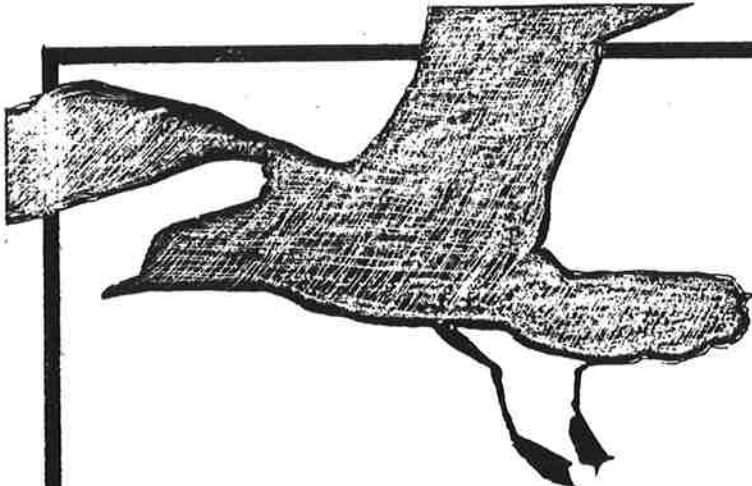


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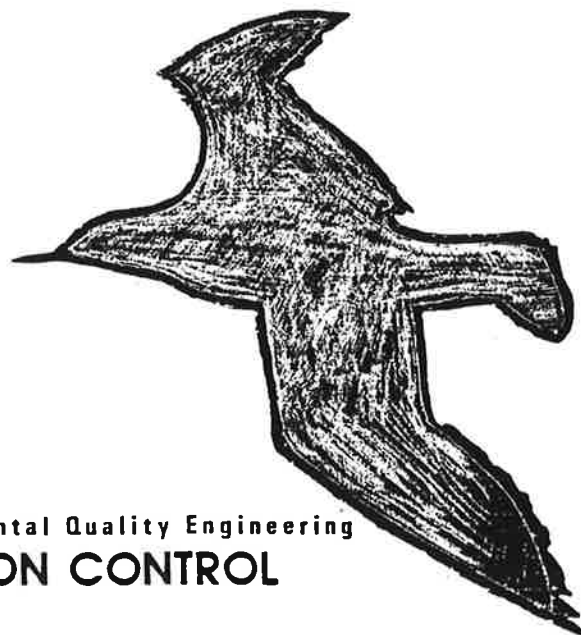
NORTH COASTAL WATER QUALITY SURVEYS



1987&88



Part A: Water Quality Survey Data
Part B: Wastewater Discharge Data
Part C: Summary of Significant Findings



Massachusetts Department of Environmental Quality Engineering
DIVISION of WATER POLLUTION CONTROL
Cornelius J. O Leary, Acting Director

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NORTH COASTAL
WATER QUALITY SURVEYS

Part A: Water Quality Survey Data
Part B: Wastewater Discharge Data
Part C: Summary of Significant Findings

1987 and 1988

Prepared By

Christine L. Duerring
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DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
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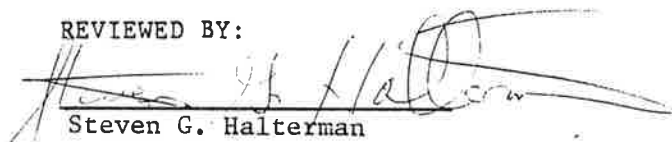
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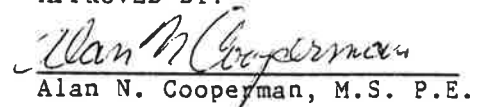
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FOREWORD

The Massachusetts Division of Water Pollution Control was established by the Massachusetts Clean Water Act, Chapter 21 of the General Laws as amended by Chapter 685 of the Acts of 1966. Included in the duties and responsibilities of the Division is the periodic examination of the water quality of various coastal waters, rivers, streams and ponds of the Commonwealth, as stated in section 27, paragraph 5 of the Acts. This section further directs the Division to publish the results of such examinations together with the standards of water quality established for the various waters. The Technical Services Branch of the Division of Water Pollution Control has, among its responsibilities, the execution of this directive. This report is published under the Authority of the Acts and is among a continuing series of reports issued by the Division presenting water quality data and analyses, water quality management plans, baseline and intensive limnological studies and other special studies.

ACKNOWLEDGMENTS

The Division of Water Pollution Control would like to extend its appreciation to the following groups and individuals for their assistance in conducting various aspects of the North Coastal Water Quality Surveys:

the staff of the Technical Services Branch (TSB) at Westborough for their assistance in sample collection, notably: Margo Webber, Christopher Scholl, Steven Halterman, Gerald Szal, Thomas Dallaire, Joseph Hogan, Wendy Norton, and Catherine O'Riordan; Joan Beskenis and Richard Marcou for chlorophyll a analysis and algae identification;

the laboratory staff at the Lawrence Experiment Station for their analytical skills;

the Salem Harbor Master, William Cahill and his staff who kindly provided boat transportation for the four Beverly Harbor Special Water Quality Surveys conducted during 1988;

William Cashins and Richard Chretien of the DEQE's Northeast Regional Office for advice and assistance in conducting the Beverly Harbor Special Water Quality Surveys after the sewer pipe break.

Ken Dominick, who prepared the graphics for this report; and to the secretarial staff at TSB, notably Theresa Vigneault and Robin O'Malley for their typing skills and patience in preparing this report.

TABLE OF CONTENTS

<u>TITLE</u>	<u>PAGE</u>
Foreword	iii
Acknowledgments	v
Abstract	ix
List of Tables	xi
List of Figures	xvii
Introduction	1
Materials and Methods	3
Water Quality Surveys	7
Salem Harbor and Tributaries	9
Beverly Harbor and Tributaries	22
Salem Sound and Marblehead Harbor	52
Manchester Harbor	60
Gloucester Harbor	64
Effluent Monitoring	81
Discussion of Significant Findings	91
References	117
Appendix A-1 Tidal Conditions During North Coastal Surveys	119
Appendix B-1 Common Sample Treatment Methods	122
Appendix B-2 Parameter and Collection Methods Employed at Sediment Stations	124
Appendix B-3 Water Sampling Parameters and Analytical Methods	125
Appendix B-4 Sediment Sampling Parameters and Analytical Methods	128
Appendix B-5 Summary of Rated Accuracy of Field Meters	130

ABSTRACT

MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL 1987 AND 1988 NORTH COASTAL WATER QUALITY SURVEYS

Part A: Water Quality Survey Data
Part B: Wastewater Discharge Data
Part C: Summary of Significant Findings

The North Coastal Water Quality Surveys were conducted in selected inshore and tidal riverine areas of Salem, Beverly, Marblehead, Manchester, and Gloucester. A total of 65 water quality stations, 28 sediment stations, and 4 compliance monitoring sites were sampled.

The following surveys were conducted during the period of June 22-September 3, 1987:

Three two-day surveys in the Salem/Beverly, Marblehead area, one one-day survey in Manchester Harbor and one three-day survey in Gloucester. In addition, four one-day surveys were conducted in Beverly Harbor during February, March, and May 1988 to monitor water quality after a sewer pipe broke in the harbor.

Areas of degraded water quality (due to extremely high coliform bacteria densities and/or low dissolved oxygen) include the North River, Goldthwait Brook, South River Channel, Crane River, Bass River, Salem Sound (at the WWTP outfall) and several coves of Inner Gloucester Harbor.

Sediments contained very high concentrations of chromium, lead, and/or zinc at stations in the North River, Salem Harbor, and in Salem Sound at the outfall site. Sediments in Inner Gloucester Inner Harbor contained high levels of zinc and lead.

The highest levels and numbers of polycyclic aromatic hydrocarbon compounds (PAHs) were found in the sediments of the North River, Goldthwait Brook, Salem Sound (SESD outfall), and Inner Gloucester Harbor. Most of these compounds are thought to be a consequence of urban runoff. Polychlorinated biphenyls (PCBs) were found in high levels at only one station, located in Inner Gloucester Harbor.

LIST OF TABLES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
1	Salem Harbor and Tributary Water Quality Survey Sampling Station Locations	10
2	Salem Harbor and Tributary Water Quality Survey Data: Time - Depth - Temperature - Salinity - Dissolved Oxygen	13
3	Salem Harbor and Tributary Survey June and July Water Quality Data	16
4	Salem Harbor and Tributary Sediment Data: Metals, TKN, TP, % Volatile Solids, and Oil and Grease	20
5	Salem Harbor and Tributary - Sediment PAH and PCB Data	21
6	Beverly Harbor and Tributary Water Quality Survey Sampling Station Locations	23
7	Beverly Harbor and Tributary Water Quality Survey Data: Time - Depth - Temperature - Salinity - Dissolved Oxygen	24
8	Beverly Harbor and Tributary Survey June Water Quality Data	28
9	Beverly Harbor and Tributary Survey August Water Quality Data	31
10	Beverly Harbor and Tributary - Sediment Data: TKN, TP, % Volatile Solids, and Oil and Grease	35
11	Beverly Harbor and Tributary - Sediment Metals Data	36
12	Beverly Harbor and Tributary - Sediment PAH and PCB Data	37
13	Beverly Harbor Special Water Quality Survey Sampling Station Locations	41
14	Beverly Harbor Special Water Quality Survey Data	44
15	Beverly Harbor Special Water Quality Survey Sediment Data: Metals, TKN, TP, and % Volatile Solids	50

LIST OF TABLES (Continued)

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
16	Beverly Harbor Special Water Quality Survey Sediment PAH and PCB Data	51
17	Salem Sound and Marblehead Harbor Water Quality Survey - Sampling Station Locations	53
18	Salem Sound and Marblehead Harbor Survey Data: Time - Depth - Temperature - Salinity - Dissolved Oxygen	54
19	Salem Sound and Marblehead Harbor Water Quality Data	56
20	Salem Sound and Marblehead Harbor Sediment Data: Metals, TKN, % Volatile Solids, and Oil and Grease	58
21	Salem Sound and Marblehead Harbor - Sediment PAH and PCB Data	59
22	Manchester Harbor Water Quality Survey Sampling Station Locations	61
23	Manchester Harbor Water Quality Survey Data: Time - Depth - Temperature - Salinity - Dissolved Oxygen	62
24	Manchester Harbor Water Quality Data	63
25	Gloucester Harbor Water Quality Survey Sampling Station Locations	65
26	Gloucester Harbor Water Quality Survey Data: Time - Depth - Temperature - Salinity - Dissolved Oxygen	67
27	Gloucester Harbor Water Quality Data	72
28	Gloucester Harbor - Sediment Data: TKN, TP, % Volatile Solids, and Oil and Grease	78
29	Gloucester Harbor - Sediment Metals Data	79

LIST OF TABLES (CONTINUED)

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
30	Gloucester Harbor Survey - Sediment PAH and PCB Data	80
31	South Essex Sewage District Wastewater Treatment Facility - Results of Laboratory Analyses	83
32	South Essex Sewage District Wastewater Treatment Facility - Purgeable Organics	84
33	New England Power Plant, Salem - Results of Laboratory Analyses	86
34	Manchester Municipal Wastewater Treatment Facility - Results of Laboratory Analyses	88
35	Gloucester Municipal Wastewater Treatment Facility - Results of Laboratory Analyses	90
36	Classification of Dredge or Fill Material by Chemical Constituents	99
37	Classification of Sediment Quality in North Coastal Stations	100
38	Ranges of Selected Parameters Measured in Sediment at Sampling Stations in Four Massachusetts Coastal Areas	101

