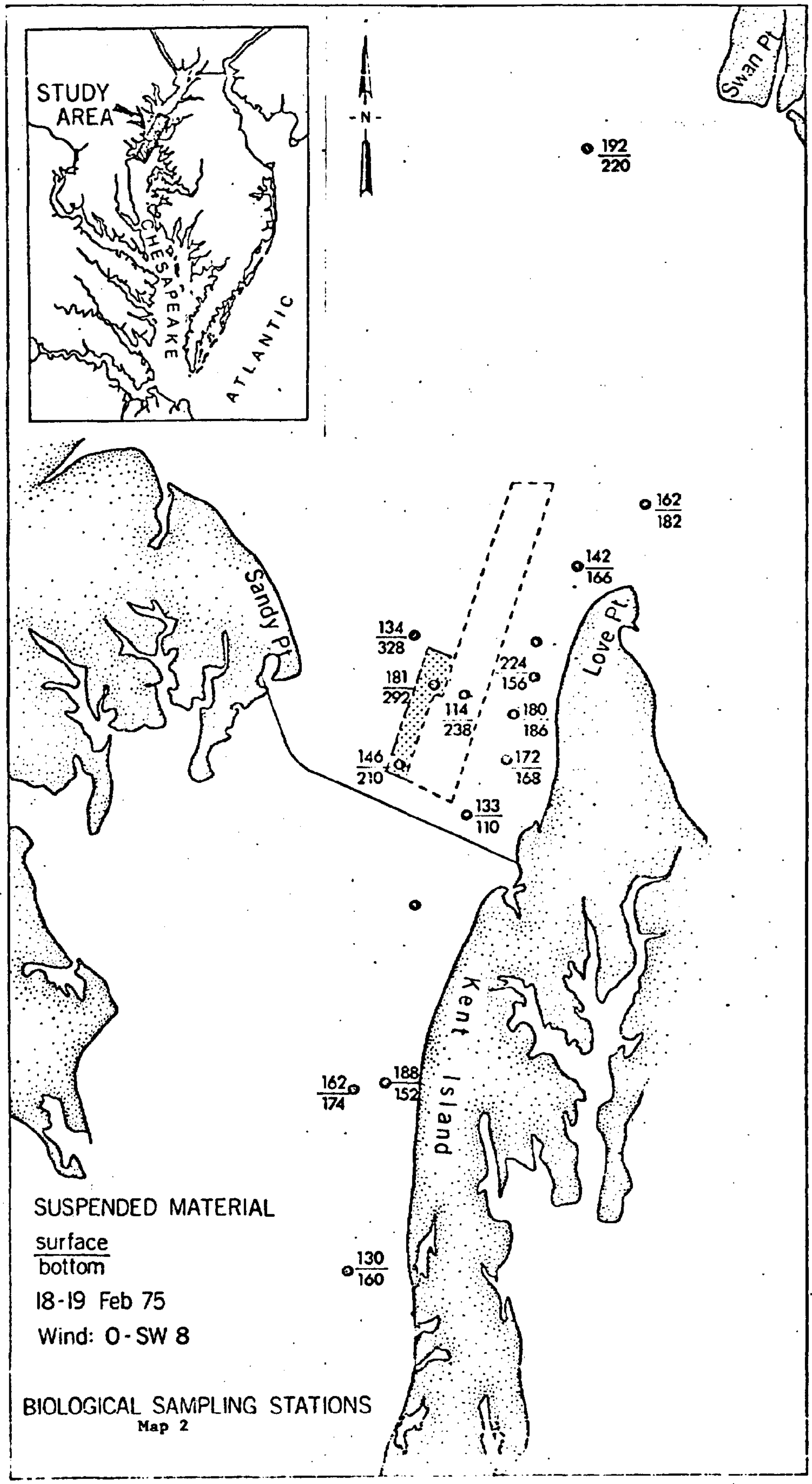
Pb < 20

APPENDIX VII: OBSERVATIONS OF SUSPENDED MATERIAL AND SALINITY

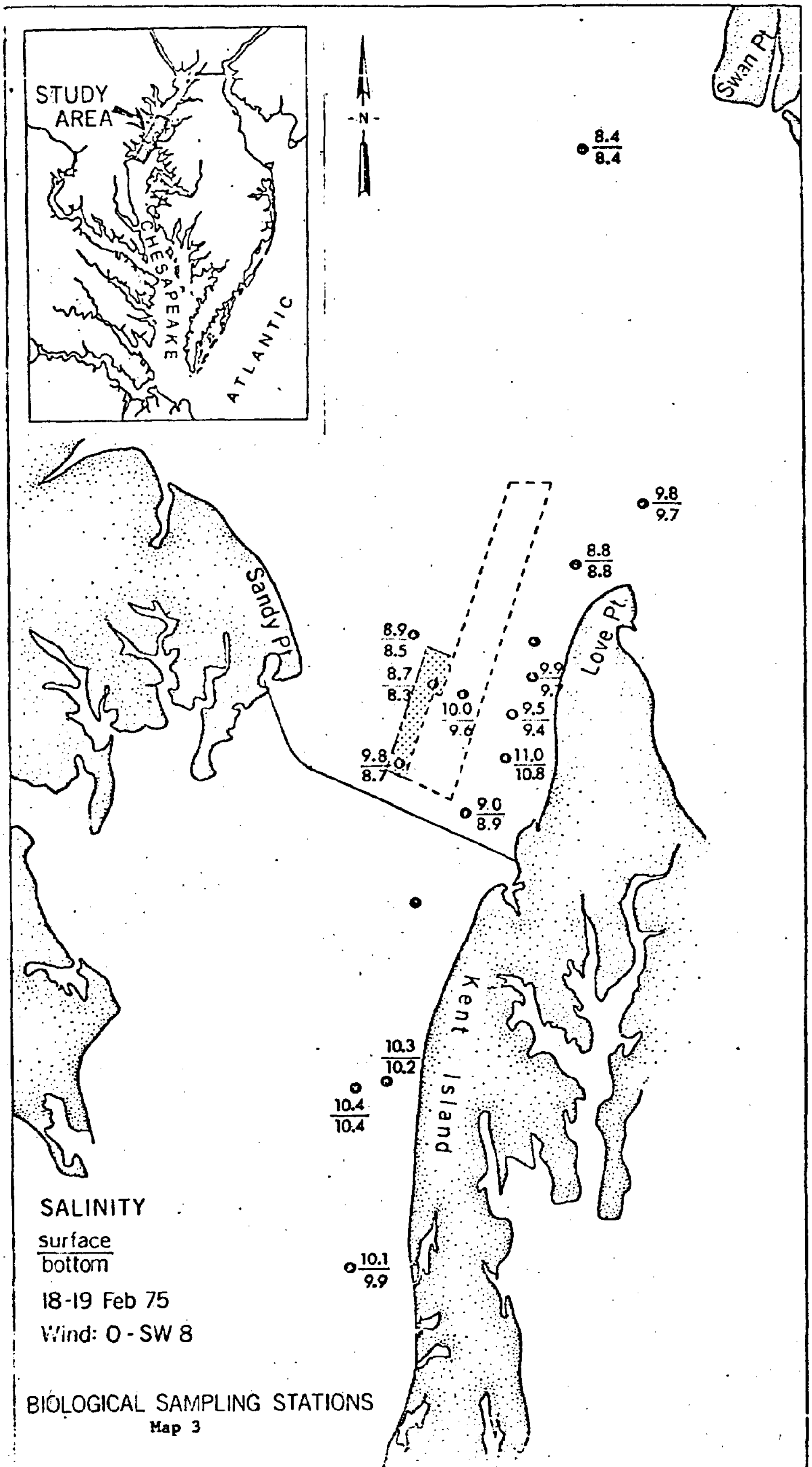


BIOLOGICAL SAMPLING STATIONS

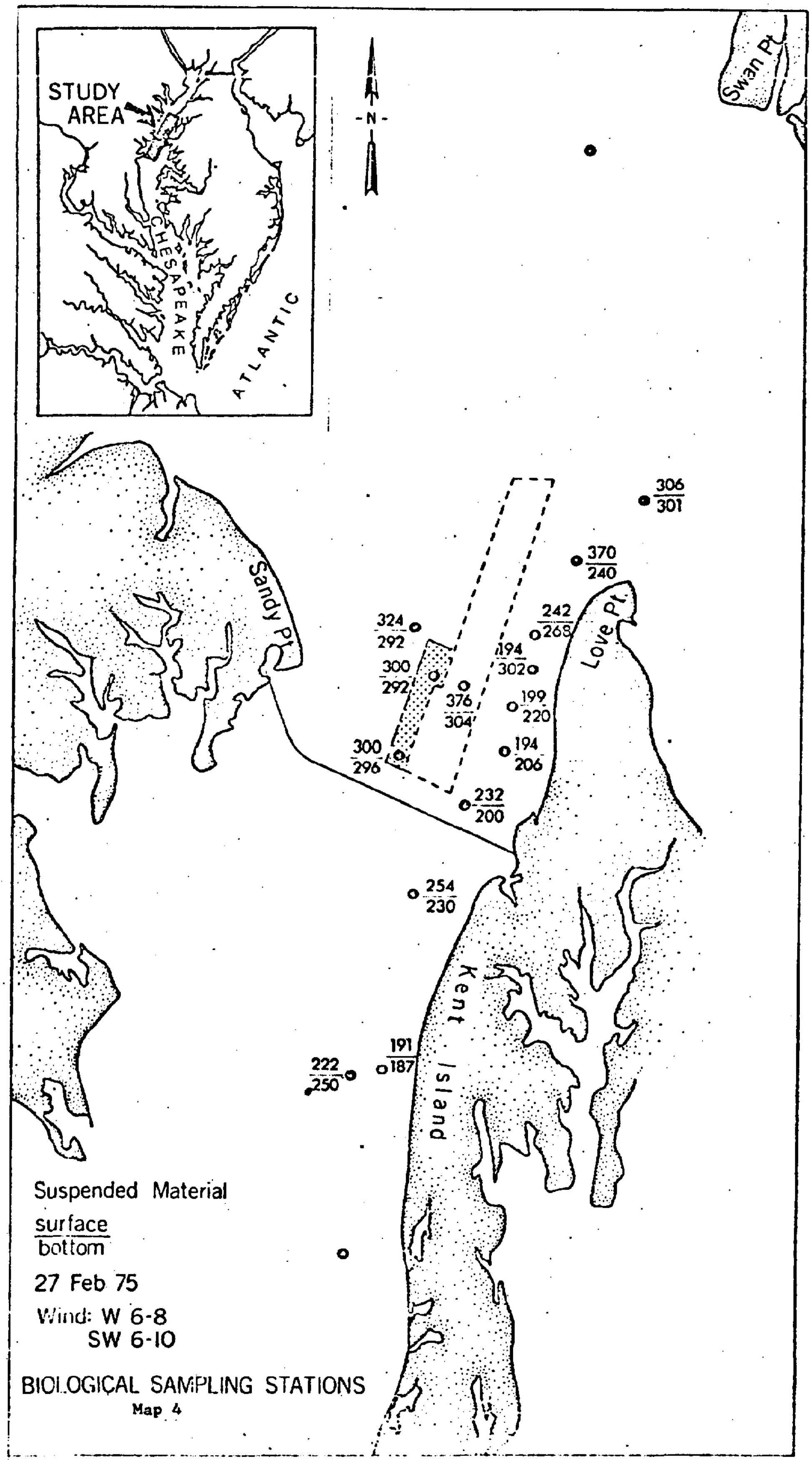
Map 1



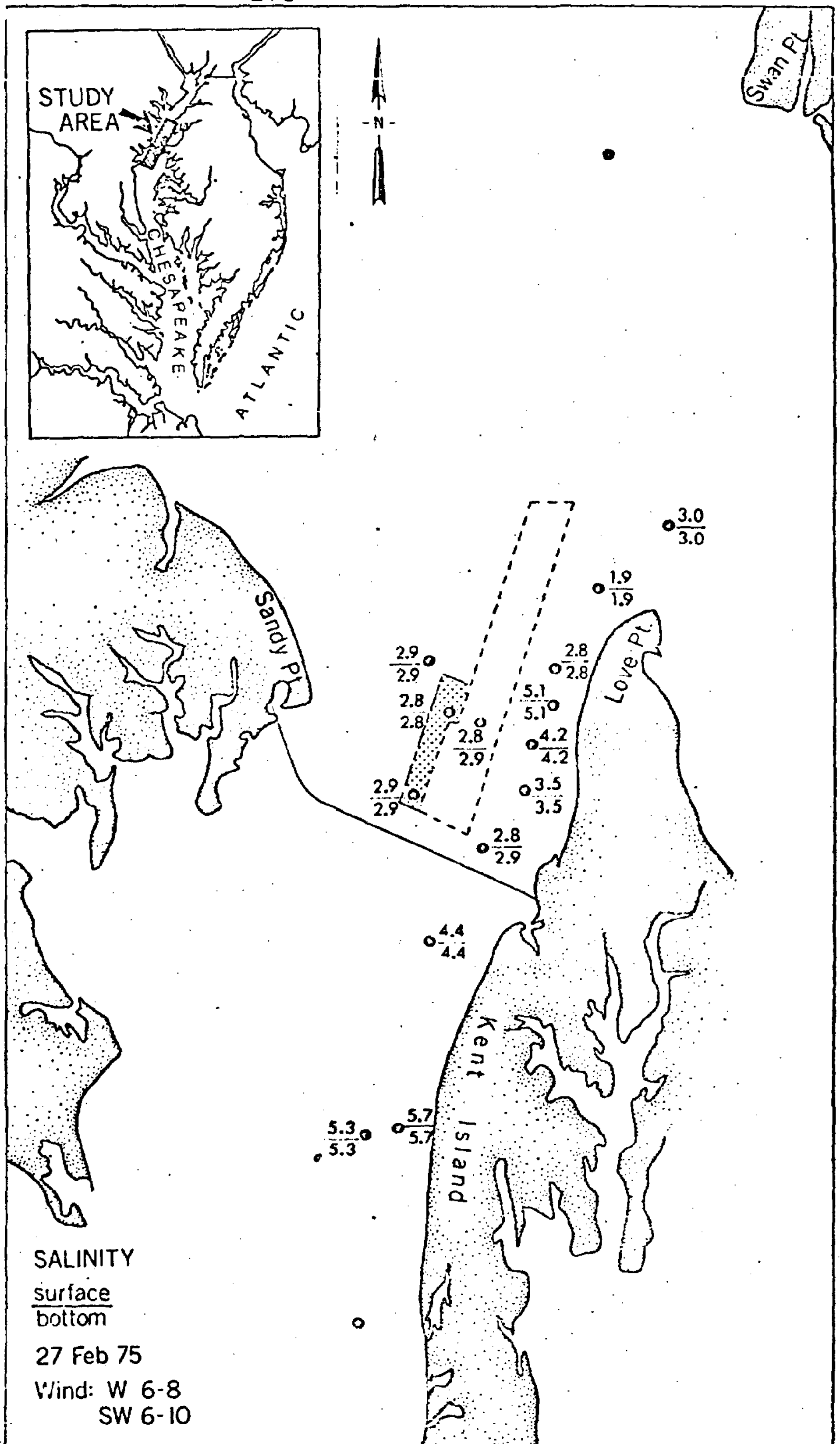
BIOLOGICAL SAMPLING STATIONS
Map 2



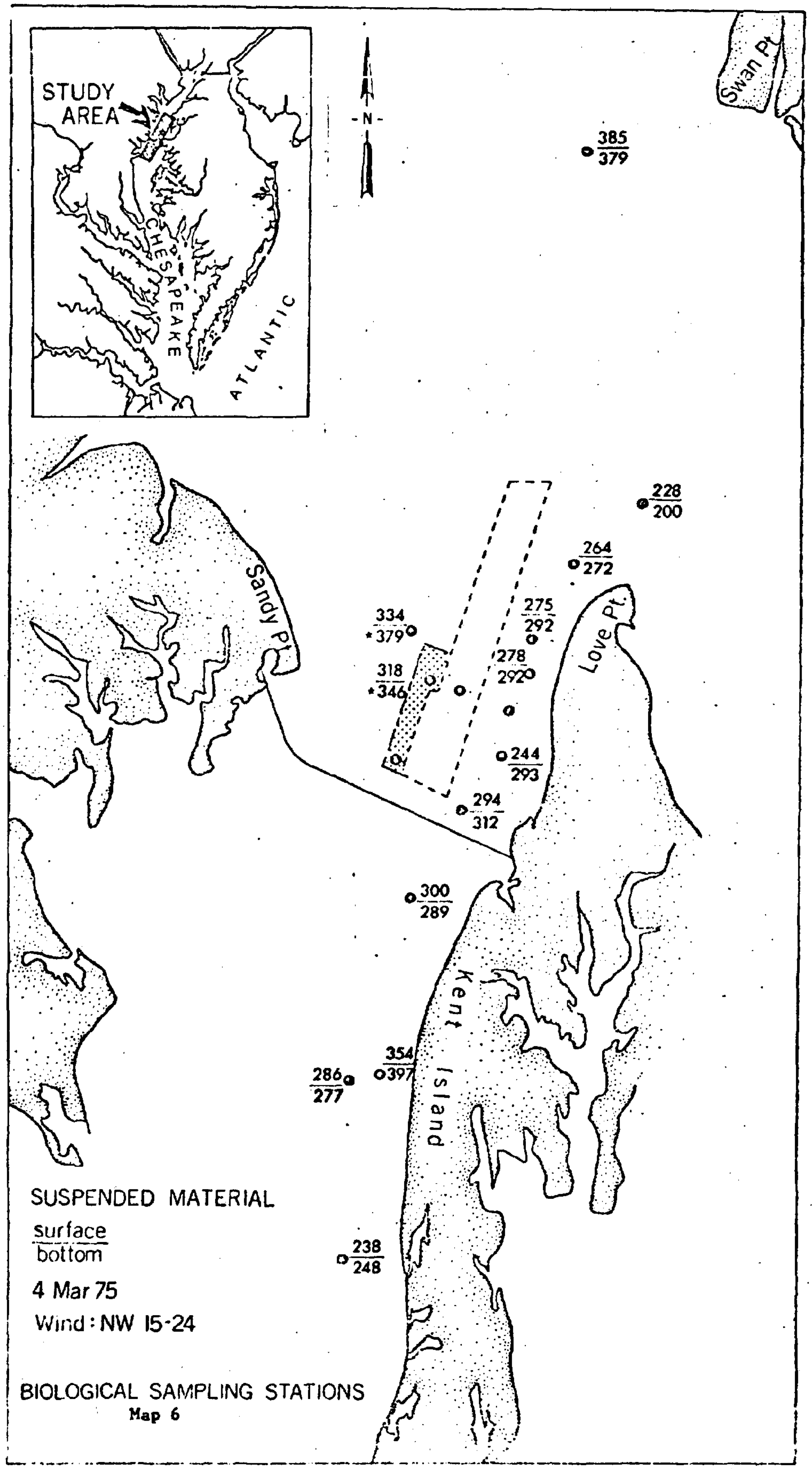
BIOLOGICAL SAMPLING STATIONS
Map 3



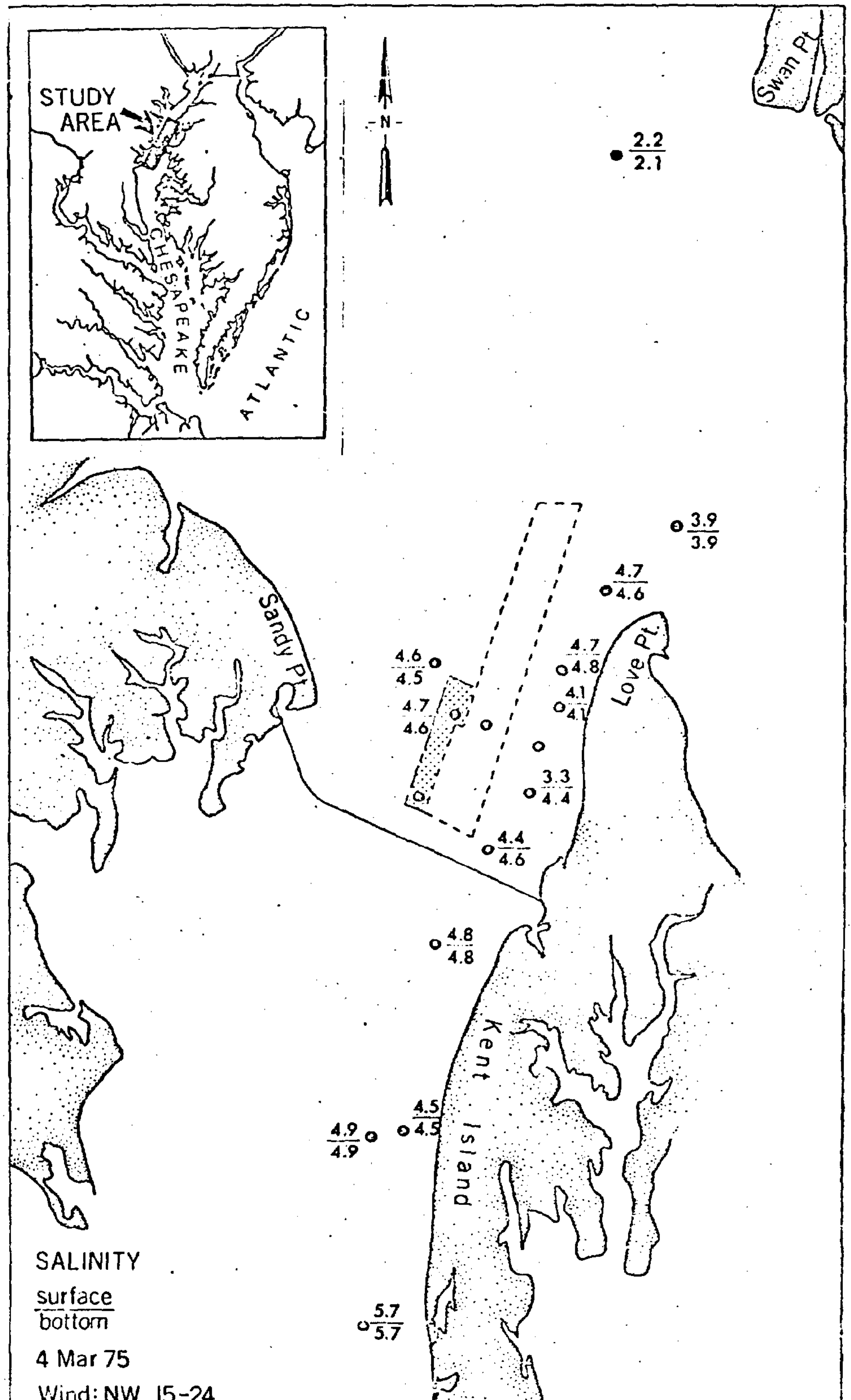
BIOLOGICAL SAMPLING STATIONS
Map 4



BIOLOGICAL SAMPLING STATIONS
Map 5

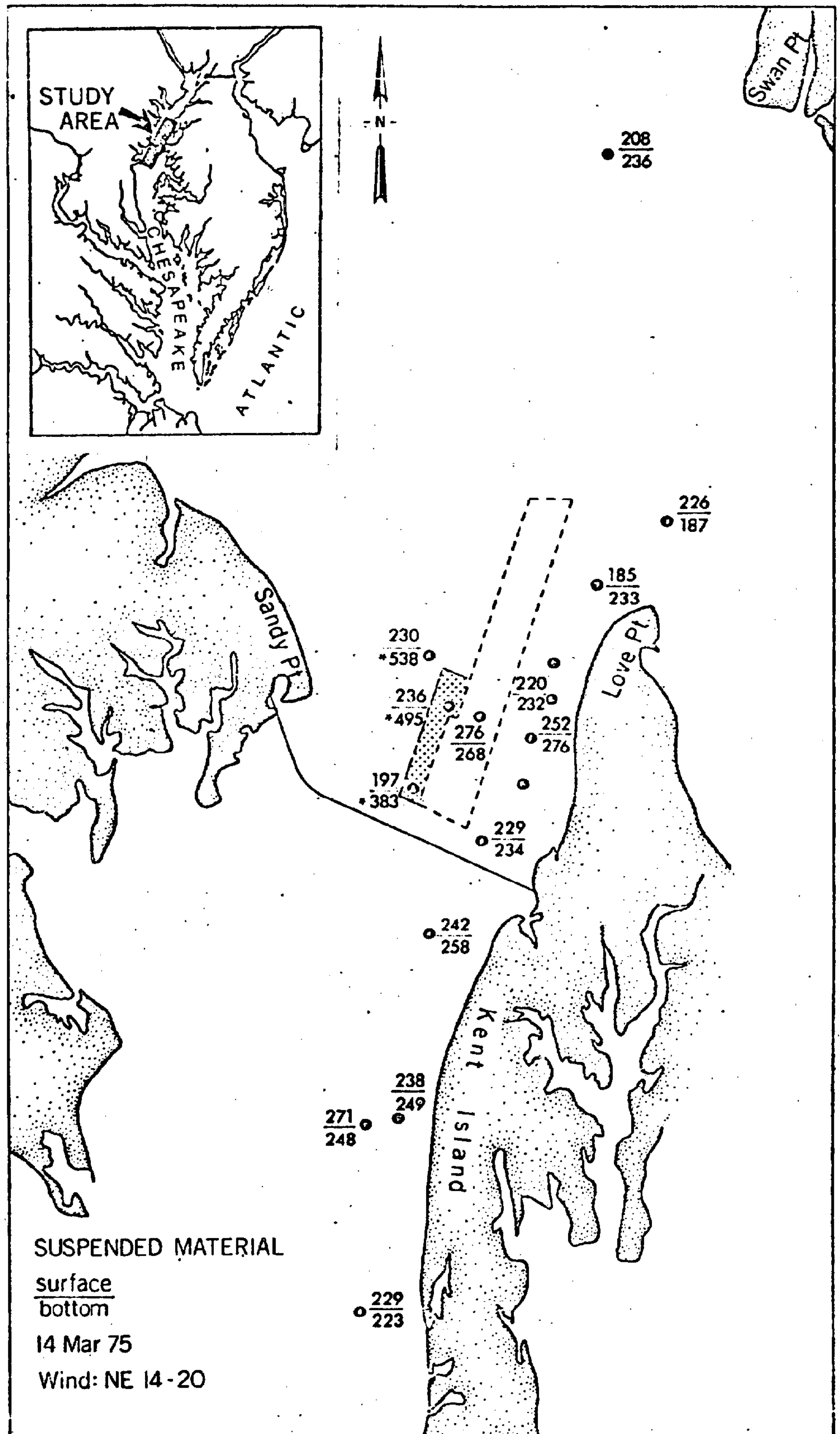


BIOLOGICAL SAMPLING STATIONS
Map 6



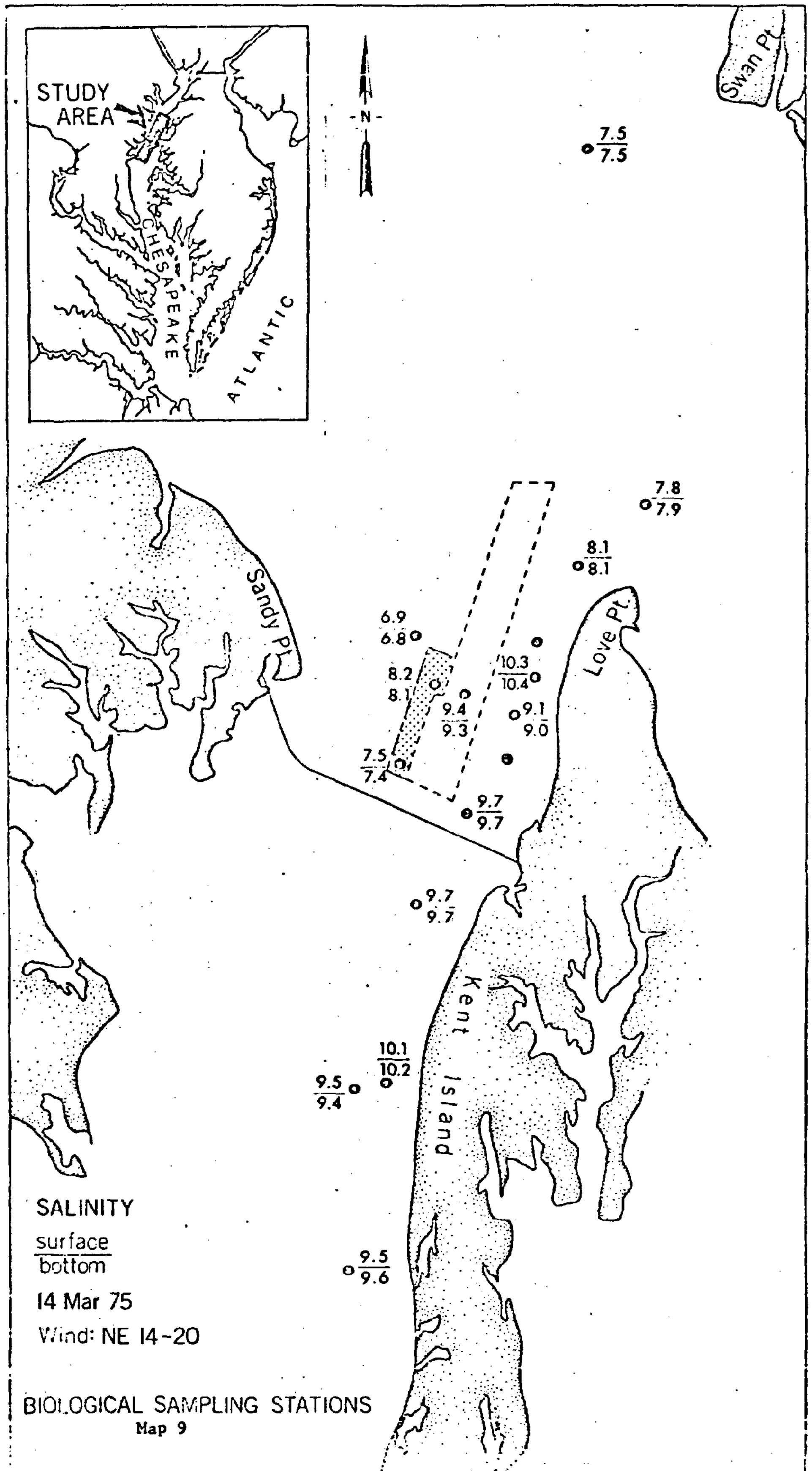
BIOLOGICAL SAMPLING STATIONS

Map 7

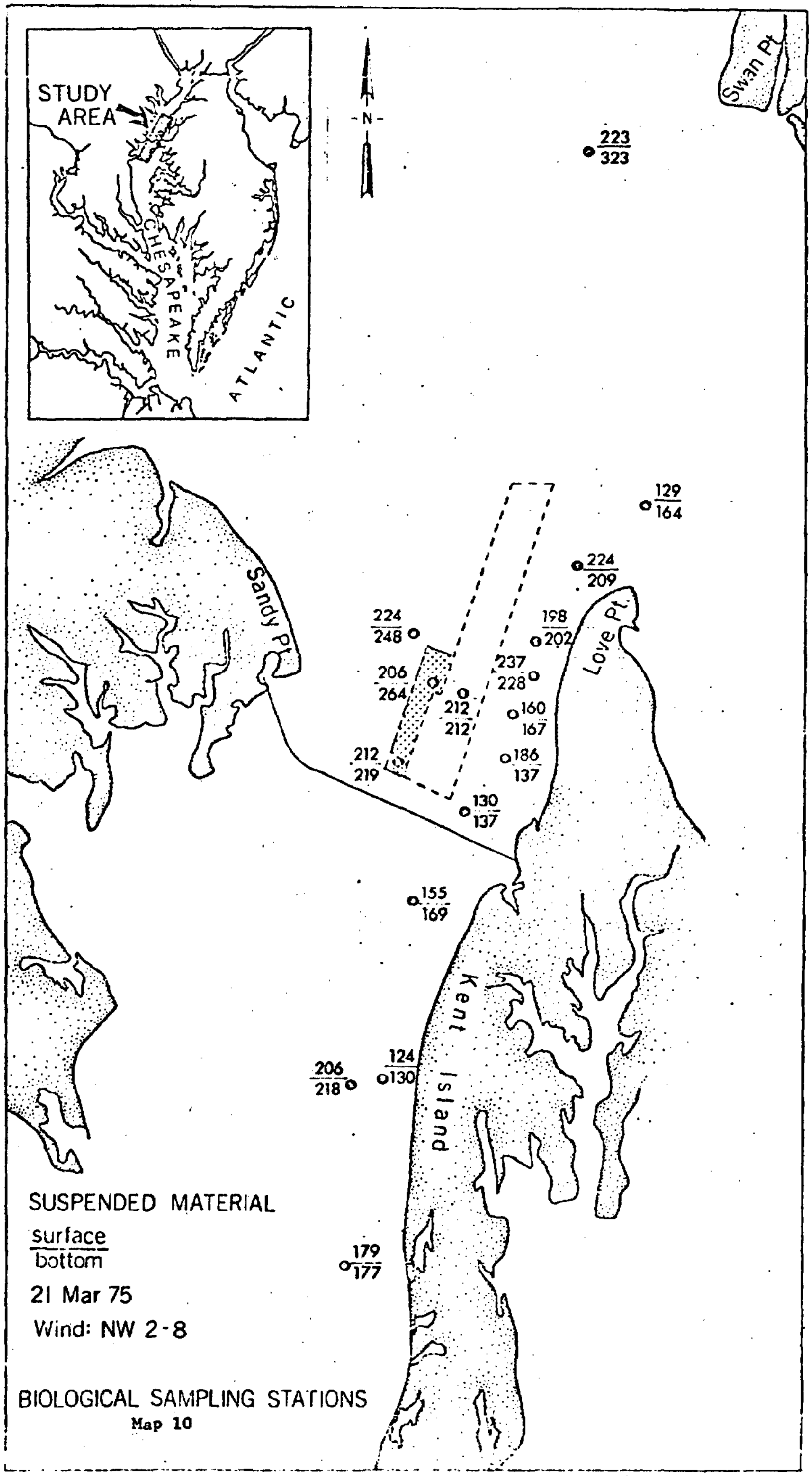


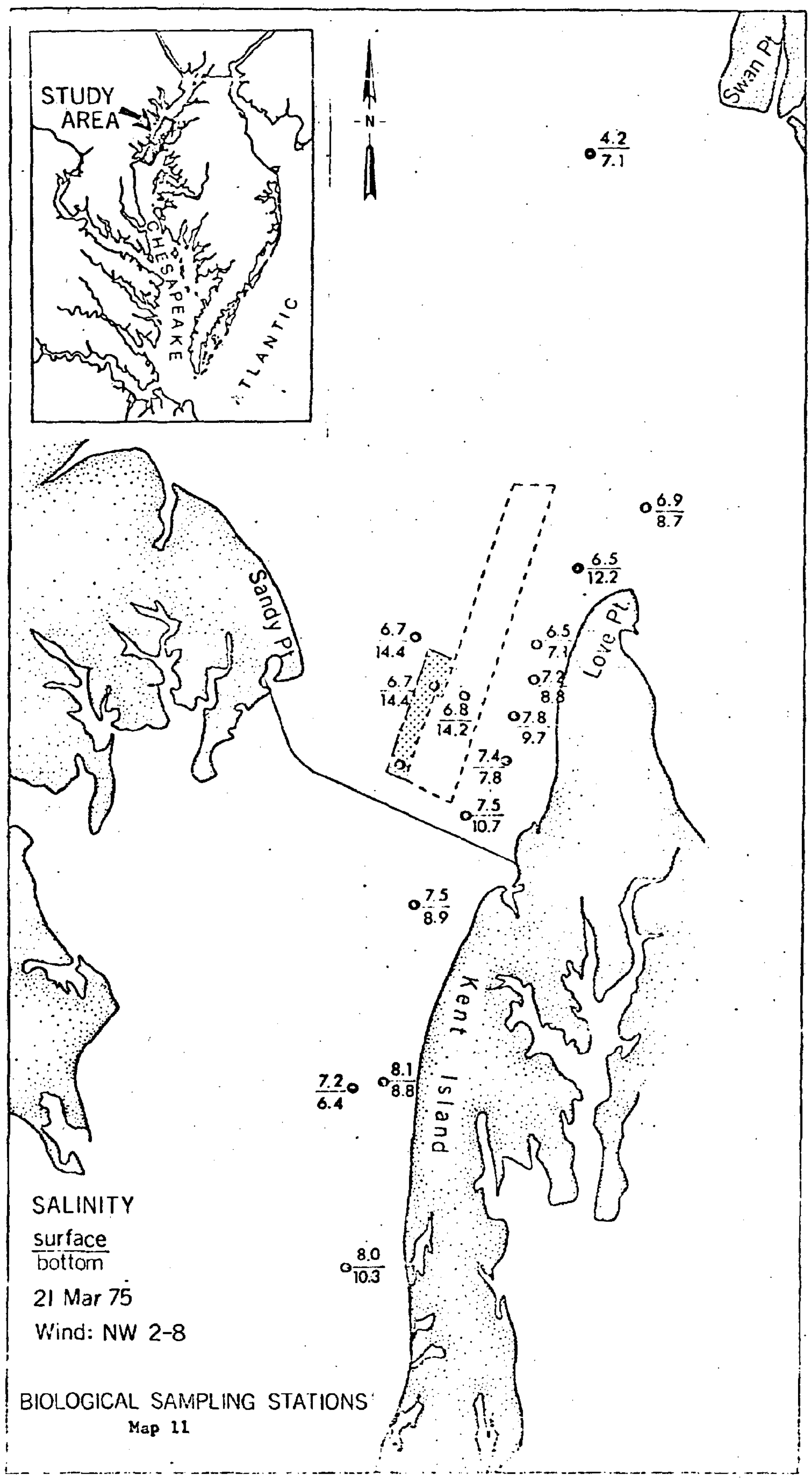
BIOLOGICAL SAMPLING STATIONS

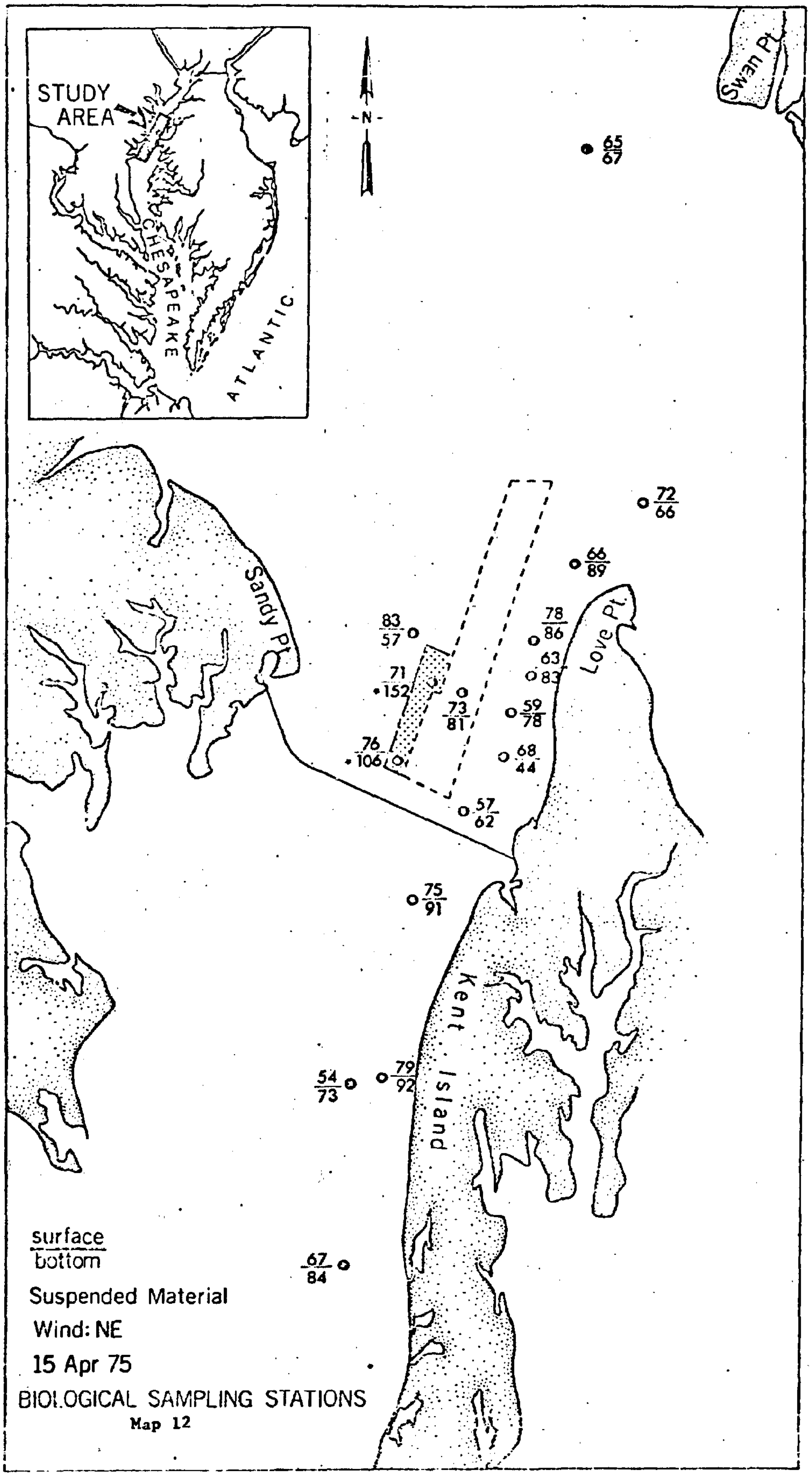
Map 8