LIST OF FIGURES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
A	North Coastal Drainage Area Map	2
1	North Coastal Water Quality Surveys 1987 Location of Sampling Stations: Salem and Beverly	11
2	North Coastal Water Quality Surveys 1987 Location of Sampling Stations: Salem Sound, Marblehead, Manchester	12
3	North Coastal Water Quality Survey 1987 Location of Sampling Stations: Beverly Harbor Special Survey	42
4	North Coastal Water Quality Survey 1987 Location of Sampling Stations: Gloucester	66
5	North Coastal Water Quality Survey 1987 Sites with Elevated Coliform Bacteria and Low Dissolved Oxygen: Salem and Beverly	102
6	North Coastal Water Quality Survey 1987 Sites with Elevated Coliform Bacteria and Low Dissolved Oxygen: Salem Sound, Marblehead and Manchester	103
7	North Coastal Water Quality Survey 1987 Sites with Elevated Lead: Salem and Beverly	104
8	North Coastal Water Quality Survey 1987 Sites with Elevated Lead: Salem Sound, Marblehead and Manchester	105
9	North Coastal Water Quality Survey 1987 Sites with Elevated Chromium: Salem and Beverly	106
10	North Coastal Water Quality Survey 1987 Sites with Elevated Chromium: Salem Sound, Marblehead and Manchester	107
11	North Coastal Water Quality Survey 1987 Sites with Elevated Zinc: Salem and Beverly	108
12	North Coastal Water Quality Survey 1987 Sites with Elevated Zinc: Salem Sound, Marblehead and Manchester	109
13	North Coastal Water Quality Survey 1987 Sites with Elevated Coliform Bacteria and Low Dissolved Oxygen: Gloucester	110

LIST OF FIGURES (CONTINUED)

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
14	North Coastal Water Quality Survey 1987 Sites with Elevated Lead: Gloucester	111
15	North Coastal Water Quality Survey 1987 Sites with Elevated Zinc: Gloucester	112
16	North Coastal Water Quality Survey 1987 Sites with Elevated Polychlorinated Biphenyls (PCB): Gloucester	113
17	North Coastal Water Quality Survey 1987 Sediment Arsenic and Mercury Concentrations for North Coastal Survey Stations	114
18	North Coastal Water Quality Survey 1987 Sediment Polycyclic Aromatic Hydrocarbon (PAH) Concentrations and % Volatile Solids for North Coastal Stations	115

INTRODUCTION

The North Coastal Water Quality Surveys, initiated in 1987, were designed to gather data that would enable the Division to characterize general water quality conditions in each of the study areas. Areas that were surveyed and included in this report are Salem and Beverly Harbors and their tributaries, Salem Sound and Marblehead Harbor, Manchester Harbor, Gloucester Inner and Outer Harbor and a segment of the Annisquam River (Figure A). Except for the Manchester survey conducted on July 8, each area was sampled for at least two consecutive days in an attempt to characterize the range of natural variability that exists in the water quality parameters we were measuring. In addition to these general surveys, sampling programs initiated in Manchester Harbor in July and in Beverly Harbor in the Spring of 1988 were conducted to assess water quality impacts when pipes carrying sewage to the treatment plant ruptured in these harbors.

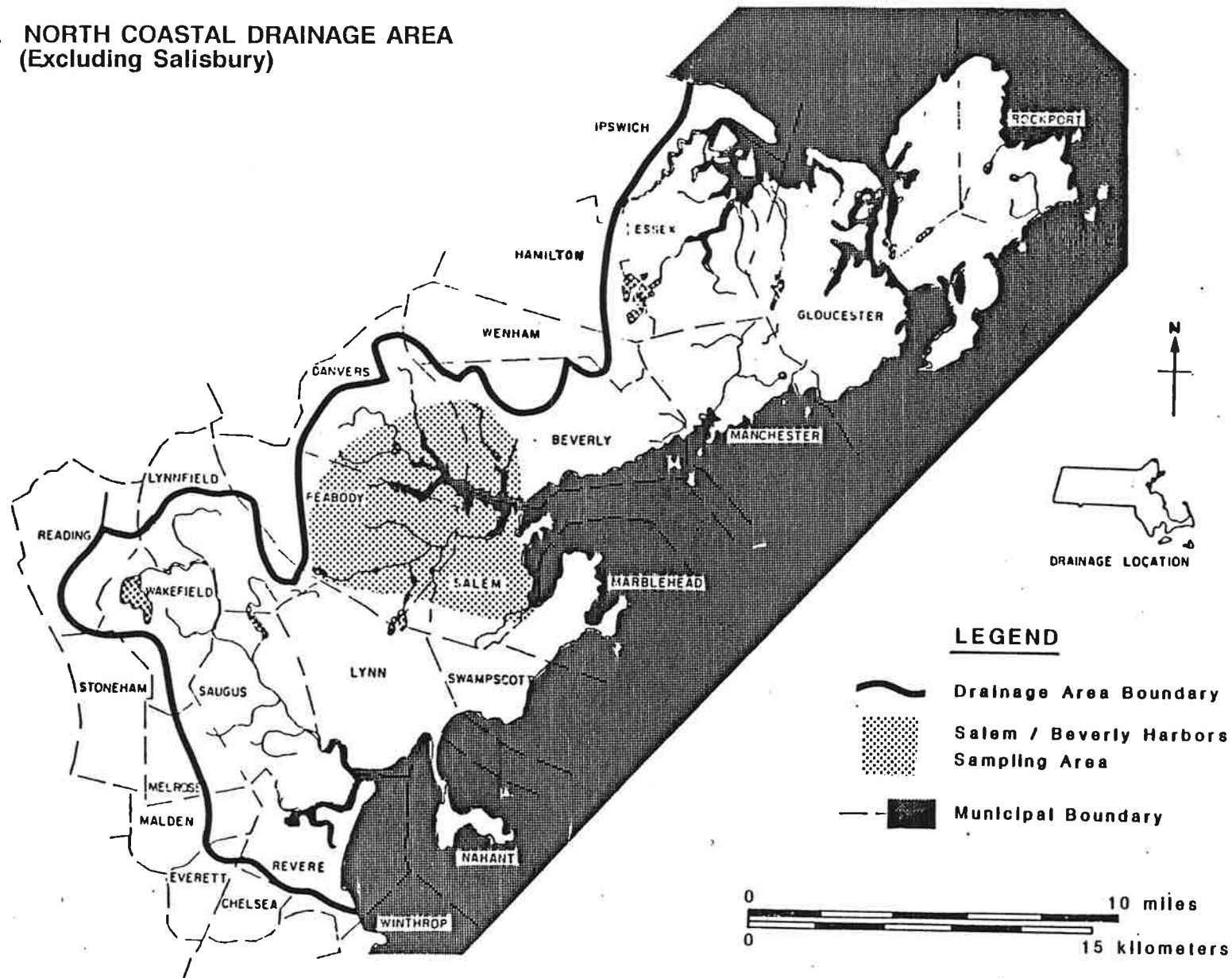
The objectives of the intensive surveys conducted in Salem/Beverly and Gloucester were fourfold:

1. Characterize overall water quality in these areas based on selected water quality parameters and as compared to criteria established in the Massachusetts Water Quality Standards.
2. Assess sediments at selected areas for heavy metals, PAH and PCB contamination.
3. Examine selected areas that may be experiencing localized water quality degradation from such sources as sewage outfalls, combined sewer overflows, industrial discharges, recreational pressure, runoff and/or contaminated tributaries.
4. Sample effluent of selected permitted discharges to the study areas and compare results to NPDES permit requirements.

Surveys were conducted during June, July and August of 1987 (with the exception of sampling conducted during the spring of 1988 in Beverly Harbor in response to a localized incident when a sewer pipe ruptured in the harbor). Surveys are conducted in the summer months so that worst case conditions in the water may be observed. When temperatures reach their maximum and recreational use is at its peak, the system is most likely to experience degraded water quality in the form of low dissolved oxygen (or anoxia), nuisance (and/or toxic) algae blooms, and high coliform bacteria densities.

Past water quality surveys of selected North Coastal areas were conducted by this office in Gloucester Harbor (1975), Salem/Beverly Harbors and tributaries (1985) and Salem Sound (1983). This report presents data obtained only from the 1987 (and spring 1988) water quality surveys conducted by this office in the North Coastal area. In addition to the data compilation the report contains a description of the field methodologies and a listing of laboratory methods used during the study, maps of the study areas with station locations, a brief description of each drainage area, and a summary of significant findings.

**FIGURE A NORTH COASTAL DRAINAGE AREA
(Excluding Salisbury)**



MATERIALS AND METHODS

General

Field sampling for this survey was conducted according to the Division's Standard Operating Procedures (SOP) which were developed from standardized and approved methodologies. Copies of the SOP documents for river sampling (MDWPC, 1987) and biomonitoring (MDPWC, 1988) are on file at the Technical Services Branch office in Westborough, Massachusetts. Coastal marine surveys conducted by this office are performed using techniques based on recommended procedures and methodologies of the U.S. Environmental Protection Agency (USEPA), academic researchers, and other state agencies. The SOP document for the Division's marine sampling protocol is currently in preparation.

All sampling stations for the North Coastal surveys were located in tidally influenced areas. Station locations were selected based on locations of: municipal treatment facility coastal outfalls, industrial discharges, combined sewer overflow pipes, and proximity to recreational, or commercial activities that may impact the water quality. Figures 1-4 provide the sampling station locations for all of the North Coastal surveys described in this report.

Field notes were recorded in bound notebooks by each survey crew. Information concerning weather, tide, and wave conditions, wildlife observations, and other phenomenon relative to water quality conditions were noted. In situ field measurements were also recorded for each station in this notebook.

Sample collections were made in accordance with the methods described below and in Appendix B. All samples were identified by tags that were attached to the bottles immediately after collection. Standard identification tags display the following information: unique station number, location, sample depth, date, time, collector, parameters for analysis and method of sample preservation in the field.

Methods employed at the Lawrence Experiment Station for analysis of the water quality parameters requested for this survey are listed in Appendix B. A summary list of the field meters together with their unit of measure and rated accuracy is also presented in Appendix B.

Physical and Chemical

Measurements of dissolved oxygen, salinity, temperature and specific conductivity at the open water stations were made "in situ" with a Hydrolab Surveyor II Model SVR2 (Hydrolab Corporation, Austin, Texas 78763).

River station "in situ" measurements for temperature and salinity were made with a model 33 SCT meter (Yellow Springs Instrument Co., Yellow Springs, Ohio 455387). Dissolved oxygen was measured by the modified Winkler method.

Open water stations were accessed by boat. Water samples were collected with a 2.2 liter Beta style van Dorn sampler (Water Supply, Saginaw, Michigan 48602) from selected water column depths. River stations were sampled from bridges or other appropriate land accessed points and water was collected from the surface with clean plastic buckets.

Samples for nutrient analysis were placed in 500 ml (16 oz.) polypropylene or glass screw cap bottles that had previously been washed in phosphate free detergent and rinsed with 30 percent HCl, followed by three rinses with dionized, distilled water and a final rinse in the field with sample water. Nutrient samples were fixed at the time of collection with 2 mls of concentrated H₂SO₄.

Samples for analysis of the other chemical parameters were placed in 1 liter polypropylene screw cap bottles that had previously been washed in phosphate free detergent and rinsed three times with dionized distilled water and one time in the field with the sample water.

Samples for chemical analysis were transported on ice in coolers to the Lawrence Experiment Station in Lawrence, Massachusetts within six hours of collection (unless noted).

The following chemical analyses were performed at the Lawrence Experiment Station: suspended solids, total solids, turbidity, total Kjeldahl-Nitrogen, ammonia-nitrogen, total phosphorus, orthophosphate, chloride. (See Appendix B.)

Biological

Phytoplankton and chlorophyll a samples were collected as described for chemical samples above. At least 200 ml of water were collected in clean, tap water rinsed polypropylene or glass screw capped bottles. Samples were kept on ice and transported in coolers back to the Division's Westborough office. The phytoplankton samples were normally analyzed within 24 hours of collection using a Whipple micrometer and Sedgewick-Rafter cell. Algal counts were reported as cells per ml according to Standard Methods (1985).

Chlorophyll a analysis was based on the methodology from a USEPA fluorometric procedure developed by the Division of Water Pollution Control at Westborough (MDWPC, 1988).

Bacteria samples were collected from surface waters only. They were taken from the bucket or van Dorn sampler before the other samples were removed, and placed in sterilized, glass, screw cap bottles. These samples were kept on ice in coolers and transported to the Lawrence Experiment Station within six hours of collection. Samples were analyzed according to Standard Methods (1985) for some or all of the following bacteria: total coliform, fecal coliform, and enterococci.

Sediments

Open water stations were sampled by boat; river stations were sampled by wading out to the collection area. At each station an attempt was made to collect fine grained sediments. If, after visual inspection of the dredged material, only coarse grained material could be collected, the site was omitted as a sediment station. Samples were collected with a petite ponar grab dredge (Karlisco International Corp, El Cajon, California 92002). The sampling area of this dredge is 15 cm X 15 cm (6" x 6") and weighs 10 kg (22 lbs). Prior to sampling the dredge was rinsed in seawater to remove any residual sediment. The inside of the dredge was then rinsed with reagent grade acetone, followed by a rinse with reagent grade hexane, followed by a final rinse in seawater. All chemical

rinse waste was collected and transported back to the laboratory for proper disposal.

The dredge contents were emptied into a plastic tray and subsamples of the sediment were scooped into separate specially cleaned 16 oz. glass, screw top, wide mouth sample jars prepared for metals and organics. Care was taken to prevent the collection of sediments in direct contact with the tray and/or the sides of the dredge.

The jars for sediment samples were first prepared by washing with phosphate-free detergent then rinsing with tap water. Jars for metals and miscellaneous parameters other than PAHs and PCBs were then rinsed with 30% HNO₃, followed by three rinses with distilled water. Screw caps were either teflon lined or the jar mouths were covered with plastic wrap before capping. The jars for PAH and PCB samples were rinsed with distilled water followed by an acetone then hexane rinse and allowed to air dry under a hood. Jars were either capped with teflon lined screw caps or covered with aluminum foil and then capped. All samples were identified with tags and stored on ice in coolers for delivery to the Lawrence Experiment Station (LES).

The sediments were analyzed at the LES for some or all of the following parameters:

Heavy metals: Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb),
(As total metals) Mercury (Hg), Nickel (Ni), Silver (Ag), Zinc (Zn), Arsenic
(As), Iron (Fe), Aluminum (Al)

Organics: Polycyclic aromatic hydrocarbons and polychlorinated
biphenyls (PCB 1242, 1254, 1260)

Other: Total Kjeldahl Nitrogen, Total Phosphorus, % Volatile Solids,
Oil and Grease.

Effluent Monitoring

Samples were collected from the wastewater treatment facilities and selected industries that have N.P.D.E.S. permitted discharges within the coastal areas under study. ISCO automatic samplers were set up at the wastewater treatment facilities to collect 24-hour composite samples for chemical including metals analysis. Grab samples were collected and sampled for total and fecal coliform bacteria, volatile organics, and oil and grease. All analyses were performed at the Lawrence Experiment Station in accordance with the APHA's Standard Methods for the Examination of Water and Wastewater (1985). Chlorine residual concentrations, temperature and pH values were determined in the field. Flow values were obtained from the plant operators.

WATER QUALITY SURVEYS

SALEM HARBOR AND TRIBUTARIES

DESCRIPTION OF SALEM HARBOR AND TIDAL PORTION OF ITS TRIBUTARIES

Salem Harbor is a relatively shallow (~ 8 meters maximum) embayment approximately 1.62 square miles, located on the north coast of Massachusetts midway between Boston and Rockport. The Salem Neck peninsula separates Salem Harbor from Beverly Harbor to the north. Marblehead, a predominately residential coastal town, lies directly to the east of Salem Harbor.

The Forest River flows north into the southern tip of Salem Harbor. Several junkyards and a closed landfill lie upstream in the freshwater portion of the drainage basin. The Forest River drains portions of Salem and Marblehead.

The South River is the other major source of freshwater to the harbor. This river flows into Salem Harbor from the west through the center of the city of Salem. The entire drainage area of this river is highly urbanized. Land use is dominated by industrial, commercial, and some residential development.

Historically, Salem was an important fishing port. Although commercial fishermen do operate from this harbor, recreational boating activities predominate. The harbor still remains an important shipping port. According to the Office of Massachusetts Coastal Zone Management (1977) over 1.3 million tons of petroleum are delivered annually through the harbor, particularly on the western shore at Salem Terminal Wharf where a deep water mooring area (10 meters) is maintained. The New England Power Company (NEPCO) operates a fossil fuel powered electric generating plant adjacent to this wharf. Its cooling water, runoff, and wastewater effluent are discharged directly into this deep area.

The South Essex Sewerage District (SESD) operates a primary wastewater treatment facility on the western shoreline of the harbor near the NEPCO plant. This approximately 25 MGD facility serves the municipalities of Salem, Beverly, Marblehead, Peabody, and Danvers. The sludge is landfilled and the effluent is discharged outside the harbor through an outfall pipe into Salem Sound.

Within the harbor many public and private moorings and marinas are maintained. A public boat ramp provides direct access to the harbor and surrounding waters at Winter Island, site of an abandoned U.S. Coast Guard Station. Several public and private beaches exist around the shoreline and Salem Willows, a city-owned waterfront park is located at the northern end of Salem Neck. Shellfishing in this area has been closed since 1972; however, closed beds exist at the mouth of the Forest River and isolated areas along the western shoreline.

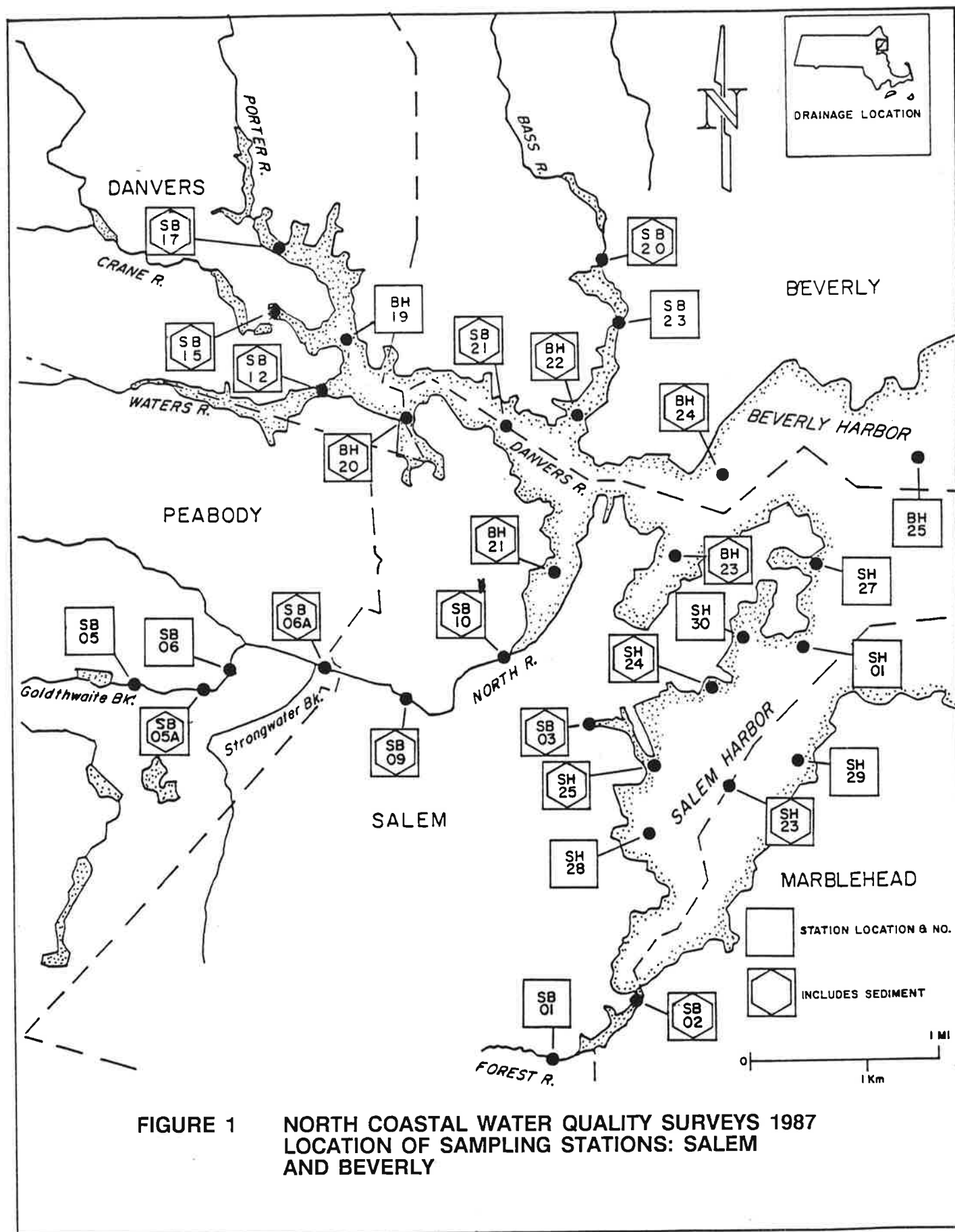
Table 1 provides a description of the stations that were sampled for this portion of the study and Figures 1 and 2 illustrates the station locations.

RESULTS

Tables 2 and 3 provide water column physical, chemical and bacteriological results. Tables 4 and 5 provide the sediment chemistry data.

TABLE 1
1987 SALEM HARBOR AND TRIBUTARY WATER QUALITY SURVEY
SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>LOCATION DESCRIPTION</u>
SB01	Forest River - Loring Avenue off Route 1A, Salem
SB02	Forest River - Route 114 beginning of harbor, Salem
SB03	South River - Discharge pipe corner of Lafayette and Derby Street, Salem
SH01	Salem Harbor - in Marblehead Channel at nun #22
SH07	Salem Harbor - in Marblehead Channel at can #1
SH23	Salem Harbor - in harbor at nun #2
SH24	Salem Harbor - in harbor offshore from Salem Terminal Wharf and N.E. Power Station
SH25	Salem Harbor - at mouth of South River channel near light house and can #5
SH27	Salem Harbor - in center of mouth of Juniper Cove
SH28	Salem Harbor - off Palmer Point near yacht yard pilings
SH29	Salem Harbor - Folger Point, offshore from beach
SH30	Salem Harbor - at mouth of Cat Cove