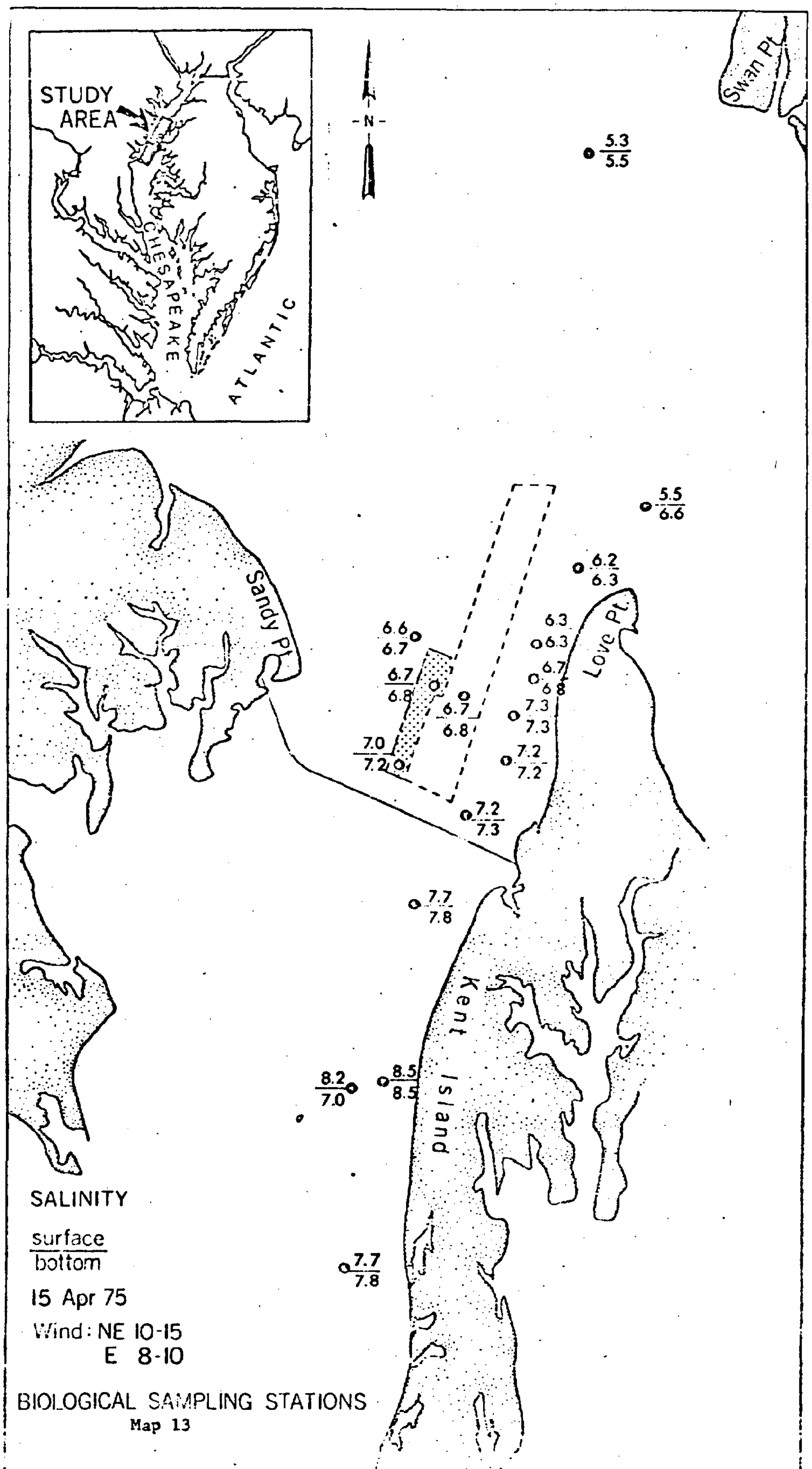
BIOLOGICAL SAMPLING STATIONS
Map 9


STUDY AREA
CHESAPEAKE
ATLANTIC
N
Swan Pt.
223
323
129
164
224
209
Sandy Pt.
224
248
198
202
Love Pt.
206
264
237
228
212
212
160
167
212
219
186
137
130
137
155
169
Kent Island
206
218
124
130
179
177
SUSPENDED MATERIAL
surface
bottom
21 Mar 75
Wind: NW 2-8
BIOLOGICAL SAMPLING STATIONS
Map 10

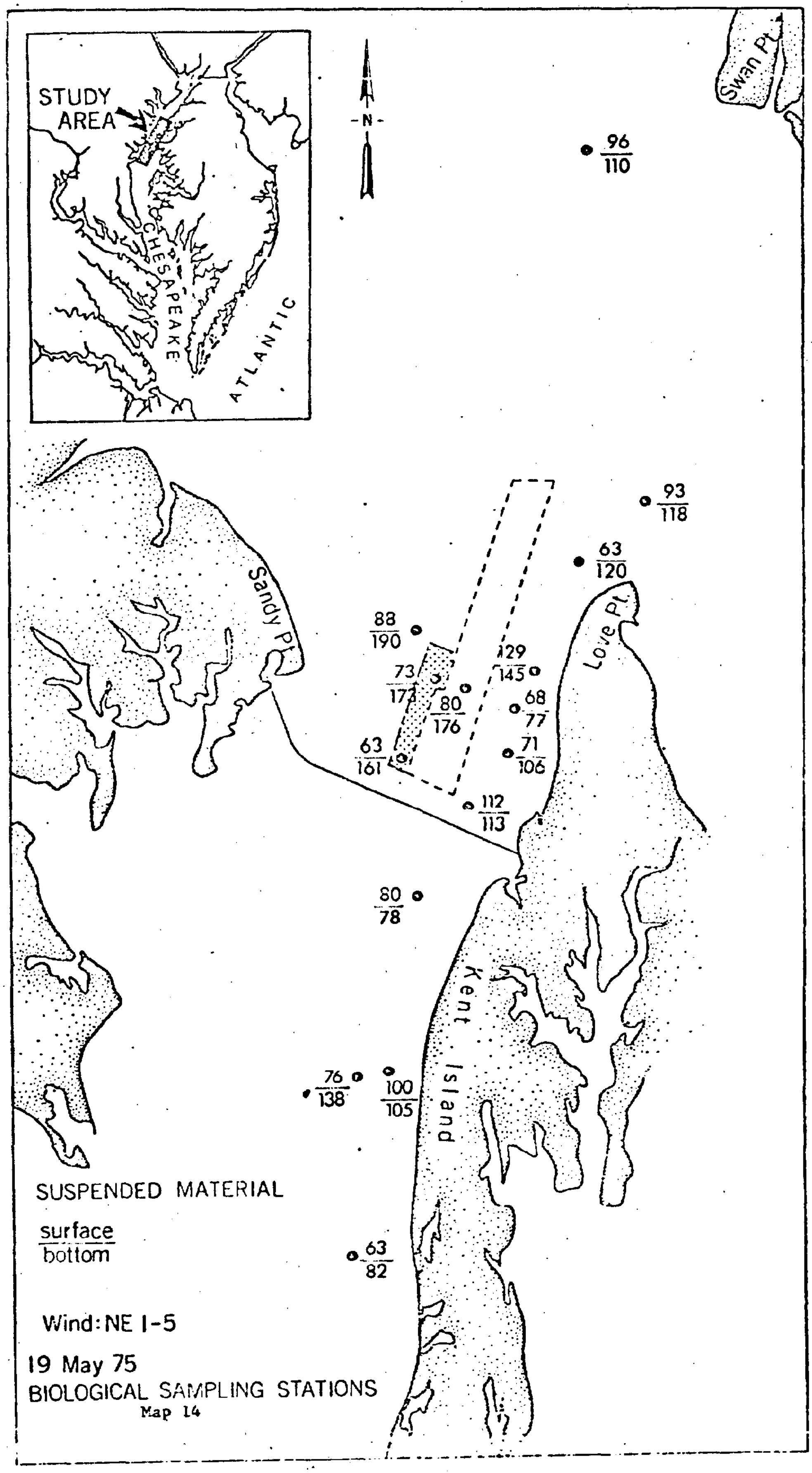

STUDY
AREA
CHESAPEAKE
ATLANTIC
N
Swan Pt.
Sandy Pt.
Love Pt.
Kent Island
4.2
7.1
6.9
8.7
6.5
12.2
6.7
14.4
6.5
7.1
7.2
8.8
6.7
14.4
6.8
14.2
7.8
9.7
7.4
7.8
7.5
10.7
7.5
8.9
7.2
6.4
8.1
8.8
8.0
10.3
SALINITY
surface
bottom
21 Mar 75
Wind: NW 2-8
BIOLOGICAL SAMPLING STATIONS
Map 11


STUDY AREA
CHESAPEAKE
ATLANTIC
N
Swan Pt.
Sandy Pt.
Love Pt.
Kent Island
65/67
72/66
66/89
83/57
78/86
63/83
71/152
73/81
59/78
76/106
68/44
57/62