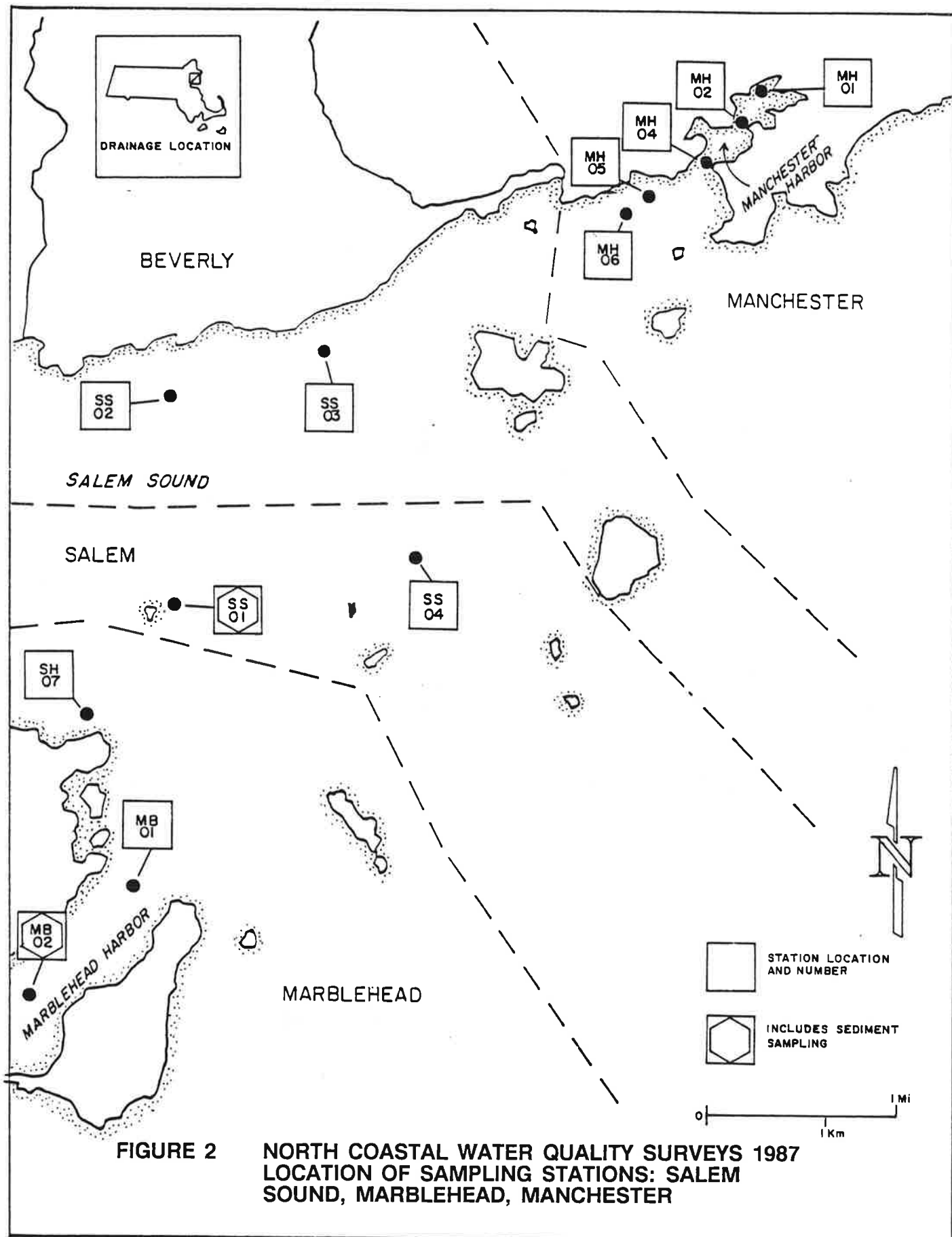


TABLE 2

1987 SALEM HARBOR AND TRIBUTARY WATER QUALITY SURVEY DATA

TIME - DEPTH - TEMPERATURE - SALINITY - DISSOLVED OXYGEN

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station SB01 (Forest River)**					
6/22/87	1220	0.1	21.8	16.0	7.1
6/23/87	1229	0.1	17.6	14.0	6.4
7/20/87	1200	0.1	26.5	21.5	6.1
7/21/87	1320	0.1	24.0	--	5.7
Station SB02 (Forest River)**					
6/22/87	1235	0.1	21.0	19.2	8.0
6/23/87	1240	0.1	18.0	20.1	7.0
7/20/87	1215	0.1	25.0	21.5	6.1
7/21/87	1335	0.1	23.5	--	4.4
Station SB03 (South River)**					
6/22/87	1250	0.1	18.5	15.8	6.9
6/23/87	1440	0.1	19.1	6.9	5.2
7/20/87	1300	0.1	19.0	12.0	4.0
7/21/87	1350	0.1	19.0	--	4.2
Station SH01 (Salem Harbor)					
6/24/87	1300	0.1	18.7	30.9	9.4
		2.0	16.7	30.3	9.6
		3.0	16.4	30.6	9.4
7/20/87	1125	0.2	20.8	31.0	9.6
		2.0	18.2	31.0	9.6
		4.0	16.8	31.0	9.2
		6.0	15.3	31.0	8.8
		8.0	14.2	31.1	8.2
7/21/87	1050	9.2	13.6	31.2	8.2
		0.2	17.9	31.1	9.6
		2.0	17.7	31.1	9.3
		4.0	15.9	31.1	8.9
		10.0	13.1	31.4	8.2

* Data obtained with Hydrolab Surveyor II

** Data obtained with Model 57 YSI Dissolved Oxygen Meter and YSI Model 33 SCT Meter

TABLE 2 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station SH07 (Salem Harbor)					
6/24/87	1130	0.1	19.2	30.9	9.4
		2.0	17.3	30.7	9.6
		4.0	15.4	30.7	9.1
		6.0	15.2	30.8	8.7
7/20/87	1045	0.2	18.6	31.0	9.8
		2.0	16.4	31.0	9.4
		4.0	15.7	30.9	8.9
		5.3	15.1	31.0	8.8
Station SH23 (Salem Harbor)					
6/24/87	1115	0.1	19.2	30.9	9.4
		2.0	17.3	30.7	9.6
		4.0	15.4	30.7	9.1
		6.0	15.2	30.8	8.7
7/20/87	1245	0.2	19.1	31.1	9.8
		2.0	18.7	31.1	9.7
		4.0	16.3	31.1	8.9
7/21/87	1225	0.2	19.2	31.1	9.9
		2.0	19.0	31.1	9.5
		4.0	17.4	31.1	8.8
Station SH24 (Salem Harbor)					
7/20/87	1155	0.2	25.0	30.7	8.4
		2.0	19.7	30.9	9.2
		4.0	16.9	30.9	9.2
		6.0	15.4	31.0	8.6
		8.0	14.0	31.2	8.2
		9.2	13.2	31.2	7.4
7/21/87	1125	0.2	26.0	30.9	8.3
		2.0	17.1	31.1	8.8
		4.0	16.0	31.1	8.8
		6.0	15.0	31.1	8.5
		8.0	13.8	31.1	8.0
		10.0	13.1	31.1	6.6

* Data obtained with Hydrolab Surveyor II

TABLE 2 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (°/‰)	DISSOLVED* OXYGEN (mg/l)
Station SH25 (Salem Harbor)					
7/20/87	1215	0.2	19.2	30.9	9.3
		2.0	17.1	31.0	9.4
7/21/87	1150	0.2	19.2	31.0	9.1
		2.0	18.1	31.1	8.9
		3.0	16.5	31.1	8.3
Station SH27 (Salem Harbor)					
7/20/87	1105	0.2	17.3	31.0	9.4
		2.0	16.9	30.9	9.2
		4.0	15.7	31.0	9.2
7/21/87	1035	0.2	17.5	31.0	9.2
		2.0	17.5	31.0	9.1
		4.0	17.4	31.0	8.9
Station SH28 (Salem Harbor)					
7/20/87	1230	0.2	18.6	31.1	9.6
		2.0	16.8	31.1	9.6
7/21/87	1215	0.2	19.1	31.1	9.3
		2.0	18.3	31.1	8.6
Station SH29 (Salem Harbor)					
7/20/87	1255	0.2	19.6	31.1	10.1
		1.0	19.6	--	10.1
7/21/87	1245	0.2	18.6	31.1	9.6
		1.5	17.7	31.2	9.1
Station SH30 (Salem Harbor)					
7/20/87	1140	0.2	18.9	31.1	9.7
		0.8	18.9	31.1	9.4
7/21/87	1110	0.2	18.0	31.1	9.4
		2.0	17.6	31.1	9.3

* Data obtained with Hydrolab Surveyor II

TABLE 3

1987 SALEM HARBOR AND TRIBUTARY SURVEY

JUNE AND JULY WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER:	SB01				SB02			
DATE:	6/22	6/23	7/20	7/21	6/22	6/23	7/20	7/21
TIME (hours):	1220	1229	1200	1320	1235	1240	1215	1335
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>								
Suspended Solids	8.0	8.5	9.5	11.0	6.5	7.2	5.5	10.0
Total Solids	28,000	16,000	24,800	21,460	33,000	38,000	30,600	31,810
Turbidity (NTU)	2.7	3.9	3.5	0.2	1.5	1.0	2.3	1.6
Total Kjeldahl-Nitrogen	1.8	1.2	1.5	2.1	1.5	0.77	1.1	2.0
Ammonia-Nitrogen	0.1	0.36	0.17	0.15	0.05	0.52	0.16	0.09
Total Phosphorus	0.10	0.08	0.17	0.13	0.08	0.08	0.15	0.13
Orthophosphate	0.06	0.06	0.08	0.08	0.05	0.01	0.07	0.07
Chloride	14,000	10,625	13,000	11,000	16,500	16,500	16,380	16,750
Total Coliform (colonies/100 ml)	600	15,000	150	1,300	480	200	200	20
Fecal Coliform (colonies/100 ml)	60	900	100	70	70	50	10	<5
Chlorophyll <u>a</u> (mg/m ³)	--	--	--	--	--	--	1.32	--

TABLE 3 (CONTINUED)

STATION NUMBER:	SB03				SH01				SH07	
	6/22	6/23	7/20	7/21	6/24	7/20	7/20	7/21	6/24	7/20
DATE:	1250	1440	1300	1350	1300	1125	1130	1050	1130	1045
TIME (hours):	1.0	1.0	1.0	1.0	1.0	1.0	9.0	1.0	1.0	1.0
DEPTH (meters):										
<u>PARAMETER</u>										
Suspended Solids	2.0	11.0	0.5	2.5	3.0	1.5	3.0	3.5	2.3	1.5
Total Solids	26,000	10,000	20,600	21,970	34,000	32,000	32,100	32,430	32,470	32,500
Turbidity (NTU)	1.8	5.3	2.4	1.5	1.2	1.2	0.8	0.7	1.1	0.9
Total Kjeldahl-Nitrogen	0.92	1.5	1.0	1.5	1.1	0.67	0.61	0.96	1.6	0.53
Ammonia-Nitrogen	0.18	0.36	0.32	0.31	<0.02	<0.02	<0.02	0.15	<0.02	<0.02
Total Phosphorus	0.07	0.17	0.08	0.07	0.06	0.07	0.08	0.03	0.09	0.08
Orthophosphate	0.06	0.11	0.06	0.06	0.02	0.03	0.06	0.02	0.03	0.04
Chloride	13,000	4,500	11,000	11,250	16,500	16,750	17,000	16,750	16,750	17,000
Total Coliform (colonies/100 ml)	7,000	40,000	35,000	18,000	40	5	--	<5	5	10
Fecal Coliform (colonies/100 ml)	300	3,000	1,900	1,200	<5	<5	--	<5	<5	<5
Chlorophyll <u>a</u> (mg/m ³)	--	--	0.69	--	--	--	--	--	--	--
Oil and Grease	--	--	5.1	0.8	--	--	--	--	--	--

TABLE 3 (CONTINUED)

STATION NUMBER:	SH23			SH24				SH25	
DATE:	6/24	7/20	7/21	7/20	7/20	7/21	7/21	7/20	7/21
TIME (hours):	1115	1245	1225	1155	1200	1125	1130	1215	1150
DEPTH (meters):	1.0	1.0	1.0	1.0	9.0	1.0	9.5	1.0	1.0
PARAMETER									
Suspended Solids	2.0	5.0	4.5	4.5	4.5	4.0	7.5	1.5	4.5
Total Solids	32,280	31,800	32,060	32,600	32,500	32,040	32,560	31,600	32,140
Turbidity (NTU)	2.1	1.9	1.0	0.9	1.2	0.9	1.0	2.0	0.9
Total Kjeldahl-Nitrogen	1.5	0.59	0.99	0.43	0.42	1.2	1.4	0.62	1.1
Ammonia-Nitrogen	<0.02	<0.02	0.32	<0.02	<0.02	0.02	0.13	<0.02	<0.02
Total Phosphorus	0.08	0.08	0.03	0.08	0.07	0.05	0.09	0.08	0.04
Orthophosphate	0.03	0.03	0.02	0.03	0.04	0.03	0.07	0.04	0.03
Chloride	17,000	16,750	17,000	17,000	17,000	17,000	17,000	16,630	17,250
Total Coliform (colonies/100 ml)	5	220	5	200	--	160	--	120	200
Fecal Coliform (colonies/100 ml)	<5	10	<5	20	--	<5	--	10	30
Enterococci (colonies/100 ml)	--	--	--	<5	--	--	--	--	--
Chlorophyll <u>a</u> (mg/m ³)	--	1.85	--	--	--	2.73	--	0.84	2.02
Total Phosphorus	0.08	0.08	0.03	0.08	0.07	0.05	0.09	0.08	0.04

TABLE 3 (CONTINUED)

STATION NUMBER:	SH27		SH28		SH29		SH30	
DATE:	7/20	7/21	7/20	7/21	7/20	7/21	7/20	7/21
TIME (hours):	1105	1035	1230	1215	1255	1245	1140	1110
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>								
Suspended Solids	1.5	3.5	2.5	1.5	2.0	4.5	4.0	2.0
Total Solids	32,000	32,030	32,100	32,060	32,200	32,340	31,900	32,200
Turbidity (NTU)	0.7	0.6	1.4	0.6	1.7	1.1	0.7	0.6
Total Kjeldahl-Nitrogen	0.47	0.91	0.59	1.1	0.76	0.92	0.54	1.3
Ammonia-Nitrogen	0.12	<0.02	<0.02	<0.02	0.06	0.14	<0.02	<0.02
Total Phosphorus	0.08	0.05	0.10	0.06	0.10	0.05	0.08	0.05
Orthophosphate	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03
Chloride	16,750	17,000	17,000	17,000	16,750	16,750	16,000	16,750
Total Coliform (colonies/100 ml)	30	5	5	<5	10	5	5	<5
Fecal Coliform (colonies/100 ml)	<5	<5	<5	<5	<5	<5	<5	<5
Enterococci (colonies/100 ml)	<5	--	--	--	--	--	--	--
Chlorophyll a (mg/m ³)	--	1.94	2.02	--	2.02	--	1.23	--

TABLE 4
1987 SALEM HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

TOTAL METALS, TOTAL KJELDAHL-NITROGEN, TOTAL PHOSPHORUS, % VOLATILE SOLIDS AND
OIL AND GREASE

STATION NUMBER:	SB02	SB03	SH23	SH24	SH25
<u>PARAMETER</u> (in mg/kg dry wt.)					
Metals:					
Iron	20,000	15,000	38,000	30,000	20,000
Aluminum	9,100	3,850	14,500	14,500	10,200
Copper	42	26	76	68	62
Zinc	110	76	180	170	140
Lead	300	150	230	130	230
Chromium	200	160	1,800	1,100	560
Cadmium	0.90	2.5	2.7	2.0	1.3
Nickel	19	11	36	43	24
Silver	0.40	0.70	0.40	0.20	0.50
Arsenic	5.2	6.1	17	13	38
Mercury	0.51	0.51	1.1	0.75	1.4
Total Kjeldahl-Nitrogen	2,300	810	5,000	4,840	3,670
Total Phosphorus	1,150	465	1,720	1,550	985
% Volatile Solids	7.28	2.95	16.0	13.6	12.3
Oil and Grease (mg/kg wet wt.)	0.91	0.42	0.19	0.12	0.13

* Samples collected on July 20 and 21, 1987

TABLE 5
1987 SALEM HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(reported as $\mu\text{g/g}$ dry weight)

STATION NUMBER:	SB02	SB03	SH23	SH24	SH25
<u>COMPOUNDS</u>					
Acenaphthene	0.69	0.74	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND
Anthracene	1.2	ND	ND	ND	ND
Benzo(a) anthracene	2.7	1.2	ND	ND	ND
Benzo(b) fluoranthene	ND	ND	ND	ND	ND
Benzo(k) fluoranthene	ND	ND	ND	ND	ND
Benzo(g,h,i) perylene	ND	ND	ND	ND	ND
Benzo(a) pyrene	ND	ND	ND	ND	ND
Chrysene	2.2	1.1	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND
Dimethyl naphthalene	ND	ND	ND	ND	ND
Fluoranthene	4.4	1.2	0.86	ND	1.1
Fluorene	0.59	ND	ND	ND	ND
Methyl anthracene	ND	ND	ND	ND	ND
Methyl fluorene	ND	ND	ND	ND	ND
Methyl naphthalene	ND	ND	ND	ND	ND
Methyl phenanthrene	ND	ND	ND	ND	ND
Methyl pyrene	ND	ND	ND	ND	NS
Phenanthrene	3.6	0.90	ND	ND	0.75
Pyrene	3.4	1.1	0.86	ND	1.1
1,1 Biphenyl	ND	ND	ND	ND	ND
PCB A 1242	<0.16	<0.16	ND	<0.16	<0.16
PCB A 1254	ND	ND	ND	ND	ND
PCB A 1260	<0.17	<0.17	<0.17	<0.17	<0.17

* Samples collected on July 20 and 21, 1987
ND Not detected

BEVERLY HARBOR AND TRIBUTARIES

DESCRIPTION OF BEVERLY HARBOR AND TIDAL PORTIONS OF ITS TRIBUTARIES

Beverly Harbor is bordered by the cities of Salem to the south and Beverly to the north. The harbor is approximately 0.78 square miles and similar in depth to Salem Harbor but receives a proportionately larger freshwater input from the combined flows of the North, Crane, Porter, Bass, and Danvers Rivers. The Danvers River is the major tributary and is tidal for its entire reach. All of the other tributaries flow into the Danvers and not directly into the harbor. This river system drains highly urbanized sections of Salem, Peabody, Danvers, and Beverly.

At least five major industries have NPDES permits to discharge cooling water, storm runoff or wastewater into the rivers that empty into Beverly Harbor. In addition to these discharges, several combined sewer overflows periodically discharge wastewater into the harbor and/or its tributaries.

Historically there were numerous tanneries in the Salem/Beverly area. Waste from the tanneries contain high levels of some heavy metals, especially chromium. In the past, these industries were not required to treat their waste discharges and now the sediments in some areas of the rivers and harbor are highly contaminated. Several confirmed hazardous waste sites and a junkyard also exist within the North River drainage system.

Recreational use of the area is high. Numerous beaches, marinas, and boat ramps are located throughout the harbor and tidal portions of its tributaries. Shell-fishing areas, although closed, exist in Collins Cove, the North, Bass, and Danvers Rivers. Many recreational boaters share the harbor and rivers with fishing and other commercial vessels.

Table 6 provides location descriptions for the stations that were samples in this study and Figure 1 illustrates the station locations.

RESULTS

Water column chemical, physical and bacteriological data are presented in Tables 7, 8 and 9. Sediment chemistry data are presented in Tables 10, 11 and 12.

TABLE 6

1987 BEVERLY HARBOR AND TRIBUTARY WATER QUALITY SURVEY

SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>LOCATION DESCRIPTION</u>
SB05	Goldthwait Brook - Peabody Street above Eastman Gelatin, Peabody
SB05A	Goldthwait Brook - Foster Street, Peabody
SB06	Goldthwait Brook - Summer Street below Metro Dry Cleaners, Peabody
SB06A	North River - Below Stahl Finishing Plant, Salem
SB09	North River - Flint Street, Salem
SB10	North River - Route 114, Salem
SB12	Waters River - Route 35, Danvers
SB15	Crane River - Route 35, Danvers
SB17	Porter River - Liberty Street, Danvers
SB20	Bass River - Elliot Street, Shoe Pond outlet, Beverly
SB21	Danvers River - Liberty Hill Avenue bridge, Salem
SB22	Danvers River - Route 1A bridge, Salem
SB23	Bass River - Bridge Street bridge, Beverly
BH19	Danvers River - at confluence of Porter and Crane Rivers, Danvers
BH20	Danvers River - off Fosters Point under power lines, Danvers
BH21	North River - in cove midway between confluence with Danvers River and North Street bridge, Salem
BH22	Bass River - off Salters Point at nun #6, Beverly
BH23	Beverly Harbor - Collins Cove, under power lines, Salem
BH24	Beverly Harbor - off Tuck Point at can #9
BH25	Beverly Harbor - off Salem Neck at nun #2

TABLE 7

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY DATA

TIME - DEPTH - TEMPERATURE - SALINITY - DISSOLVED OXYGEN

DATE	TIME (hr/min)	DEPTH (m)	TEMPERATURE** (°C)	SALINITY** (‰)	DISSOLVED** OXYGEN (mg/l)
Station SB05 (Goldthwait Brook)					
8/19/87	1200	0.1	20.0	--	3.0
Station SB05A (Goldthwait Brook)					
8/18/87	0950	0.1	23.0	--	3.0
8/19/87	1225	0.1	21.0	--	2.0
Station SB06A (North River)					
8/18/87	1025	0.1	24.0	--	4.0
8/19/87	1240	0.1	22.0	--	5.5
Station SB09 (North River)					
6/22/87	1145	0.1	21.0	1.3	7.2
6/23/87	1200	0.1	17.8	0.1	7.0
8/18/87	1040	0.1	26.0	1.0	8.6
8/19/87	1246	0.1	29.0	1.0	14.1
Station SB10 (North River)					
6/22/87	1200	0.1	21.0	7.5	4.6
6/23/87	1213	0.1	17.2	3.0	6.3
8/18/87	1105	0.1	22.0	12.5	4.2
8/19/87	1258	0.1	22.0	9.0	5.2
Station SB12 (Waters River)					
6/22/87	1420	0.1	20.0	20.1	6.6
6/23/87	1416	0.1	17.1	18.8	7.1
8/18/87	1235	0.1	24.0	19.5	7.3
8/19/87	1404	0.1	21.0	21.0	9.4
Station SB15 (Crane River)					
6/22/87	1411	0.1	20.5	17.6	6.9
6/23/87	1408	0.1	17.6	17.4	6.6
8/18/87	1225	0.1	24.0	18.5	6.7
8/19/87	1356	0.1	25.0	14.0	7.6

** Data obtained with YSI Model 33 SCT Meter and Winkler Method for Dissolved Oxygen

TABLE 7 (CONTINUED)

DATE	TIME (hr/min)	DEPTH (m)	TEMPERATURE** (°C)	SALINITY** (‰)	DISSOLVED OXYGEN** (mg/l)
Station SB17 (Porter River)					
6/22/87	1400	0.1	20.8	19.6	6.0
6/23/87	1400	0.1	17.9	19.1	6.3
8/18/87	1210	0.1	24.0	18.0	7.0
8/19/87	1345	0.1	24.0	17.0	7.4
Station SB20 (Bass River)					
6/22/87	1348	0.1	21.8	13.0	7.7
6/23/87	1347	0.1	17.1	8.1	7.5
8/18/87	1155	0.1	24.0	8.5	6.6
8/19/87	1335	0.1	28.0	7.0	6.8
Station SB21 (Danvers River)					
6/22/87	1336	0.1	18.9	21.0	8.6
6/23/87	1337	0.1	17.0	20.8	8.6
8/18/87	1300	0.1	22.0	19.0	8.0
8/19/87	1417	0.1	20.0	15.0	8.3
Station SB22 (Danvers River)					
6/22/87	1305	0.1	18.0	21.1	9.0
6/23/87	1300	0.1	16.6	21.0	8.6
8/18/87	1127	0.1	18.0	16.5	7.3
8/19/87	1312	0.1	20.0	17.0	8.0
Station SB23 (Bass River)					
6/22/87	1323	0.1	19.8	18.8	8.8
6/23/87	1325	0.1	17.0	20.0	7.8
8/18/87	1139	0.1	22.0	20.0	9.0
8/19/87	1325	0.1	20.0	15.0	9.2
Station BH19 (Danvers River)*					
8/18/87	0930	0.2	22.2	30.3	10.0
		1.0	21.4	30.4	11.0
8/19/87	1040	0.2	21.5	30.4	9.0
		2.0	18.9	30.8	9.0
		3.3	17.8	30.9	8.3

* Data obtained with Hydrolab Surveyor II

** Data obtained with YSI Model 33 SCT Meter and Winkler Method for Dissolved Oxygen

TABLE 7 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station BH24 (Beverly Harbor)					
6/24/87	1430	0.2	16.7	30.5	9.1
		2.0	16.5	30.6	9.0
		4.0	16.5	30.7	9.0
		6.0	16.3	30.6	8.9
		7.7	15.6	30.8	8.6
8/18/87	0740	0.2	15.2	31.3	8.7
		1.0	15.0	31.3	8.5
		2.0	14.2	31.3	8.3
		3.0	13.1	31.3	8.3
8/19/87	1120	0.2	14.1	31.2	9.1
		2.0	13.3	31.4	9.0
		4.0	12.7	31.3	8.9
		6.0	12.3	31.4	8.9
		8.0	12.1	31.5	8.9
Station BH25 (Beverly Harbor)					
6/24/87	1410	0.2	16.7	30.7	9.5
		2.0	16.2	30.8	10.1
		4.0	14.5	31.0	9.2
		6.0	14.4	31.0	8.6
8/18/87	1030	0.2	16.7	31.1	9.2
		2.0	16.1	31.2	9.1
		4.0	12.2	31.4	***
8/19/87	1145	0.2	17.2	31.2	8.9
		2.0	14.0	31.4	9.3
		4.0	12.7	31.5	9.7
		6.0	11.8	31.5	9.4
Station BH20 (Danvers River)					
8/18/87	0950	0.2	21.0	30.6	7.8
8/19/87	1020	0.2	20.4	30.6	8.1
		1.0	19.1	30.8	8.6
Station BH21 (North River)					
8/18/87	0840	0.2	18.3	30.7	8.1
8/19/87	0930	0.2	18.4	30.4	7.6
		1.3	15.8	31.1	8.5