75/91
54/73
79/92
67/84
surface/bottom
Suspended Material
Wind: NE
15 Apr 75
BIOLOGICAL SAMPLING STATIONS

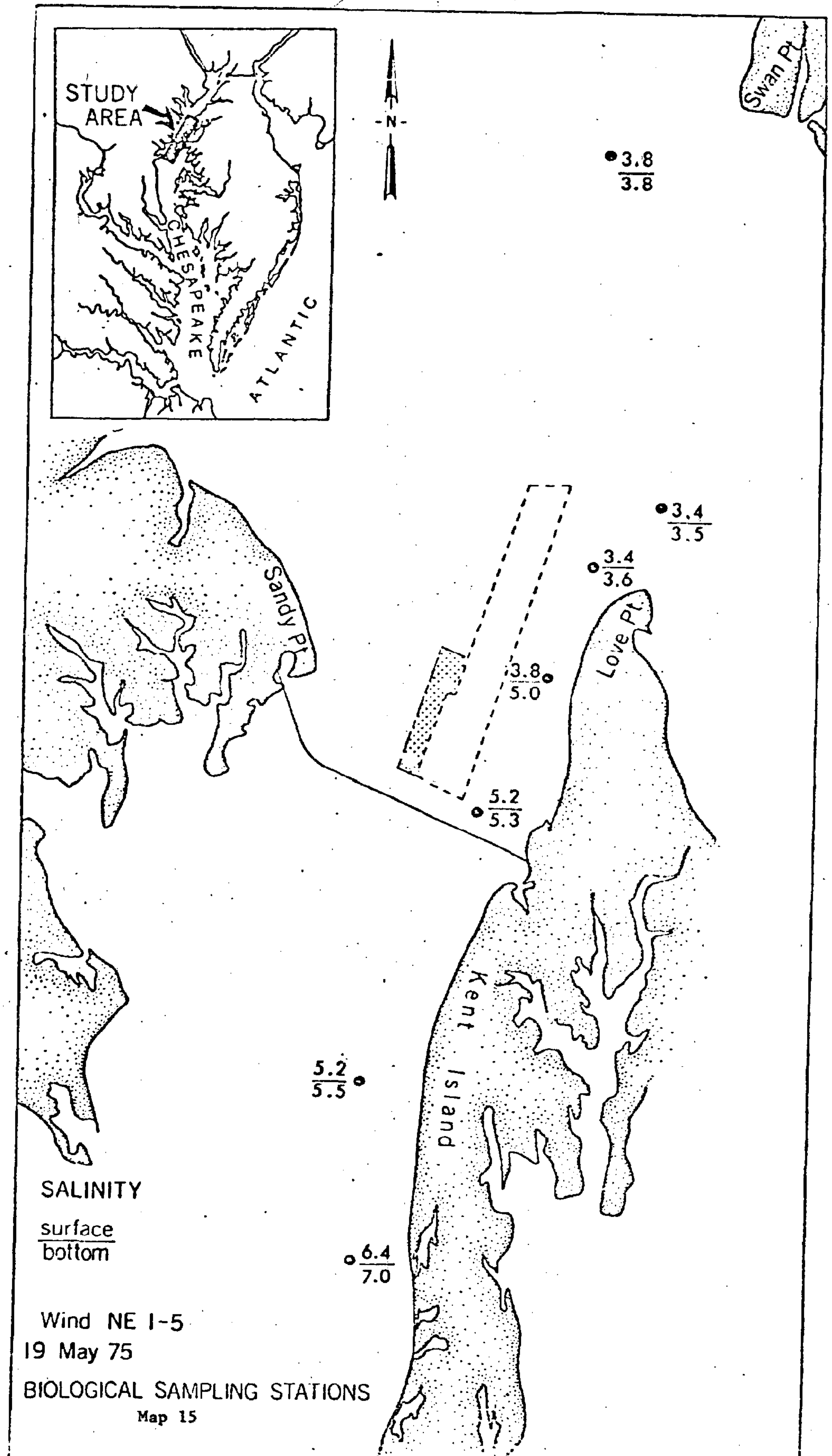
Map 12


STUDY
AREA
CHESAPEAKE
ATLANTIC
N
Swan Pt.
Sandy Pt.
Love Pt.
Kent Island
5.3 / 5.5
5.5 / 6.6
6.2 / 6.3
6.3 / 6.3
6.7 / 6.8
7.3 / 7.3
7.2 / 7.2
7.2 / 7.3
6.6 / 6.7
6.7 / 6.8
6.7 / 6.8
7.0 / 7.2
7.7 / 7.8
8.2 / 7.0
8.5 / 8.5
7.7 / 7.8
SALINITY
surface / bottom
15 Apr 75
Wind: NE 10-15
E 8-10
BIOLOGICAL SAMPLING STATIONS

Map 13



19 May 75
BIOLOGICAL SAMPLING STATIONS
Map 14


STUDY AREA
CHESAPEAKE
ATLANTIC
N
Swan Pt.
3.8
3.8
3.4
3.5
3.4
3.6
Sandy Pt.
Love Pt.
3.8
5.0
5.2
5.3
Kent Island
5.2
5.5
6.4
7.0
SALINITY
surface
bottom
Wind NE 1-5
19 May 75
BIOLOGICAL SAMPLING STATIONS

Map 15

SECTION FIVE:

BACTERIOLOGICAL AND PUBLIC HEALTH IMPACTS

REPORT ON THE PUBLIC HEALTH IMPACT OF DREDGE SPOIL DISPOSAL OPERATIONS AT KENT ISLAND AS MEASURED BY BACTERIOLOGICAL WATER QUALITY, BACTERIOLOGICAL CONCENTRATIONS IN SHELLFISH, AND LEVELS OF TRACE METALS AND CHLORINATED HYDROCARBONS IN SHELLFISH.

OCTOBER 1975

Department of Health and Mental Hygiene
Environmental Health Administration
Division of General Sanitation

TABLE OF CONTENTS

ABSTRACT

In accordance with its public health responsibility, the Environmental Health Administration monitored the disposal operations of dredge spoil material at the Kent Island Spoil Disposal Site.

Bacteriological levels in water and in shellfish were monitored to insure that no deviance from public health standards resulted from the disposal operations. Levels of trace metals, polychlorinated biphenyls (PCBs) and chlorinated hydrocarbons were also monitored in shellfish.