* Data obtained with Hydrolab Surveyor II

*** Hydrolab malfunction

TABLE 7 (CONTINUED)

DATE	TIME* (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station BH22 (Bass River)					
8/18/87	0900	0.2	20.2	30.5	9.9
8/19/87	0955	0.2	19.1	30.4	8.5
		2.0	14.9	31.4	8.6
		4.0	14.0	31.4	8.7
Station BH23 (Beverly Harbor)					
8/18/87	0805	0.2	17.3	31.1	7.9
8/19/87	0850	0.2	17.1	30.9	8.0
		1.5	15.3	31.1	8.7

* Data obtained with Hydrolab Surveyor II

TABLE 8

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

JUNE WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER:	SB09		SB10		SB12		SB15	
DATE:	6/22	6/23	6/22	6/23	6/22	6/23	6/22	6/23
TIME (hours):	1145	1200	1200	1213	1420	1416	1411	1408
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>								
Suspended Solids	2.5	2.5	2.5	5.8	7.8	8.0	5.5	9.7
Total Solids	1,900	270	12,000	24,000	32,000	30,000	27,000	27,000
Turbidity (NTU)	2.7	6.1	2.0	4.7	2.4	2.1	2.0	1.8
Total Kjeldahl-Nitrogen	1.4	1.2	1.8	1.8	1.1	1.2	1.5	1.1
Ammonia-Nitrogen	0.15	0.49	0.29	0.54	0.07	0.22	0.08	0.28
Total Phosphorus	0.07	0.22	0.09	0.23	0.07	0.18	0.07	0.18
Orthophosphate	0.06	0.16	0.08	0.15	0.06	0.08	0.05	0.07
Chloride	870	70	5,750	1,500	16,000	14,750	13,250	13,250
Total Coliform (colonies/100 ml)	60,000	51,000	26,000	38,000	60	1,300	1,800	6,000
Fecal Coliform (colonies/100 ml)	5,100	5,000	2,000	4,000	5	300	250	450
Chlorophyll <u>a</u> (mg/m ³)	--	--	2.8	--	--	--	--	--

TABLE 8 (CONTINUED)

STATION NUMBER: DATE: TIME (hours): DEPTH (meters):	SB17		SB20		SB21	
	6/22	6/23	6/22	6/23	6/22	6/23
	1400	1400	1348	1347	1336	1337
	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>						
Suspended Solids	5.5	4.0	8.5	11.0	5.2	3.5
Total Solids	31,000	30,000	19,000	11,000	34,000	36,000
Turbidity (NTU)	2.4	1.4	8.3	26.0	1.3	0.9
Total Kjeldahl-Nitrogen	0.71	1.1	1.0	1.3	0.65	0.89
Ammonia-Nitrogen	0.05	0.12	0.25	0.36	0.05	0.22
Total Phosphorus	0.07	0.15	0.07	0.18	0.06	0.15
Orthophosphate	0.05	0.07	0.06	0.13	0.04	0.04
Chloride	15,250	14,500	9,500	5,250	16,750	16,500
Total Coliform (colonies/100 ml)	530	1,200	4,000	60,000	80	490
Fecal Coliform (colonies/100 ml)	30	250	120	8,000	20	30
Chlorophyll <u>a</u> (mg/m ³)	--	--	11.76	--	21.0	--

TABLE 8 (CONTINUED)

STATION NUMBER: DATE: TIME (hours): DEPTH (meters):	SB22		SB23		BH24	BH25	
	6/22	6/23	6/22	6/23	6/24	6/24	6/24
	1305	1300	1323	1325	1430	1400	1410
	1.0	1.0	1.0	1.0	1.0	1.0	5.0
<u>PARAMETER</u>							
Suspended Solids	2.7	4.5	4.8	7.5	5.5	1.5	2.5
Total Solids	33,000	34,000	31,000	32,000	32,190	32,100	32,410
Turbidity (NTU)	1.0	1.0	2.4	6.3	1.3	1.1	1.3
Total Kjeldahl-Nitrogen	0.72	0.92	0.78	1.1	1.0	1.6	0.89
Ammonia-Nitrogen	<0.02	0.17	0.11	0.48	<0.02	<0.02	<0.02
Total Phosphorus	0.07	0.11	0.08	0.13	0.09	0.07	0.15
Orthophosphate	0.03	0.04	0.06	0.06	0.04	0.03	0.04
Chloride	17,000	16,500	15,500	15,750	18,250	19,250	18,250
Total Coliform (colonies/100 ml)	20	460	20,000	10,000	20	5	--
Fecal Coliform (colonies/100 ml)	<5	30	1,250	1,000	<5	<5	--
Chlorophyll <u>a</u> (mg/m ³)	20.16	--	33.6	--	6.72	--	--

TABLE 9

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

AUGUST WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER:	SB05	SB05A		SB06A		SB09		SB10	
DATE:	8/19	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19
TIME (hours):	1200	0950	1225	1025	1240	1040	1246	1105	1258
DEPTH (meters):	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<u>PARAMETER</u>									
Suspended Solids	6.5	5.5	9.5	3.0	5.0	4.0	3.5	3.0	4.0
Total Solids	270	340	320	300	290	2,540	920	21,700	20,000
Turbidity (NTU)	2.1	5.4	22.0	3.5	6.7	3.3	3.2	3.5	3.8
Total Kjeldahl-Nitrogen	2.2	7.5	5.0	7.0	5.4	4.6	1.9	2.2	1.6
Ammonia-Nitrogen	1.0	3.0	2.6	3.2	3.0	1.2	.99	0.69	0.68
Total Phosphorus	1.9	0.30	0.31	0.49	0.66	0.34	0.34	0.31	0.23
Orthophosphate	1.6	0.12	0.31	0.30	0.52	0.16	0.25	0.14	0.15
Chloride	60	110	80	85	80	1,000	390	11,000	10,250
Total Coliform (colonies/100 ml)	5,000	2,700	8,000	950,000	1,200,000	89,000	48,000	74,000	2,100
Fecal Coliform (colonies/100 ml)	360	320	600	120,000	500,000	8,000	4,000	7,000	900
Chlorophyll <u>a</u> (mg/m ³)	--	--	--	--	--	--	--	--	2.9

TABLE 9 (CONTINUED)

STATION NUMBER:	SB12		SB15		SB17		SB20		SB21	
DATE:	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19
TIME (hours):	1235	1404	1225	1356	1210	1345	1155	1335	1300	1417
DEPTH (meters):	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<u>PARAMETER</u>										
Suspended Solids	9.0	4.0	8.0	6.0	10.0	6.0	6.5	10.0	10.0	4.5
Total Solids	31,200	32,000	30,500	28,000	30,800	32,000	11,500	12,000	32,800	33,000
Turbidity (NTU)	2.1	1.6	1.8	2.7	2.2	1.8	1.5	1.4	1.0	1.0
Total Kjeldahl-Nitrogen	1.8	0.46	2.0	0.54	1.0	0.58	1.9	0.46	2.6	0.40
Ammonia-Nitrogen	0.08	0.09	0.07	0.10	0.07	0.06	0.08	0.10	0.04	0.05
Total Phosphorus	0.14	0.12	0.11	0.11	0.15	0.13	0.13	0.12	0.13	0.12
Orthophosphate	0.12	0.06	0.06	0.05	0.09	0.05	0.04	0.06	0.05	0.04
Chloride	16,000	15,750	15,250	14,250	15,250	16,250	5,500	5,250	16,750	16,500
Total Coliform (colonies/100 ml)	100	50	2,000	500	260	120	5,000	3,000	40	120
Fecal Coliform (colonies/100 ml)	30	10	730	10	10	5	560	250	<5	5
Chlorophyll a (mg/m ³)	--	3.47	--	1.93	--	4.5	--	--	--	5.58

TABLE 9 (CONTINUED)

STATION NUMBER:	SB22		SB23		BH19		BH20		BH21	
DATE:	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19
TIME (hours):	1127	1312	1139	1325	0930	1040	0950	1020	0840	0930
DEPTH (meters):	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
<u>PARAMETER</u>										
Suspended Solids	6.5	7.0	7.5	10.0	7.5	4.5	6.5	3.5	4.0	1.5
Total Solids	33,000	33,000	31,500	32,000	32,000	33,000	32,200	28,000	32,300	33,000
Turbidity (NTU)	1.1	0.9	1.3	1.3	1.1	1.1	1.0	1.4	0.9	0.9
Total Kjeldahl-Nitrogen	2.0	0.71	1.7	0.51	1.5	1.2	0.82	0.62	0.54	0.90
Ammonia-Nitrogen	0.02	0.17	<0.02	<0.02	0.11	<0.02	<0.02	0.02	<0.02	0.02
Total Phosphorus	0.11	0.15	0.11	0.13	0.11	0.11	0.12	0.24	0.09	0.25
Orthophosphate	0.03	0.04	0.04	0.04	0.02	0.02	0.03	0.06	0.03	0.03
Chloride	16,750	17,000	16,250	16,500	16,500	16,750	16,250	14,000	16,500	16,250
Total Coliform (colonies/100 ml)	500	100	240	600	20	80	80	900	3,500	1,300
Fecal Coliform (colonies/100 ml)	40	10	20	30	<5	10	40	80	390	140
Chlorophyll a (mg/m ³)	--	1.98	--	--	6.34	--	--	3.96	2.16	--

TABLE 9 (CONTINUED)

STATION NUMBER:	BH22		BH23		BH24		BH25	
DATE:	8/18	8/19	8/18	8/19	8/18	8/19	8/18	8/19
TIME (hours):	0900	0955	0805	0850	0740	1120	1030	1145
DEPTH (meters):	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<u>PARAMETER</u>								
Suspended Solids	3.5	2.0	5.0	2.0	3.0	1.5	3.0	2.0
Total Solids	32,700	33,000	32,900	33,000	32,900	33,000	33,200	33,000
Turbidity (NTU)	0.7	0.7	0.7	0.7	0.7	0.6	0.8	0.6
Total Kjeldahl-Nitrogen	1.8	0.63	0.70	0.90	1.7	0.48	1.1	0.53
Ammonia-Nitrogen	<0.02	0.14	<0.02	0.03	<0.02	<0.02	<0.02	<0.02
Total Phosphorus	0.09	0.24	0.09	0.28	0.15	0.16	0.07	0.14
Orthophosphate	0.02	0.02	0.03	0.04	0.03	0.02	0.03	0.03
Chloride	16,500	18,000	16,750	17,000	17,500	17,250	16,500	16,750
Total Coliform (colonies/100 ml)	560	750	140	150	60	30	40	10
Fecal Coliform (colonies/100 ml)	40	90	5	10	10	<5	10	<5
Chlorophyll <u>a</u> (mg/m ³)	2.7	--	--	2.88	3.96	--	--	1.9

TABLE 10

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

TOTAL KJELDAHL-NITROGEN (TKN), TOTAL PHOSPHORUS, % VOLATILE SOLIDS AND
OIL AND GREASE

STATION NUMBER	TKN ¹	TOTAL P ¹	% VOLATILE SOLIDS	OIL AND GREASE ²
SB05A	530	850	2.63	0.25
SB06A	10,860	3,190	31.4	0.25
SB09	2,680	1,580	10.8	0.31
SB10	1,880	1,640	12.8	0.25
SB12	930	720	4.14	0.29
SB15	2,360	1,280	8.18	0.09
SB17	1,620	790	6.06	0.15
SB20	2,450	1,700	12.7	0.26
SB21	1,410	930	5.98	0.15
BH20	1,490	770	7.88	0.09
BH21	5,120	1,890	16.9	0.61
BH22	2,090	860	5.67	0.11
BH23	970	440	3.28	0.09
BH24	1,140	540	3.66	0.15

* Samples collected August 18 and 19, 1987

¹ mg/kg dry weight² mg/kg wet weight

TABLE 11

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

TOTAL METALS (mg/kg dry weight)