Water quality was found to exhibit no significant bacteriological degradation resulting from disposal operations. Similarly, microbial levels in shellfish demonstrated no significant increase. Levels of trace metals, PCBs and chlorinated hydrocarbons in shellfish did not significantly increase throughout the study period.

INTRODUCTION

In accordance with its responsibility to the public health of the citizens of Maryland, the Environmental Health Administration of the Department of Health and Mental Hygiene conducted a program of monitoring the Army Corps of Engineers' disposal of dredge spoil material at the Kent Island disposal site. The efforts of the Environmental Health Administration were in conjunction with those of the Water Resources Administration and the Chesapeake Biological Laboratory.

The most immediate public health consideration of the dumping activities was the possibility of a microbiological loading resulting from sediment bound bacteria being dispersed into surrounding waters, thereby contaminating viable oysters and clams which are commercially harvested in the areas adjacent to the disposal site.

To assess the potential health impact of such a loading, the Environmental Health Administration established monitoring stations immediately over and in the surrounding vicinity of the actual disposal site. Information derived from these monitoring stations in conjunction with historical bacterial profiles of the area coming from previously established shellfish waters sampling stations made possible a quantitatively accurate statement of the bacteriological impact of disposal activities.

Water temperature and salinity measurements were also recorded at these stations.

In addition to monitoring water quality, oysters and clams were collected and examined for bacterial concentrations throughout the study. Oysters and clams were also analyzed for levels of trace metals, polychlorined biphenyls (PCBs) and chlorinated hydrocarbons. These levels were determined both before and after disposal activities.

The function of this report shall be to describe the dredge spoil disposal's impact on the public health as measured in terms of: (1) Bacteriological water quality (2) bacteriological concentrations in marketable shellfish, and (3) levels of trace metals and chlorinated hydrocarbons in oysters and clams.

METHODS

A. Bacteriological Examination of Water and Shellfish

Personnel of the Environmental Health Administration were utilized for sampling and transporting samples to the laboratories. Bacteriological examinations were performed at the Department of Health and Mental Hygiene Central Laboratory in Baltimore and in the Department's branch laboratory in Easton. All sampling and examination procedures were conducted in accordance with Standard Methods for the Analysis of Sea Water and Shellfish, Fourth Edition, 1970, American Public Health Association, Inc. Field methods included standard aseptic collection techniques and icing of samples during transport to the laboratories. Samples of shellfish were collected before, during, and after disposal operations using conventional dredging equipment.

B. Concentrations of Trace Metals, Polychlorinated Biphenyls (PCBs), and Chlorinated Hydrocarbons in Shellstock

Shellfish were collected at stations from Swan Point to Bloody Point. These samples were then subject to analysis for trace metals, chlorinated hydrocarbons and PCBs utilizing the following procedures:

Metals in Shellstock

1. Metals

25.000 g portion, previously homogenized, is placed in a preweighed 250 ml glass-stoppered digestion flask. 25 mls concentrated nitric acid is added and allowed to sit overnight to prevent frothing upon addition of heat. The sample is then refluxed, attached to a reflux water cooled condenser, for 45 minutes. The cooled sample is filtered through glass wool and brought to volume (100 mls) and processed by atomic absorbtion analysis.

2. <u>Mercury</u>

0.500 g portion is placed in a pre-weighed 250ml glass-stoppered digestion flask. 10-20 mg vanadium pentoxide is added to sample followed by 20 mls (1+1) nitricsulfuric acid mixture. The digestion flask containing the sample is then attached to a water cooled reflux condenser and refluxed for ten minutes. 15ml distilled water is added through the condenser. 2 drops hydrogen peroxide are added through the condenser followed by an additional 15ml of distilled water. The sample is then filtered through glass and brought to volume (100 ml). Just before atomic absorption analysis, 20ml stannous chloride reducing solution is added to sample.

Pesticides in Shellstock

For a representative sample, 100 gms is taken from the total homogenized sample.

1. <u>Extraction</u>

Sample is blended with acetonitrile and filtered. The acetonitrile filtrate contains the pesticide residues which are then partitioned into petroleum ether and cleaned up with water.

The petroleum ether is put through a florisil column using the following elutions:

a. 200 ml Hexane - the PCBs come out in this elution

b. 200 ml 6% ethyl-ether in petroleum ether - this elution brings out chlordane, heptachlor, toxaphene, DDD, DDT and numerous other chlorinated hydrocarbons

c. 200 ml 15% ethyl ether in petroleum ether - this elution brings out dieldrin, endrin, parathion, etc.

Each elution is concentrated to 10 ml and 5 ml or less is injected into the G.C.

2. Gas Chromatographs

Barber Colman 5360 - column 10% DC 200 on Chromosorb WHP
Ni 63 Detector

Perkin-Elmer 900 - column 10% DC 200-15% QFI on Chromosorb
WHP Ni 63 Detector

Tracor 220 - column 3% OV 1 on Chromosorb WHP
Flame photometric Detector specific
for organo phosphates

The Ni 63 detectors are specific for the chlorinated hydrocarbons. The columns give different separations and one can be used to confirm residues found in the other. Thin layer chromatography is also used as a qualitative confirmatory procedure.

OBSERVATIONS AND DISCUSSION

A. Bacteriological Water Quality

At the time of actual disposal operations, fecal coliform populations at the disposal site were compared to fecal coliform concentrations in the water at stations ranging from 2.8 nautical miles (5,110 meters) north of disposal site to 4.8 nautical miles (8,890 meters) south of the disposal site. Essentially, it was found that waters associated immediately with the disposal site demonstrated no significant difference in water quality when compared to any of the other monitoring stations.

The absence of a loading phenomenon is evidenced in Table I which compares median and geometric mean values of fecal coliform organisms (MPN/100ml) at the disposal site to stations adjacent to the disposal site and stations located north and south of the disposal site.

Water samples collected from February 27 to March 6, 1975 and on March 25, 1975 as summarized in Table 2, reflect elevated concentrations of fecal coliforms at all stations. However, this increase is probably not attributable to disposal activities, but to the runoff resulting from the heavy rainfall during the later part of February (Appendix #1) as recorded by the National Oceanic and Atmospheric Administration and evidenced by associated decreases in salinity (Appendix #2).

In concluding discussion of the bacteriological water quality section of this report, no measured microbiological loading was found to be associated with the disposal operations.

B. Bacteriological Concentrations in Oysters and Softshell Clams.

As with water, the primary concern with shellfish was the potential transfer of sediment bound bacteria.

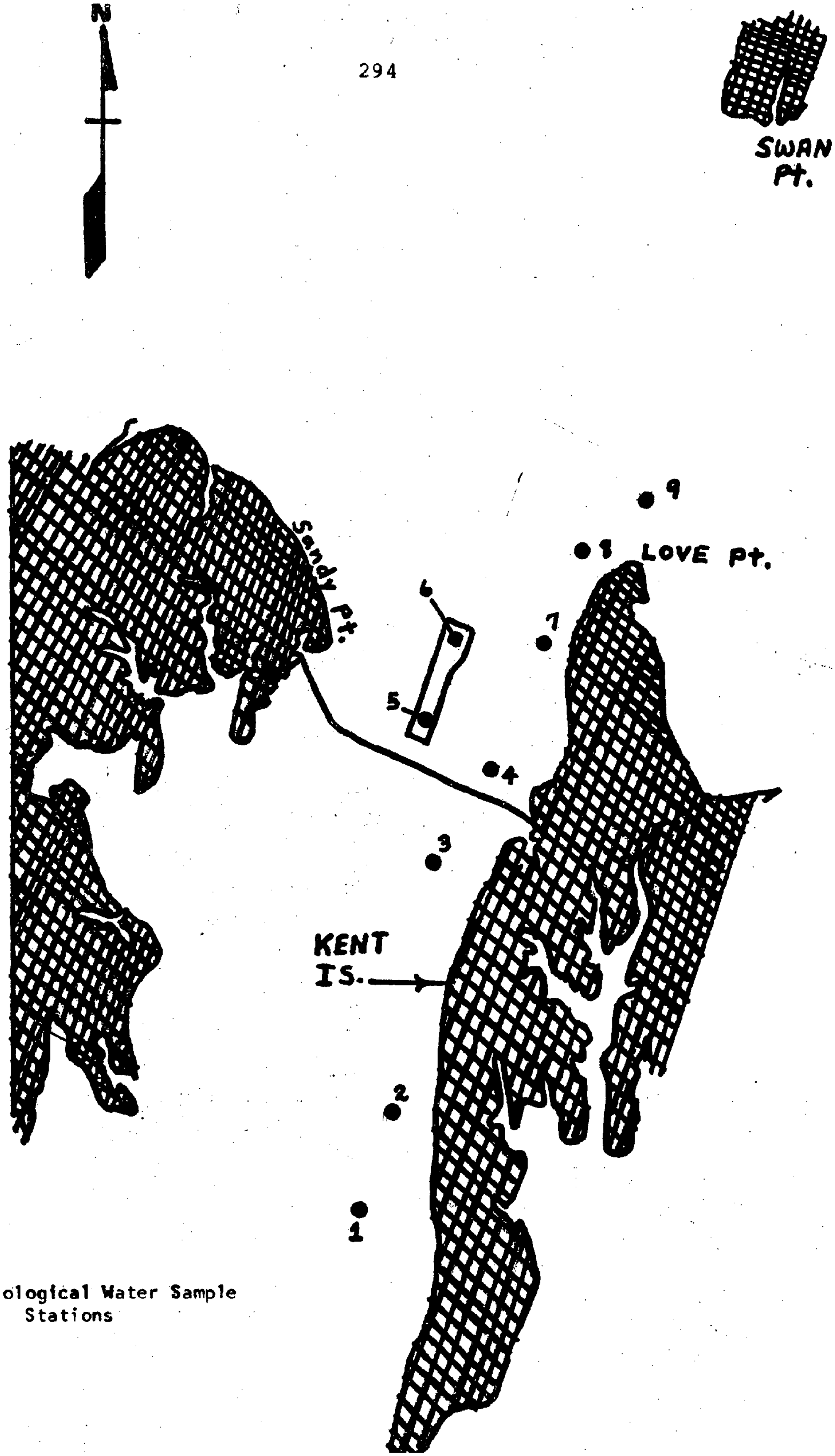
Bacteriological examination of oysters and softshell clams for fecal coliforms and standard plate counts (S.P.C.) taken from stations located from Swan Point to Kentmoor, before, during and after disposal operations indicate that no significant increase of these indicator organisms had occurred due to disposal operations.

Table 3 and 4 summarize the fecal coliform and standard plate counts (S.P.C.) concentrations found in shellfish before, during and after disposal operations. It is significant to note that concentrations of fecal coliforms in shellfish did not increase with the short term increase of fecal coliform organisms in water that was associated with the runoff following the rainfall in late February. This is most probably due to the reduced pumping rate of oysters at temperatures below 50° F (10° C).

C. Concentration of Trace Metals and Chlorinated Hydrocarbons in Shellstock

No significant increase was observed in shellstock samples for trace metals, PCB and chlorinated hydrocarbons. Tables 5 to 9 summarize the comparison between shellstock sampled before, during and after disposal operations.

For no parameter, at any point, was a significant increase in either trace metals or chlorinated hydrocarbons evidenced.



Bacteriological Water Sample
Stations

TABLE 1

COMPARISON OF MEDIAN AND GEOMETRIC MEAN
VALUES OF FECAL COLIFORM ORGANISMS (MPN)/100 ml.
AT THE DISPOSAL SITE TO ALL OTHER STATIONS
DURING THE TIME OF DISPOSAL OPERATIONS

Station Number	Distance from Disposal Site: Nautical Miles	Distance from Disposal Site: Meters	Median Fecal Coliforms (MPN/100ml.)	Geometric Mean Fecal Coliforms (MPN/100ml.)	Number of Samples
	Stations at Disposal Site				
5	0	0	*3	3.8	11
6	0	0	3.6	5.9	13
	Stations between Disposal Site and Kent Island Shore				
4	0.80	1,482	3.6	5.0	13
7	0.70	1,300	3.6	8.0	13
	Stations North of Disposal Site				
8	1.40	3,520	*3	6.3	13
9	2.80	5,110	*3	6.5	12
	Stations South of Disposal Site				
3	2.10	3,890	3.6	5.8	13
2	3.40	6,300	3.6	5.0	12
1	4.80	8,890	*3	4.1	12

* = less than

TABLE 2

BACTERIOLOGICAL WATER SAMPLE RESULTS

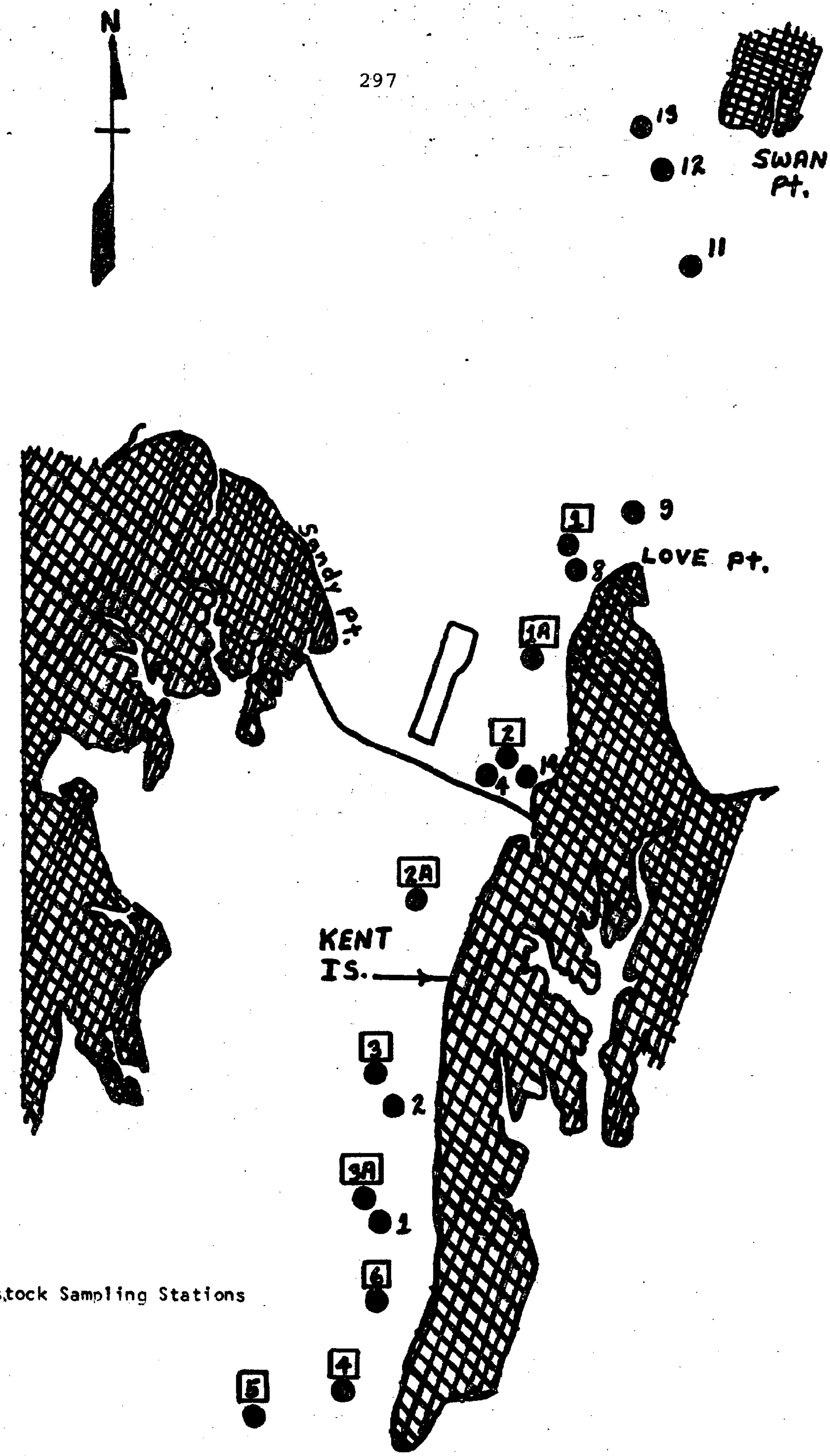
(REPORTED IN FECAL COLIFORM ORGANISMS (MPN)/100ml.)

(February 19 to March 25, 1975)

Station Number / Date	1	2	3	4	5	6	7	8	9	
2/19/75	*3	*3	*3	*3	*3	*3	*3	*3	*3	Surface Samples
	*3	*3	*3	3.6	*3	*3	*3	*3	*3	Bottom Samples
2/24/75	*3	*3	*3	*3	*3	*3	*3	*3	*3	Surface Samples
										Bottom Samples
2/26/75			3.6	*3	*3	*3	*3	*3	*3	Surface Samples
										Bottom Samples
2/27/75	3.6	3.6	23	43	93	93	93	240	43	Surface Samples
										Bottom Samples
3/4/75	240	93	93	43	N.S.	93	240	93	93	Surface Samples
	23	93	93	23	N.S.	39	240	150	240	Bottom Samples
3/5/75	15	15	43	93	150	93	75	43	75	Surface Samples
										Bottom Samples
3/6/75	23	43	75	23	43	23	43	43	23	Surface Samples
										Bottom Samples
3/11/75	3.6	3.6	*3	*3	*3	3.6	9.1	3.6	3.6	Surface Samples
										Bottom Samples
3/13/75	*3	3.6	3.6	3.6	3.6	*3	3.6	*3		Surface Samples
										Bottom Samples
3/14/75	*3	*3	*3	*3	*3	*3	*3	*3	*3	Surface Samples
	*3	*3	*3	*3	*3	3.6	*3	*3	*3	Bottom Samples
3/21/75	*3	*3	*3	*3	*3	*3	*3	*3	3.6	Surface Samples
										Bottom Samples
3/25/75	*3	*3	*3	43	3.6	23	23	93	43	Surface Samples
	*3	*3	3.6	23	43	23	*3	150	23	Bottom Samples

*= Less than

N.S.= no sample



Shellstock Sampling Stations

TABLE 3 - LEVELS OF FECAL COLIFORMS PER 100 GRAMS FOUND IN SHELLSTOCK COLLECTED FROM STATIONS LOCATED FROM SWAN POINT TO KENTMOOR. (JANUARY 8, 1975 TO MARCH 25, 1975)

		STATIONS LOCATED NORTH OF DISPOSAL SITE					STATIONS LOCATED ADJACENT TO DISPOSAL SITE				STATIONS LOCATED SOUTH OF DISPOSAL SITE							
	DATE COLLECTED	STATION NUMBER 8	9	11	12	13	STATION NUMBER [2]	4	[1A]	[1]	STATION NUMBER [2A]	[3]	2	[3A]	1	[6]	[4]	[5]
SHELLSTOCK SAMPLES COLLECTED PRIOR TO DISPOSAL OPERATIONS	1/8/75	Samples not collected					20			230								
	1/16/75	Samples not collected					78			45		20				40	*18	45
	1/28/75	Samples not collected					20			45	*18	*18		*18		20	61	78
SHELLSTOCK SAMPLES COLLECTED DURING DISPOSAL OPERATIONS	2/24/75		*18	*18		*18		*18										
	2/27/75																	
	3/4/75	*18		*18	*18			20					*18		*18			
	3/5/75	20																
	3/14/75	*18	*18			78		*18					*18		*18			
SHELLSTOCK SAMPLES COLLECTED AFTER DISPOSAL OPERATIONS	3/25/75	*18	*18	*18				*18					*18		*18			

* = LESS THAN

TABLE 4 - STANDARD PLATE COUNT (S.P.C.) PER GRAM FOUND IN SHELLSTOCK COLLECTED FROM STATIONS LOCATED FROM SWAN POINT TO KENTMOOR. (JANUARY 8, 1975 TO MARCH 25, 1975)

	DATE COLLECTED	STATIONS LOCATED NORTH OF DISPOSAL SITE STATION NUMBER 8	9	11	12	13	STATIONS LOCATED ADJACENT TO DISPOSAL SITE STATION NUMBER 2	4	1A	1	STATIONS LOCATED SOUTH OF DISPOSAL SITE STATION NUMBER 2A	3	2	3A	1	6	4	5
SHELLSTOCK SAMPLES COLLECTED PRIOR TO DISPOSAL OPERATIONS	1/8/75	Samples not collected					*3,000			*3,000								
	1/16/75	Samples not collected					15,000			18,000		12,000				8,800	5,200	36,000
	1/28/75	Samples not collected					7,400			18,000	5,000	*3,000		10,000		6,400	6,000	6,200
SHELLSTOCK SAMPLES COLLECTED DURING DISPOSAL OPERATIONS	2/24/75		*3,000	*3,000		*3,000		46,000										
	2/27/75																	
	3/4/75	*3,000		*3,000	*3,000			*3,000					*3,000		*3,000			
	3/5/75	*3,000																
	3/14/75	*3,000	*3,000			*3,000		*3,000					*3,000		4,800			
SHELLSTOCK SAMPLES COLLECTED AFTER DISPOSAL OPERATIONS	3/25/75	*3,000	*3,000	*3,000				*3,000					4,900		*3,000			

* = LESS THAN

TABLE 5 - COMPARISON OF TRACE METALS, PCBs AND CHLORINATED HYDROCARBONS IN OYSTERS BEFORE, DURING AND AFTER DISPOSAL OPERATIONS AT STATIONS LOCATED BETWEEN DISPOSAL SITE AND KENT ISLAND SHORE

DATE	STATION NUMBER	Cu.	Zn.	Cd.	Hg.	Pb.	Cr.	PCB	CHLOR-DANE	DDT	DDD	DDE	DIEL-DRIN	ENDRIN	BHC
	AT SITE BEFORE														
1/8/75	[1]	86.7	2201	3.88	.025	*0.1	*0.1	0.05	0.05		0.006		0.005	0.005	
	AT SITE DURING														
2/24/75	4	82.7	2619	2.55	0.026	*0.1	*0.1	0.03	0.04		0.006		0.004		0.003
2/26/75	4	72.3	1830	2.51	0.019	*0.1	*0.1	0.03			0.007		0.004		0.003
3/14/75	4	80.6	2064	2.6	0.013	*0.1	no results	0.05	0.04				0.007	0.003	0.003
	AT SITE AFTER														
3/25/75	4	85.9	2191	2.8	0.015	*0.1	no results	0.03	0.04				0.005		

* = LESS THAN

TABLE 6 - COMPARISON OF TRACE METALS, PCB, AND CHLORINATED HYDROCARBONS IN SOFT CLAMS (MYA ARENARIA) BEFORE AND AFTER DISPOSAL OPERATIONS AT STATIONS LOCATED BETWEEN DISPOSAL SITE AND KENT ISLAND SHORE

DATE	STATION NUMBER	Cu.	Zn.	Cd.	Hg.	Pb.	Cr.	PCB	CHLOR-DANE	DDT	DDD	DDE	DIEL-DRIN	ENDRIN	BHC
AT SITE BEFORE															
1/16/75	2	11.4	25	0.24	0.016	*0.1	0.4		0.04		0.01		0.02	0.007	0.003
1/16/75	1	11.1	29	0.35	0.015	*0.1	0.4		0.04		0.01		0.01	0.007	0.004
1/28/75	1	17.8	28	0.28	0.013	*0.1	0.4	0.03	0.04		0.006		0.008	0.004	0.004
1/28/75	2	17.5	28	0.14	0.021	*0.1	0.4	0.03	0.03		0.005		0.005	0.002	0.004
AT SITE AFTER															
7/21/75	11	13.2	26.4	.26	.012	*.1	*.1	.04	.03		.009		.007		.003

* = LESS THAN

TABLE 7 - COMPARISON OF TRACE METALS, PCBs, AND CHLORINATED HYDROCARBONS IN OYSTERS DURING AND AFTER DISPOSAL OPERATIONS AT STATIONS LOCATED NORTH OF DISPOSAL SITE

DATE	STATION NUMBER	Cu.	Zn.	Cd.	Hg.	Pb.	Cr.	PCB	CHLOR-DANE	DDT	DDD	DDE	DIEL-DRIN	ENDRIN	BHC
UPSTREAM: DURING															
2/27/75	13	103.7	2478	3.07	0.023	*0.1	*0.1	0.03	0.04		0.007		0.002		0.002
2/27/75	9	94.1	2275	3.29	0.040	*0.1	*0.1	0.04	0.04		0.008		0.002		0.003
3/4/75	12	119.2	2663	3.57	0.017	*0.1	*0.1	0.02	0.02		0.006		0.003		0.002
3/14/75	13	118.4	2289	2.9	0.013	*0.1	No Results	0.04	0.03				0.006	0.003	0.002
UPSTREAM: AFTER															
3/25/75	9	89.5	2314	3.2	0.023	0.4	No Results	0.02	0.02				0.004		
3/25/75	11	129.4	2393	3.2	0.019	*0.1	No Results	0.03	0.03				0.007		

* = LESS THAN

TABLE 8 - COMPARISON OF TRACE METALS, PCBs AND CHLORINATED HYDROCARBONS IN OYSTERS BEFORE AND DURING DISPOSAL OPERATIONS AT STATIONS LOCATED SOUTH OF DISPOSAL SITE

DATE	STATION NUMBER	Cu.	Zn.	Cd.	Hg.	Pb.	Cr.	PCB	CHLOR-DANE	DDT	DDD	DDE	DIEL-DRIN	ENDRIN	BHC
DOWNSTREAM: BEFORE															
1/23/75	3	105.5	2209	3.45	0.013	*.10	*.10	0.05	0.03		0.009		0.006	0.001	0.002
DOWNSTREAM: DURING															
3/4/75	1	59.4	1997	2.32	0.025	*0.1	0.1	0.05	0.03		0.004		0.003		0.002
3/4/75	2	78.0	2334	2.85	0.023	*0.1	0.1	0.05	0.02		0.003		0.004		0.002
3/14/75	1	63.6	1875	2.2	0.016	*0.1	No Result	0.05	0.04				0.006	0.005	0.003
3/14/75	2	61.9	1636	2.4	0.021	*0.1	No Result	0.06	0.04				0.006	0.003	0.003

* = LESS THAN

TABLE 9 - COMPARISON OF TRACE METALS, PCBs AND CHLORINATED HYDROCARBONS IN SOFT CLAMS (*MYA ARENARIA*) BEFORE AND AFTER DISPOSAL OPERATIONS AT STATIONS LOCATED SOUTH OF DISPOSAL OPERATIONS

DATE	STATION NUMBER	Cu.	Zn.	Cd.	Hg.	Pb.	Cr.	PCB	CHLOR-DANE	DDT	DDD	DDE	DIEL-DRIN	ENDRIN	BHC
	DOWNSTREAM: BEFORE														
1/16/75	3	12.1	26	0.24	0.020	*0.1	0.4		0.03		0.007		0.01	0.005	0.002
1/16/75	4	10.4	23	0.17	0.014	*0.1	0.4		0.03		0.008		0.009	0.004	0.002
1/16/75	5	11.2	24	0.15	0.016	*0.1	0.4		0.03		0.008	0.005	0.01	0.006	0.002
1/16/75	6	13	26	0.28	0.018	*0.1	0.4		0.04		0.01	0.007	0.01	0.005	0.003
1/28/75	5	18.2	30	0.20	0.013	*0.1	0.4	0.4	0.03		0.004		0.009	0.003	0.003
1/28/75	2A	2.4	14	0.25	0.007	0.1	0.4	0.04	0.02		0.008		0.008	0.004	0.004
1/28/75	6	18.5	28	0.13	0.014	*0.1	0.4	0.04	0.03		0.006		0.01	0.005	0.004
1/28/75	4	14.0	30	0.24	0.014	*0.1	0.4	0.02	0.02				0.004	0.002	0.003
	DOWNSTREAM: AFTER														
7/15/75	4	12	23.6	.32	.009	*.1	*.1	.08	.04		.01		.009	.002	.003
7/16/75	1	14.5	23.6	0.32	0.008	*0.1	*0.1	0.09	0.04		0.01		0.009	0.002	0.004
7/21/75	5	11.1	22.4	0.38	0.018	*.1	*.1	0.08	0.08		0.01	0.01		0.001	0.004
7/22/75	4	13	30.3	.26	.01	*.1	*.1	.09	.04		.009		.009	.002	.004

* = LESS THAN

SUMMARY AND CONCLUSIONS

In conclusion, the observations of this report support the following statements:

(1) Bacteriological water quality, described in terms of organisms of the fecal coliform group, reflected no significant degradation resulting from disposal operations. Runoff occurring after heavy rainfall in late February had an impact upon bacteriological water quality that could have masked the effects of the spoil disposal operation.