STATION NUMBER	Fe	Al	Cu	Zn	Pb	Cr	Cd	Ni	Ag	As	Hg+
SB05A	13,000	5,100	130	150	150	40	0.50	22	0.80	9.2	0.38
SB06A	11,000	8,600	160	1,100	950	6,800	9.2	20	0.60	15.0	1.8
SB09	16,000	11,000	140	380	520	940	2.5	24	0.50	5.6	3.1
SB10	17,000	9,200	120	320	420	430	2.8	20	0.60	12.0	1.95
SB12	15,000	7,200	36	83	120	220	0.50	15	0.80	7.0	0.52
SB15	10,000	11,000	66	17	160	220	1.0	12	0.60	14.0	1.99
SB17	14,000	7,300	45	130	120	240	0.70	20	0.40	8.3	1.27
SB20	19,000	10,500	13	300	160	500	1.8	13	0.60	19	1.70
SB21	6,400	6,000	24	82	140	250	1.6	21	0.40	8.8	0.70
BH20	13,000	6,100	39	110	110	550	1.5	11	0.40	25	1.5
BH21	13,000	11,600	150	500	560	4,700	8.6	27	0.70	24	5.0
BH22	9,000	5,400	48	120	120	420	1.6	14	0.70	20	1.2
BH23	4,800	4,100	17	54	53	210	0.80	7.4	0.20	8.5	1.1
BH24	4,400	3,700	19	48	52	240	0.80	6.3	0.20	1.5	0.37

* Samples collected August 18 and 19, 1987

TABLE 12

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(reported as $\mu\text{g/g}$ dry weight)

STATION NUMBER:	SB05A	SB06A	SB09	SB10	SB12	SB15	SB17	SB20
<u>COMPOUNDS</u>								
Acenaphthene	1.0	0.79	0.55	0.39	ND	ND	ND	ND
Acenaphthylene	ND	0.47	0.40	0.87	ND	ND	ND	ND
Anthracene	3.7	1.2	0.52	3.0	ND	ND	ND	ND
Benzo(a) anthracene	13	9.2	3.5	4.6	ND	ND	ND	ND
Benzo(b) fluoranthene	+	+	+	+	ND	ND	ND	ND
Benzo(k) fluoranthene	10	9.1	3.7	4.7	ND	ND	ND	ND
Benzo(g,h,i) perylene	11	ND	ND	1.9	ND	ND	ND	ND
Benzo(a) pyrene	16	7.5	3.6	4.4	ND	ND	ND	ND
Chrysene	10	5.9	2.9	3.9	ND	ND	ND	ND
Dibenzofuran	+	+	ND	+	ND	ND	ND	ND
Dimethyl naphthalene	+	+	ND	ND	ND	ND	NO	ND
Fluoranthene	21	15	4.4	13	ND	2.1	1.4	1.7
Fluorene	2.0	1.2	0.64	1.6	ND	ND	ND	ND
Methyl anthracene	ND	+	ND	+	ND	ND	ND	ND
Methyl fluorene	ND	ND	ND	+	ND	ND	ND	ND
Methyl naphthalene	+	ND	ND	ND	ND	ND	ND	ND
Methyl phenanthrene	ND	+	ND	+	ND	ND	ND	ND
Methyl pyrene	ND	+	ND	+	ND	ND	ND	ND
Phenanthrene	21	7.4	2.1	14	ND	ND	ND	ND
Pyrene	17	11	3.5	9.3	ND	1.9	1.3	1.7
1,1 Biphenyl	ND	+	ND	ND	ND	ND	ND	ND
PCB A 1242	ND	ND	ND	ND	<0.17	ND	ND	ND
PCB A 1254	ND	ND	ND	ND	ND	<0.56	ND	<0.56
PCB A 1260	6.6**	<0.17	0.32	0.66	0.27	<0.17	0.17	ND

* Samples collected on August 18 and 19, 1987

** Result suspect

+ No standard available for quantitation. Mass spectrum compared to mass spectral database for identification.

ND Not detected

TABLE 12 (CONTINUED)

1987 BEVERLY HARBOR AND TRIBUTARY SURVEY

SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(reported as $\mu\text{g/g}$ dry weight)

STATION NUMBER:	SB21	BH20	BH21	BH22	BH23	BH24
<u>COMPOUNDS</u>						
Acenaphthene	ND	ND	0.52	ND	ND	ND
Acenaphthylene	ND	ND	0.38	ND	ND	ND
Anthracene	ND	ND	0.72	ND	ND	ND
Benzo(a) anthracene	ND	ND	4.2	ND	ND	ND
Benzo(b) fluoranthene	ND	ND	+	ND	ND	ND
Benzo(k) fluoranthene	ND	ND	4.0	ND	ND	ND
Benzo(g,h,i) perylene	ND	ND	ND	ND	ND	ND
Benzo(a) pyrene	ND	ND	4.0	ND	ND	ND
Chrysene	ND	ND	3.2	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND
Dimethyl naphthalene	ND	ND	ND	ND	ND	ND
Fluoranthene	1.9	ND	5.2	3.6	ND	ND
Fluorene	ND	ND	0.72	ND	ND	ND
Methyl anthracene	ND	ND	ND	ND	ND	ND
Methyl fluorene	ND	ND	ND	ND	ND	ND
Methyl naphthalene	ND	ND	ND	ND	ND	ND
Methyl phenanthrene	ND	ND	ND	ND	ND	ND
Methyl pyrene	ND	ND	ND	ND	ND	ND
Phenanthrene	1.4	ND	2.8	ND	ND	ND
Pyrene	2.0	ND	4.2	ND	ND	ND
1,1 Biphenyl	ND	ND	ND	ND	ND	ND
PCB A 1242	<0.16	<0.16	0.23	<0.16	N.D.	<0.16
PCB A 1254	ND	<0.56	ND	<0.56	<0.56	<0.56
PCB A 1260	<0.17	ND	1.8	ND	ND	ND

* Samples collected on August 18 and 19, 1987

+ No standard available for quantitation. Mass spectrum compared to Mass spectral database for identification.

ND Not detected

BEVERLY HARBOR SPECIAL WATER QUALITY SURVEY

INTRODUCTION

During the period of February through May of 1988 four water quality surveys were conducted in Beverly Harbor by Division personnel. The sampling was conducted to monitor water quality in the area in response to a break in the 60 year old 30" force main sewer pipe which conducts untreated sewage from the Beverly pumping station at Tuck Point under Beverly Harbor to the SESD wastewater treatment plant on Salem Neck. The rupture occurred at approximately 1:15 p.m. on Saturday, February 13, 1988. At the time, the area was being dredged so that a new sewer line could be installed. On February 21 a second break occurred when the dredge pulled up sections of old pipe near the Salem shoreline. By Wednesday, February 24, 1988 the new 42" line was in place and all flow from the pumping station in Beverly was, once again, transported under the harbor to the treatment plant. During the 11 day period of the break an average of 10.6 MGD of untreated sewage flowed into the harbor. An additional average of 0.94 MGD of sewage was discharged from the River Street and Wilson Avenue bypass gates during this period. Due to tidal conditions that influenced the flow of sewage from the bypass points, repairs to the pipe by divers could only be undertaken three hours before and three hours after low tide. During this period, sewage was diverted from the force main to the bypass points on the Danvers and Waters rivers.

The SESD also conducted special water sampling (mainly for bacteria) during and after the break at nine stations around Beverly Harbor and the Danvers and Waters rivers. Samples of wastewater entering the Beverly Pumping Station were also analyzed on two separate days by SESD.

DESCRIPTION OF STUDY AND METHODOLOGY

Samples were collected in Beverly Harbor and the Danvers River on four occasions during the winter-spring period of 1988. The sampling station descriptions and dates of collection for the study are listed in Table 13. Figure 3 illustrates the station locations and approximate location of the break in the pipe. Stations were selected so that the impact of the rupture on water quality could be assessed in the immediate vicinity of the pipe as well as at various upstream and downstream locations. Samples were also collected upstream on the Danvers River to test for signs of sewage contamination that may have been transported upriver on the incoming tide.

Stations 21 and 22 on the Danvers River were accessed from bridges. Water samples were collected with a bucket from these locations. All other stations in Beverly Harbor were accessed by boat. The Salem Harbormaster, Jim Cahill, supplied boat transport for each survey. Water samples were collected from the boat with a van Dorn grab sampler at one meter below the surface and one meter above the bottom. Sediment samples were collected with a Petite Ponar dredge from all of the harbor stations (A thru E) on May 4 as described in the methods section of this report.

The samples were transported on ice to the Lawrence Experiment Station (LES) within three hours of collection and analyzed for the following:

Water samples: BOD, pH, total solids, suspended solids, chloride, turbidity, conductivity, total Kjeldahl nitrogen, ammonia nitrogen, total phosphorus, and total and fecal coliform bacteria.

Sediment samples: heavy metals, PAHs, PCBs, total phosphorus, total Kjeldahl nitrogen and percent volatile organics.

The methods of analyses performed at LES are described in Appendix B.

Salinity and conductivity were measured in the field with a SCT meter (Yellow Springs Model 33). Temperature was taken with a hand-held thermometer; dissolved oxygen determinations were conducted by the modified Winkler technique.

TABLE 13

BEVERLY HARBOR SPECIAL WATER QUALITY SURVEY
SAMPLING STATION LOCATIONS

<u>STATION</u>	<u>DESCRIPTION</u>
A	As outgoing current flows, approximately 50 meters east of break in pipe
B	As incoming current flows, approximately 50 meters west of break in pipe
C	Approximately 100 meters off Woodbury Point
D	Off Sandy Point at can #3
E	Off Tuck Point jetty at nun #8
21	Danvers River, Liberty Hill Avenue Bridge
22	Danvers River, Route 1A Bridge

SURVEY DATES

<u>STATION</u>	<u>SAMPLE DATE</u>	<u>PIPE RUPTURED</u>
A, B, C, D, E	2/25, 3/7, 3/30, 5/4	2/13-2/24
21, 22	3/7, 3/30	

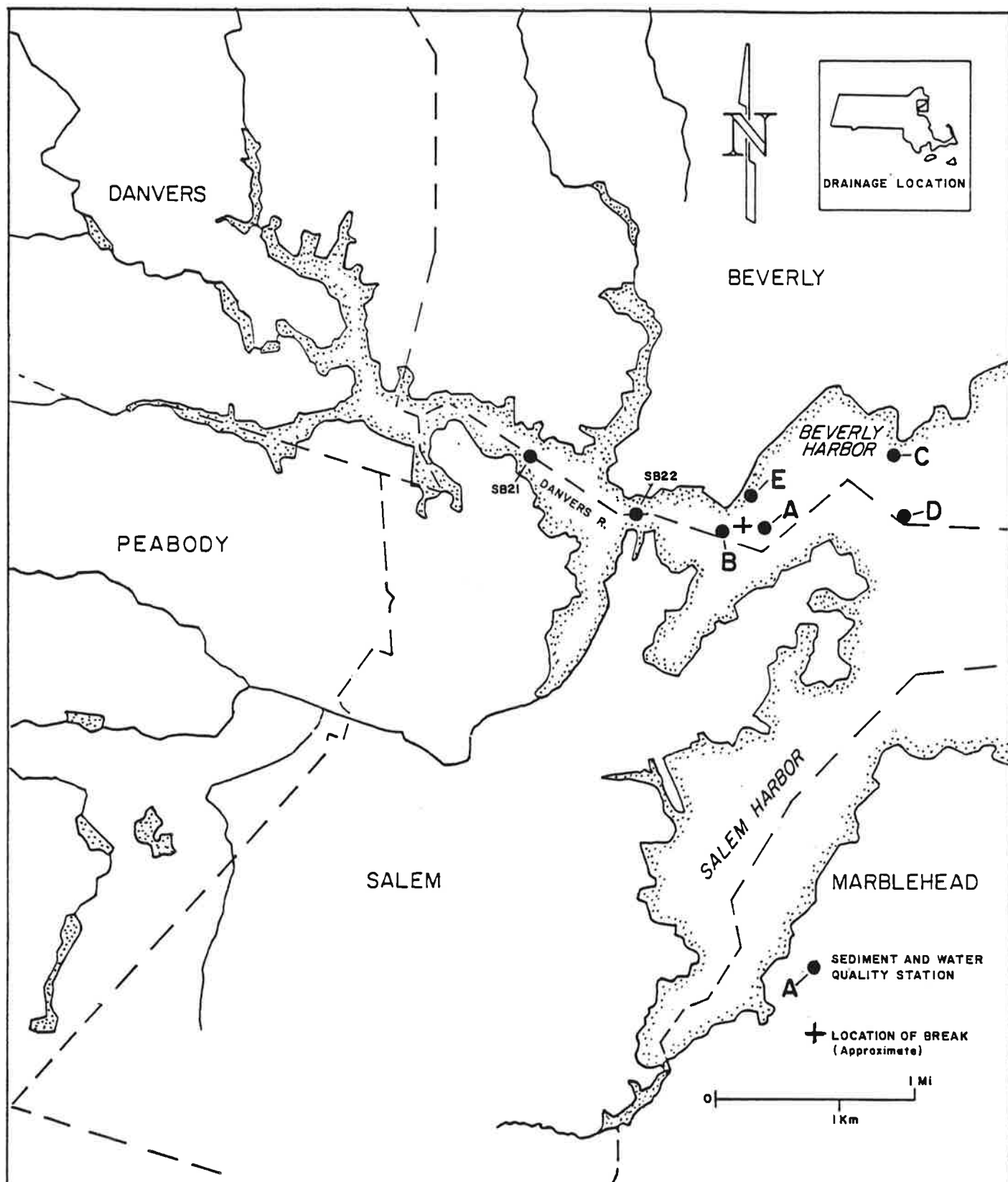


FIGURE 3

NORTH COASTAL WATER QUALITY SURVEY 1988
LOCATION OF SAMPLING STATIONS: BEVERLY
HARBOR SPECIAL SURVEY

RESULTS AND DISCUSSION

Water quality and sediment sampling results are listed in Tables 14 through 16.