(2) Bacterial concentrations in marketable shellfish collected throughout the study indicate that no significant bacteriological uptake occurred.

(3) Levels of trace metals, PCBs and chlorinated hydrocarbons in shellfish collected throughout the study indicate that no significant increase was observed.

APPENDIX

DAILY PRECIPITATION

MARYLAND AND DELAWARE
FEBRUARY 1975

STATION	TOTAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
MARYLAND																																
* * * SOUTHERN EASTERN SHORE 01																																
ASSATEAGUE STATE PARK	4.39	.19	.08		.06	.85		.23	T	.04	T	T	.40			T	.36	.12	.14	.12				.04		1.78						
CRISFIELD SOMERS COVE	2.33	.10	.10			.50		.18		T			.25				.30	.22	.02	.07				.05	.34	.20						
POCOMOKE CITY	2.87	.10	.22			.76		.20		.03			.29				.36	.15	.04	.08				.08	.26	.30						
PRINCESS ANNE	2.33	.09	.19			.67		.09		.35			.31				.25	.03	T					.01	.34							
SALISBURY	2.81	.05	.03			.71		.29		.05			.44	T			.30	.19	.05	.10				.05	.30	.24	.01					
SALISBURY FAA AP	2.75	.09	.17		.24	.37	.04	.26		.04		T	.42				.40	.06	T	.12				.05	.49							
SNOW HILL 4 N	2.79	.12	.20		T	.85	T	.21		.03		T	.40				.26	.08	.04	.10				.05	.13	.28						
* * * CENTRAL EASTERN SHORE 02																																
BLACKWATER REFUGE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
CAMBRIDGE 4 W	2.83	.15	.14		.03	.79		.20		T			.76				.11	.04	.10	.02				.13	.38							
DENTON 1 S	2.92	.15	.10		T	.45	.06	.19		T			.60				.15	.10	.08	.02				.52	.30	.20						
EASTON POLICE BARRACKS	2.67	.12	.10			.68	.03	.14		.02			.63				.05	.06	.13					.28	.32	.13						
PRESTON 1 S	2.24	.10	.08			.81				.02			.60				.12	.17	.02					.15	.23	.13						
ROYAL OAK	2.66	.10	.10		T	.85	.02	.09		T			.66				.06	.05	.11	.01				.35	.12	.14						
VIENNA	2.96	.15	.13			.70							.70					.33	.10	.05				.17	.45	.20						
* * * LOWER SOUTHERN 03																																
LA PLATA 1 W	2.20	.09	.17		.31	.57	T			T			.53				T	.10						.21	.20	.02						
LEONARDTOWN 3 NW	2.10	.14	.18	.01	.50		.08	.22					.64					.04	.14						.12	.02						
MECHANICSVILLE 1 SE	3.26	.18	.20			.85	.19	.10	.01	.01			.75					.17	.13	.07				.11	.17	.32						
OWINGS FERRY LANDING	2.19		.24		.31	.29				T			.43					.11						.31	.50							
PRINCE FREDERICK 1 N	2.63	.05	.15		T	.85							.58				T	.07	.11					.20	.40	.22						
SOLOMONS	2.85	.11	.20		.03	.81		.22		T			.59				.06	*	.23	T				.05	.25	.10						
WALDORF POLICE BRKS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
* * * UPPER SOUTHERN 04																																
ANNAPOLIS USN ACADEMY	2.98	.05	.05		.75	.80	.05	.09		T			.38				.03	.05	.10					.64	.20	.03						
BALTIMORE WSO AP R	2.47	.02	.07		.52	.29	.04			T			.46	T		T	.03	.14	T	T				.70	.20							
BELTSVILLE	2.05	.10	.16			.53		.07					.31					.12	.15	T					.38	.23						
BELTSVILLE PLANT STA 5	2.34	.09	.13			.53		.05					.35	.10				.05	.20	.01				.20	.25	.32						
COLLEGE PARK	2.31		.19			.74	.03	.10					.43				.04	.11	.04	.01				.34	.26	.02						
DALECARLIA RESVR D C	2.39	.05	.13	.02	.02	.66		.05					.47	.02				.10	.10	.01				.28	.42	.04						
FORT GEORGE G MEADE	2.41	.05	.09			.69	.03	.07					.47				T	.12						.60	.23	.06						
GLENN DALE BELL STA	2.11	.05	.14		T	.70	.03	.06		T			.36				T	.07	.09					.39	.15	.06						
LAUREL 3 W	2.82		.32		.43	.21	.05						.45				.02	.21	T					.58	.55							
NATIONAL ARBORETUM D C	1.84	.01	.04	.01		.73	.02	.01	T				.22	.11	T			.20	.12	T					.25	.12						
U. S. SOLDIERS HOME DC	2.25	.06	.11		.19	.57	.03	.09		T			.47	T			.03	[illegible]	.06	T				.16	.38							
UPPER MARLBORO 3 NNW	D 2.24	.100	.10			.94	.05	.07					.15	.25					.17						.26	.15						
* * * NORTHERN EASTERN SHORE 05																																
CENTREVILLE	3.47	.11	.04	.03		.58	.05	.11					.80	T				.08	.12					.83	.70	.05						
CHESTERTOWN	3.03	.10	.04		.21	.52	.07	T		.02			.50	T			.03	.14	.02					.81	.57							
EASTERN NECK ISLAND	2.61	.03	.07			.56	.05				T		.80	T			T	.04	.10					.72	.29	.15						
MILLINGTON	2.94	.13	.06			.65	.05	.05		.02			.50						.27					.76	.45							
* * * NORTHERN CENTRAL 06																																
ABERDEEN PHILLIPS FLD	2.38		.06			.47	.03	T					.50					.08	.17					.70	.25	.12						
BALTIMORE WSO CI R	2.50		.06		.41	.34	.05						.46					.15						.65	.36							
BENSON POLICE BARRACKS	2.70	.40	.05			.37							.27					.03	.24	.04				.63	.41	.28						
BOYDS 2 NW	1.97		.10		.09	.67							.29					.14	.18					.25	.24	.03						
BRIGHTON DAM	2.82		.28		.50	.29	.03						.48				.02	.17						.44	.61							
CATOCTIN MOUNTAIN PARK	3.50	.02	.09		.07	.80							.49				T	.16	.15	.03				.71	.98	.21						
CLARKSVILLE 3 NNE	2.84	.07	.08		T	.68	.08	.06					.52				T	.05	.19					.52	.81	.06						
CONOWINGO DAM	2.69	T	T		*	.99	.05						.08	T			.02	.20	.03		.03			.62	.65	.02						
DAMASCUS 2 SW	2.20	.03	.06		.30	.42	.08	T		T			.49	T			T	.13	.05	.01				.23	.29	.09						
ELKTON	2.91	.06	.03			.65	.03			T			.51						.22	.04				.66	.54	.13						
EMMITSBURG 2 SE	3.30	T	.10		.10	.67							.55				.05	.12	.22					.67	.77	.05						
FREDERICK POLICE BARR	1.98	.01	.09		.10	.07	.10						.32	T			T	.09	.18					.40	.50	.12						
FREDERICK 3 E	2.45	.31	T	.09		.58	T							.50				T	.24	T				T	.52	.21						
LOCH RAVEN DAM	D 3.40		0 .08			.90	.20						.40				*	*	*	.60				.60	.52	.10						
PARKTON 2 SW //	2.75	.03	.07		.25	.47	.01			T			.56				.03	.22	.03	.03				.41	.59	.05						
POTOMAC FILTER PLANT	2.10		.10		.70	.01	.01						.50				T	.14						.28	.36							
ROCKVILLE 3 NE	D 2.91	.01	.05		*	.960	.15	.02					.52	.02				T	.20					.46	.52							
TOWSON	2.60	.05	.04		T	.70	.03	.03		T			.43	T	T			.05	.25	.02				.70	.25	.05						
UNIONVILLE	2.31	.01	.05		.13	.45	.12						.46	T			.01	.20	.03	.02				.41	.34	.08						
WESTMINSTER 2 SSE	2.29	T	.09			.56	.13						.04	.42				.02	.17	.01				T	.60	.25						
WHEATON REGIONAL PARK	2.36		.09		.03	.62	.17						.21	.10				.07	.06	.02				.41	.50	.06						
WOODSTOCK	2.91	.04	.06		.11	.71	.07						.58					.07	.08	.03				.50	.60	.04						
* * * APPALACHIAN MOUNTAIN 07																																
BOONSBORO 1 NE	2.78	T	.07		.20	.45	.06						.48				.05	.05	.06	.02				.62	.57	.15						
CUMBERLAND 2	3.15	.03	.20	T		.70	.19	T	T		T		.39	.09	T		T	.07	.49	T	T			.14	.62	.23	T					
CUMBERLAND POLICE BRKS	3.95	.16	.18		.16	*	.63						.82				T	.55	.14	.02				.49	.55	.05						
EDGEMONT	3.11		.06			.53							.27	.24				.04	.21					.13	.74	.89						
FROSTBURG 2	2.31	.09	.36	.03		.56	.16	.06	.03		.01	T	.30	.08	.02		T	.02	.32	T	.02			.07	.10	.07	T					
HAGERSTOWN	2.70		.11		.20	.36	.11						.31				.04	.29	.04					.60	.64	T						
HANCOCK FRUIT LAB	2.70		.17			.46	.23						.34	.09				.02	.33					.40	.42	.24						
WESTERNPORT UPRC	3.52	.14	.13		.26	.60	.26						.68					.43		.03				.60	.34	.03						
WILLIAMSPORT	2.61		.09	.01		.56	.11						.25	.20				.04	.35	.01				.04	.49	.47						
* * * ALLEGHENY PLATEAU 08																																
BITTINGER 2 NW	3.70	.25	.22		.31	.26	.22	.15		.07		.05	.65	.05		.03	.12	.25		.04				.61	.33	.05	.05					
MCHENRY 2 NW	2.71	.18	.16			.18	.20	.16	T	T	.04		.38	.18	T			.02	.09	.10	.02			.52	.42	.06	.02					
MERRILL	3.12	.17	.16			.48	.25	.07	.02		.01		.48	.10				.12	.28	.06	.02			.50	.36	.05						
OAKLAND 1 SE	4.14	.28	.21		.38	.04	.56	.05		.04		.04	.90			.04	.07	.23		.11				.85	.26	.08						
SAVAGE RIVER DAM	3.38	.06	.26	T		.50	.32	T		T		T	.62	.32			.01	.10	.39	.02	T			.20	.58	.10	T					

Source: National Oceanic and Atmospheric Administration
Climatological Data

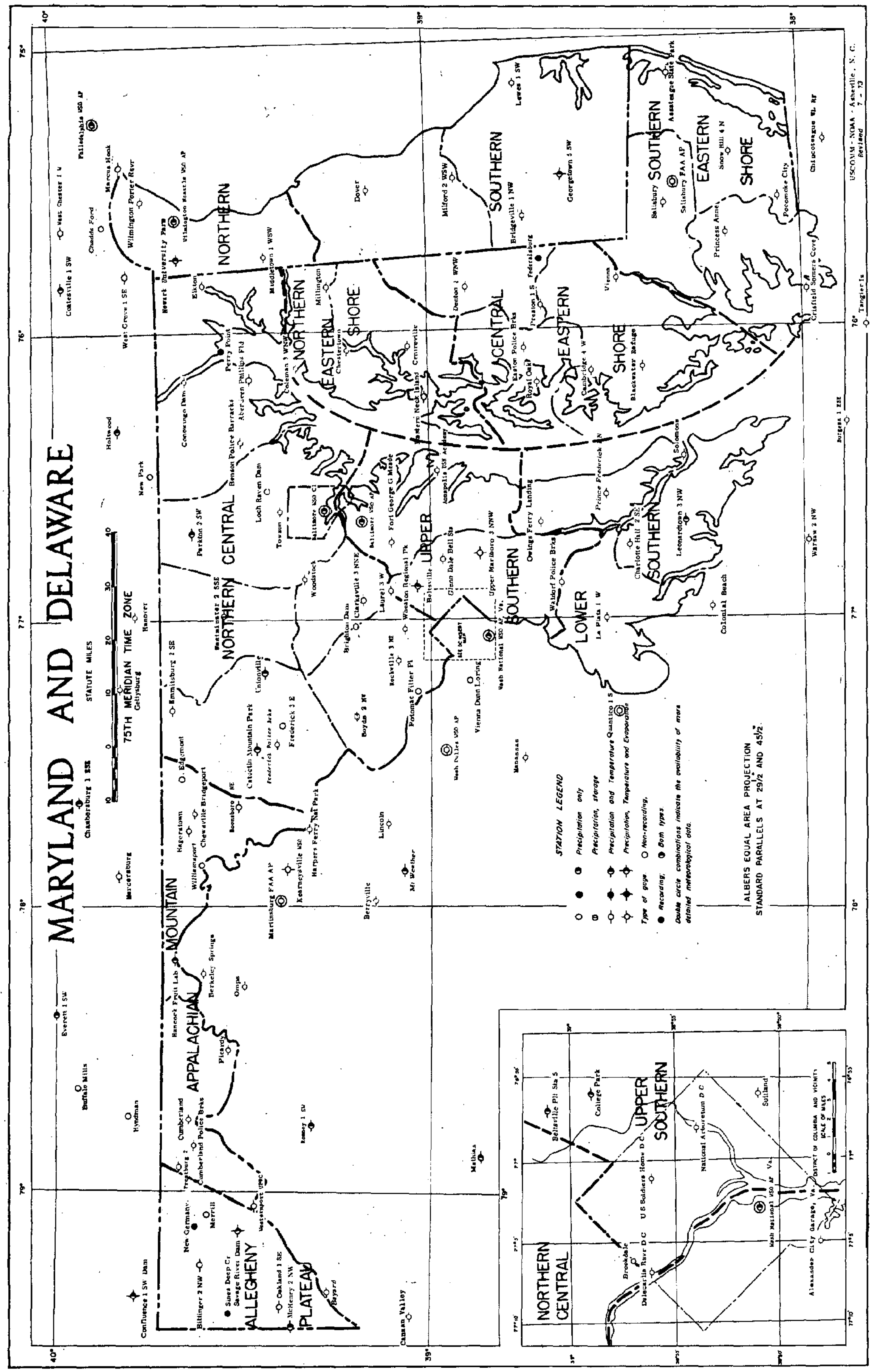
Appendix 1-2

DAILY PRECIPITATION

MARYLAND AND DELAWARE
MARCH 1975

STATION	TOTAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
MARYLAND																																
* * * SOUTHERN EASTERN SHORE 01																																
ASSATEAGUE STATE PARK	6.36		.09					T	T				.40	.50	2.00	.20		.87		.56	T			.03	.32	.40		T			.99	
CRISFIELD SOMERS COVE	7.27		.15					.01			.20	.21	.35	.12	.99	.05		1.10		1.68	.05		.01	.13	.47	.17					1.58	
POCOMOKE CITY	7.73		.33					.05	.03		.22	.28	.44	.14	1.27			1.27		1.70	.02		.03	.09	.30	.25					1.31	
PRINCESS ANNE	7.46		.18					.05			.38	T	.38	1.01	.17			1.13		2.21			T	.05	.45	.26					1.19	
SALISBURY	7.50		.32					.10	.02		.20	.21	.48	.25	1.16	T	T	1.00	.01	2.00	.02		.02	.13	.20	.30					1.08	
SALISBURY FAA AP	7.63	.03	.16					.09	T		.31		.47	.43	.78		.14	.76		2.08	.01		.14		.96					T	1.28	
SNOW HILL 4 N	7.35		.41	T				.03	T		.18	.19	.44	.18	1.46			1.02		1.46	.01		.02	.07	.50	.20					1.20	
* * * CENTRAL EASTERN SHORE 02																																
BLACKWATER REFUGE	-		.05					.07			.27	.03	.55	.18	.99			.13		-			.05	T	.12					.67		
CAMBRIDGE 4 W	5.92		.05					.07			.27	.03	.55	.18	.99	.04		1.13		1.98			.05	T	.17	T				T	.43	
DENTON 1 S	5.50		.05					.05	T		.19	.13	.66	.18	.65	.02		.40		2.02	.08		.12	.09	.19	.03				.20	.26	
EASTON POLICE BARRACKS	5.40		T					.05			.08	.28	.47	.15	1.18	.02		.69		1.65	.07		.01	.02	.09	.07	.15				.44	
PRESTON 1 S	5.58		.03					.03	T		.20	.09	.53	.14	.94			.88		1.98	.02		.07	.04	.17						.48	
ROYAL OAK	5.45		.05					.08			.23	.17	.61	.14	1.28	.02		.71		1.56			T	T	.23	T					.39	
VIENNA	6.34		.13								.25	.05	.45	.20	1.04			1.08		1.87	.04		.05		.38					.65	.05	
* * * LOWER SOUTHERN 03																																
LA PLATA 1 W	5.63		.06					.08	T		.33	.04	.68	.16	1.12	.01		.80		1.12	.16		.04		.44					.01	.46	
LEONARDTOWN 3 NW	3.50		.18	.01				.05			.20	.10	.53	.18	1.10					.88				.05	.22							
MECHANICSVILLE 1 SE	7.19		.20					.13	.05		.29		.94	.17	1.25	.07		1.47		1.03	.55			.10	.07	.22	T			.05	.60	
OWINGS FERRY LANDING	4.18							.01			.17	T	.74	.10	1.00	.04				1.27	.05				.40						.41	
PRINCE FREDERICK 1 N	5.65		T					.13			.15	.10	.62	.13	1.20			1.23		1.20			T	.15	.21						.53	
SOLOMONS	6.56		.08					.08			*	*	*	*	1.78	*	*	1.53		1.88	.35		*	*	.21	.03					.85	
WALDORF POLICE BRKS	3.47										.15		.11		.98			.10	.03	1.60					.03						.50	
* * * UPPER SOUTHERN 04																																
ANNAPOLIS USN ACADEMY	4.61							.05			.30		.61		.95	.03		.38		1.15			.04	T	.72					T	.38	
BALTIMORE WSO AP R	5.17		T					.06	T		.12		.47	.14	.99		.09	.29		1.58			.01		.77				T	.14	.49	
BELTSVILLE	4.99								.08			.18	T	.40	.44	.70		.44		.27	1.16				.11	.69					.45	
BELTSVILLE PLANT STA 5	4.87								.10			.15	.02	.45	.45	.58		.40		.35	.90				.30	.52					.45	
COLLEGE PARK	5.24		T					.07	T		.29		.55	.02	1.15	.03		.44		1.36					.86	T					.47	
DALECARLIA RESVR D C	5.49							.08			.14	.04	.51	.03	1.22	.05		.48	.04	1.66			.05	.08	.64	.03				.08	.40	
FORT GEORGE G MEADE	5.22							.09			.12	.04	.52	.01	1.17	.05	.01	.40		1.77			.01	.01	.81	.11				.10		
GLENN DALE BELL STA	5.02		T					.08	T		.13	.07	.72	.03	1.10	.06		.48		1.60			.04		.68	.46				.04	.43	
LAUREL 3 W	4.69		T					.09	T		.22		.16	.07	.97		.05	.38		1.62			.01		.58					T	.54	
NATIONAL ARBORETUM D C	6.10		T						.05		T	.16	T	.63	.55	.68		.49	.06	.24	1.01		.02	.03	.08	1.75					.44	.02
U. S. SOLDIERS HOME DC	5.33		T					.08			.15	.03	.57	.03	1.23	.06		.48		1.44	T	T	.04	T	.80					.04	.38	T
UPPER MARLBORO 3 NNW	6.80								.05			.22		.78	.53	.61		.57		.35	1.20		T	.05	.27	.82					.46	T
* * * NORTHERN EASTERN SHORE 05																																
CENTREVILLE	5.27		.02	T							.08	.15	.64	.12	1.05			.21		1.51	T				.48	.60					.41	
CHESTERTOWN	6.23		T					.01	T		.27		.60	.03	.90					1.68	T		.10		1.18	T				.04	.41	
EASTERN NECK ISLAND	5.33		T					.01	T		.08	.31	.60	.11	1.08	.05		.35		1.40	.12		.10		.71	T				.02	.39	
MILLINGTON	-		.02						T		.08	.14	.55	-	-					1.40	.37			.08	.98						.43	
* * * NORTHERN CENTRAL 06																																
ABERDEEN PHILLIPS FLD	3.89							T			.07	.10	.39	.04	.82			T		1.22	.08				.36	.31					.22	.28
BALTIMORE WSO CI R	5.91							.05			.09		.43	.03	1.10		.09	.29		2.34					.88					.08	.53	
BENSON POLICE BARRACKS	4.68		T					T	.09		.06	.01	.30	.01	.72	.10		.03		2.03			T		.72	.01				.10	.55	
BOYDS 2 NW	4.25										.22		.56		1.02	.14				1.09					.37					.28	.60	
BRIGHTON DAM	D 5.26							.10			D .10		.60	.03	1.06		.03	.46		1.60					.53					.20	.65	
CATOCTIN MOUNTAIN PARK	7.16		T					.09	.01		.16		.92		1.04	.09		.32		3.67	.09		.19	.05	.32					.23	.40	
CLARKSVILLE 3 NNE	5.99		T					.13	T		.15	.07	.51		.97	.06		.46		2.09	.01		.06	.07	.50	.10				.18	.61	
CONOWINGO DAM	4.81							.06	T		.19	.02	.34	T	.91	T		T		1.97	T		.04		.66	T				.09	.53	
DAMASCUS 2 SW	4.91		T	T				.08	T		.18	T	.54	.01	1.31	.01	T	.36	T	1.18			.09		.30	.02	T		T	.21	.60	
ELKTON	4.74							.07			.08	.10	.40	T	.72	.05				1.88	.26				.70	.10				T	.40	
EMMITSBURG 2 SE	4.48							.08			.15		.60		.95	.10		.22		1.10			.15		.55		T			.22	.46	
FREDRICK POLICE BARR	3.80							.12			.09	.04	.60		.30	.11		.33		1.06			.14	.03	.30	.09				.20	.49	
FREDERICK 3 E	4.24								.09			.15		.84		.90		.30		.15	.72			.12	.20	.34					.53	
LOCH RAVEN DAM	5.41										T		.70		1.04	T		.30		1.93	.05			.10	.34	.21					.74	
PARKSTON 2 SW //	4.52		T					.07	T		.13		.37	T	1.02					1.72	T		.09		.51					.15	.46	
POTOMAC FILTER PLANT	4.38							.10			.10		.45	.09	1.10		.02	.35	.02	.97			.03		.43					.05	.67	
ROCKVILLE 3 NE	5.33							.07	T		.07	.14	.44		1.14	.04	.01	.45		1.63	.02	.02	.04	.03	.40	.09		T		.19	.55	
TOWSON	5.44		T					.04	T		.16	.04	.40	T	.65	.10		.26		2.45	T		.10	T	.60	T	T			.12	.50	
UNIONVILLE	4.46							.08	T		.17	T	.46	.01	1.04	.08		.25		1.10	.01		.11		.50					.22	.41	
WESTMINSTER 2 SSE	5.26			T					.16	T		.16		.42	.44	.63		.27		.19	1.86			.14	.11	.53				.11	.44	
WHEATON REGIONAL PARK	5.36							.09			.11	.06	.38		.85	.06		.39		1.38	T		.01	.02	.95	.43				.10	.46	
WOODSTOCK	5.61							.11			.20	.03	.46	T	.91	.09		.37		1.90	T		.10	.02	.55	.03				.15	.69	
* * * APPALACHIAN MOUNTAIN 07																																
BOONSBORO 1 NE	4.69		T					.09	.04		.10		.93	T	.82	.08		.23		1.65	.01		.10		.29	.02				.21	.42	
CUMBERLAND 2	4.07	T		T	T				.46	T		.14	.10	.29	.32	.46		.08	T	.25	1.10			.13	.12	.17	T			.12	.35	T
CUMBERLAND POLICE BRKS	4.16		T	T	T			.47	T		.15	.06	.42	T	.15	T		.16		1.61	.03		.01	T	.52					.12	.25	
EDGEMONT	4.66								.09			.07		.61	.29	.75		.10		.20	1.43			.21	.12	.16				.09	.50	
FROSTBURG 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HAGERSTOWN	4.15		T					.11	T		.18		.51		.69	.13				1.29	.09		.13		.26					.32	.47	
HANCOCK FRUIT LAB	4.12			T	T				.20	T		.12	.14	.39	.20	.45		.15		.75	.88			.10	.11	.07				.13	.45	
WESTERNPORT UPRC	3.37		.03					.42			.07	.03	.30		.76	.09				1.11			.06		.33	T	T		.05	.06		.06
WILLIAMSPORT	5.03								.11			.13		.46	.28	.57		.27		.40	1.90			.08	.18	.16				.11	.78	
* * * ALLEGHENY PLATEAU 08																																
BITTINGER 2 NW	6.73	.18	.21	.22	.10			.68	.28	T	.14	.04	.92	.13	.48	.07				.77	.38		.23			.58	.12			.18	.40	.04
MCHENRY 2 NW	6.30	.10	.03	.21	.13				.94	.08		.14	.25	.80	.22	.25	T	.04		.30	.69			.16	.38	.24	.10	.03		.16	.35	
MERRILL	3.98	.08	.02	.12	.05	.01		T	.69	T		.12	.17	.21	.45	.18		.03	T	.50	.43			.14	.30	.13	.05	.02		.09	.19	.03
OAKLAND 1 SE	4.10	.02	.03	.22	.03			.61	.30	T	.12	.02	.37	.02	.46	.05		.03		.33	.29		.24	T	.39	.03	.06			.21	.23	.04
SAVAGE RIVER DAM	3.40	T	.02	.02	T	T			.72	T		.09	.15	.22	.35	.41	T	.05	T	.41	.35			.24	.14	.07	T	T	T		.14	.02

Source: National Oceanic and Atmospheric Administration
Climatological Data



Source: National Oceanic And Atmospheric Administration Climatological Data

APPENDIX 2

SALINITY CONCENTRATIONS (P.P.T.) 2/19/75 to 3/25/75

DATE	Station #1 S.	Station #1 B.	Station #2 S.	Station #2 B.	Station #3 S.	Station #3 B.	Station #4 S.	Station #4 B.	Station #5 S.	Station #5 B.	Station #6 S.	Station #6 B.	Station #7 S.	Station #7 B.	Station #8 S.	Station #8 B.	Station #9 S.	Station #9 B.
2/19/75	10.1	12.4	9.8	11.5	8.9	12.7	8.9	11.9	9.1	8.8	9.4	9.5	9.9	12.3	9.9	7.6	10.0	12.0
2/20/75	10.1	12.4	9.8	11.5	8.9	12.7	8.9	11.9	9.1	8.8	9.4	9.5	9.9	12.3	9.0	7.6	10.0	12.0
2/21/75						8		8		8		7		9		10		
2/24/75		9.4		9.9		9.9		9.1		9		9		9.6		8.0		9.1
2/25/75						9.1		8.9		9.0		9.4		9.4		8.8		8.9
2/27/75		9.1		7.1		8		4.1		7		3		5.1		5	.2	5.1
2/28/75		9.1		5.8		6.0		8.0		2.8		3.1		6.8		4.0		4.1
3/4/75	5.7	5.6	4.9	4.9	4.8	4.8	4.7	4.5	4.6	4.5	4.5	4.5			4.7	4.7	3.9	3.9
3/5/75		10.5		5.9		8.1		6.1		5.5		5.2		4.2		3.9		4.1
3/11/75		9.1		9.0		8.6		8.2		8.2		8.2		8.1		7.0		6.3
3/13/75		9		9		8		8.5		7.5		8		9		8		
3/14/75	9.5	9.6	9.5	9.4	9.7	9.7	9.7	9.7	7.5	7.4	6.9	6.8	10.3	10.4	8.1	8.1	7.8	7.8
3/21/75	8.0		9.0		7.5		7.5		7.0		7.5		7.0		6.8		7.0	
3/25/75	5.8	6.1	5.2	5.4	3.9	4.2	2.2	2.2	3.3	3.6	3.0	3.2	3.8	3.9	2.2	3.9	2.1	2.2

S = SURFACE

B = BOTTOM