On February 25, one day after the break was repaired, total and fecal coliform densities at Stations A and E were elevated. These counts exceeded the maximum value allowed to meet the criteria for SB class waters as defined by the Massachusetts Water Quality Standards (total coliform > 700 MPN/100 ml). Beverly Harbor and the Danvers River are classified as SB according to these standards. At the time of the survey on February 25 the tide was going out, thus Stations A and E were the closest downcurrent stations to the break area. Although the break had been repaired the previous day the data indicate that there was still some residual bacteria contamination in the immediate vicinity. All other stations exhibited elevated counts on this day but were within the standards for SB class waters.

Surface dissolved oxygen concentrations on February 25 at stations A, B, and C were below the SB standard of 6.0 mg/l. Stressful environmental conditions, for some biota, would have existed at Station B where DO reached 2.2 mg/l.

During all other sampling dates and at all other stations no other water quality standards were violated and all parameters were within expected ranges. Stations 21 and 22, located upstream on the Danvers River, did not exhibit signs of significant long term negative impacts from the break. Dissolved oxygen was high and bacteria densities were low on both sampling dates. These stations were sampled much later after the break was repaired. From this survey it could not be ascertained if sewage was impacting up-river areas during incoming tides while the break occurred.

Coliform bacteria sampling conducted by the SESD during and after the break indicated that up river stations as far as the Waters River (River Street, Danvers) were being impacted by the break up until the day the pipe was repaired.¹ SESD data show that two days after the sewage flow into the harbor was abated, the bacteria counts at all stations were low, indicating that the cause of the coliform contamination was most likely from the rupture. As a precaution shellfish beds in Marblehead and Manchester were closed immediately after the break was discovered.

Sediment analyses found below detection limits for all but one polycyclic aromatic hydrocarbon. Pyrene was measured at a level just above the detection limit at Station E. No PCBs were found at any of the stations.

The sediment metals concentrations were compared to the metals criteria established for classifying dredge spoils for disposal (MDWPC, 1983a). Stations A, C, and E had metals concentrations well within the limits of category I. Category I sediments are considered suitable for use as fill material or topsoil without restrictions. Stations B and D had very high levels of chromium (category 3) and moderately high levels of mercury (category 2) in the sediments. It is unlikely that these elevated levels of metals are related to the sewage line break. Sediment collected in the summer previous to the break had similarly high levels of metals (see Beverly Harbor and Tributaries section).

These data show that the impact of the break was localized and that water quality degradation was limited to the time of the break.

¹ Unpublished data and report from the South Essex Sewerage District and William Cashins, DEQE, NERO, (Woburn)

TABLE 14

1988 BEVERLY HARBOR SPECIAL WATER QUALITY SURVEY

WATER QUALITY DATA
(Results in mg/l unless noted)

STATION A

DATE:	2/25	2/25	3/07	3/07	3/30	3/30	5/04	5/04
TIME (hours):	1030	1020	1047	1055	1047	1056	1020	1027
DEPTH (meters):	1	5	1	4.5	1	5	1	3
<u>PARAMETER</u>								
Temperature (°C)	4.5	3.5	5.5	4.5	7.0	6.0	11.0	10.1
Dissolved Oxygen	5.7	11.2	13.3	14.9	11.4	11.3	9.5	9.5
pH (Standard Units)	7.9	7.9	8.0	8.1	8.1	8.1	7.9	7.9
Salinity ‰	32	33	30.5	29.2	31	31	22.5	22.5
BOD ₅	1.5	1.2	2.1	2.1	1.8	1.5	1.8	1.5
Suspended Solids	0.0	0.0	2.5	3.5	2.0	3.0	3.5	1.0
Total Solids	34,000	35,000	35,000	35,000	34,000	35,000	34,100	34,900
Turbidity (NTU)	0.6	0.7	0.4	0.9	0.5	0.4	1.0	0.4
Specific Conductivity (µmhos)	27,000	27,500	28,000	27,200	31,000	31,000	25,500	25,500
Total Kjeldahl-Nitrogen	0.43	0.88	0.46	0.45	1.0	1.0	1.4	1.3
Ammonia-Nitrogen	0.07	0.06	<0.02	<0.02	0.02	<0.02	0.05	0.05
Total Phosphorus	0.09	0.12	0.07	0.07	0.10	0.09	0.08	0.08
Chloride	15,000	17,000	17,000	17,000	16,500	17,000	16,500	16,000
Total Coliform (colonies/100 ml)	790	490	20	<20	<5	10	10	40
Fecal Coliform (colonies/100 ml)	140	490	<10	<10	<5	5	<5	10
Tide (Incoming - I)	0	0	I	I	0	0	I	I
(Outgoing - O)								

TABLE 14 (CONTINUED)

STATION B

DATE:	2/25	2/25	3/07	3/07	3/30	3/30	5/04	5/04
TIME (hours):	1040	1045	1105	1108	1102	1110	1043	1049
DEPTH (meters):	1	5	1	5	1	5	1	5

PARAMETER

Temperature (°C)	3.0	3.0	5.0	5.0	6.5	6.0	11.0	10.1
Dissolved Oxygen	2.2	11.2	13.7	14.0	11.0	11.8	10.0	9.8
pH (Standard Units)	7.9	7.6	8.1	8.0	8.1	8.1	7.9	7.9
Salinity ‰	32	32	27.8	28.0	29.5	30.0	21.2	22.0
BOD ₅	1.2	2.4	1.2	2.4	1.2	1.8	1.5	1.5
Suspended Solids	0.5	1.5	2.0	1.0	2.5	5.0	1.0	3.5
Total Solids	34,000	34,000	34,000	34,000	33,000	35,000	34,800	34,000
Turbidity (NTU)	0.5	0.5	0.4	0.4	0.7	0.6	0.4	0.4
Specific Conductivity (µmhos)	27,000	27,000	27,000	27,000	30,000	30,000	24,800	25,000
Total Kjeldahl-Nitrogen	0.76	0.86	0.54	0.58	1.0	1.2	1.2	1.3
Ammonia-Nitrogen	0.07	0.05	<0.02	<0.02	0.03	<0.02	0.05	0.04
Total Phosphorus	0.11	0.12	0.07	0.08	0.08	0.10	0.07	0.08
Chloride	16,000	16,500	16,500	17,000	16,000	16,500	16,500	16,500
Total Coliform (colonies/100 ml)	170	110	20	60	430	<5	<5	30
Fecal Coliform (colonies/100 ml)	20	20	<10	20	<5	<5	<5	<5
Tide (Incoming - I)	0	0	I	I	0	0	I	I
(Outgoing - O)								

TABLE 14 (CONTINUED)

STATION C

DATE:	2/25	2/25	3/07	3/07	3/30	3/30	5/04	5/04
TIME (hours):	1055	1102	1125	1128	1122	1130	1109	1114
DEPTH (meters):	1	3	1	5	1	5	1	5
<u>PARAMETER</u>								
Temperature (°C)	3.0	3.0	5.0	4.5	7.0	6.0	11.0	10.0
Dissolved Oxygen	5.1	12.1	14.5	14.8	11.4	11.8	10.2	--
pH (Standard Units)	7.9	7.9	8.1	8.1	8.1	8.1	7.9	7.9
Salinity ‰	31	31	28.0	28.5	30.0	31.0	21.0	21.0
BOD ₅	1.8	1.8	2.1	1.8	1.8	1.2	1.5	1.2
Suspended Solids	0.5	0.5	1.5	2.5	4.5	4.5	<1.0	8.5
Total Solids	36,000	35,000	35,000	35,000	34,000	35,000	34,400	35,200
Turbidity (NTU)	0.5	0.4	0.4	0.3	0.6	0.5	0.5	0.5
Specific Conductivity (µmhos)	27,500	28,000	27,000	27,500	31,000	31,000	24,500	24,500
Total Kjeldahl-Nitrogen	0.70	0.78	0.49	0.54	1.1	0.97	1.3	1.1
Ammonia-Nitrogen	0.04	0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.04
Total Phosphorus	0.09	0.08	0.08	0.08	0.10	0.07	0.07	0.09
Chloride	17,000	17,000	17,000	17,000	17,000	17,500	16,500	16,500
Total Coliform (colonies/100 ml)	170	110	<20	<20	<5	<5	<5	30
Fecal Coliform (colonies/100 ml)	20	20	<10	<10	<5	<5	<5	<5
Tide (Incoming - I)	0	0	I	I	0	0	I	I
(Outgoing - O)								

TABLE 14 (CONTINUED)

STATION D

DATE:	2/25	2/25	3/07	3/07	3/30	3/30	5/04	5/04
TIME (hours):	110	1114	1135	1140	1135	1142	1128	1133
DEPTH (meters):	1	5	1	5	1	5	1	5

PARAMETER

Temperature (°C)	3.0	3.0	5.0	4.0	6.0	6.0	11	10
Dissolved Oxygen	11.9	8.8	14.4	14.4	11.0	11.5	9.8	9.9
pH (Standard Units)	7.9	7.9	8.0	8.0	8.1	8.1	7.9	7.9
Salinity ‰	30.5	31.5	28.0	28.9	31.0	31.0	20.5	22.0
BOD ₅	2.4	2.1	2.1	2.1	0.9	1.5	1.5	1.5
Suspended Solids	1.5	0.5	1.0	2.0	2.0	4.5	2.5	<1.0
Total Solids	35,000	35,000	35,000	35,000	34,000	36,000	35,700	34,700
Turbidity (NTU)	0.5	0.4	0.4	0.4	0.7	0.4	0.4	0.3
Specific Conductivity (μmhos)	27,500	28,000	27,000	27,500	31,000	31,000	24,000	25,000
Total Kjeldahl-Nitrogen	0.54	0.40	0.59	0.80	0.40	0.68	1.2	0.78
Ammonia-Nitrogen	0.05	<0.02	<0.02	<0.02	0.02	<0.02	0.05	0.02
Total Phosphorus	0.10	0.09	0.07	0.08	0.09	0.11	0.09	0.08
Chloride	16,500	16,500	17,500	17,500	17,000	17,000	16,500	16,500
Total Coliform (colonies/100 ml)	--	--	<20	<20	<5	<5	20	<5
Fecal Coliform (colonies/100 ml)	--	--	<10	<10	<5	<5	<5	<5
Tide (Incoming - I)	0	0	I	I	0	0	I	I
(Outgoing - O)								

TABLE 14 (CONTINUED)

STATION E

DATE:	2/25	2/25	3/07	3/07	3/30	3/30	5/04	5/04
TIME (hours):	1125	1130	1149	1153	1151	1155	1148	1153
DEPTH (meters):	1	5	1	4.5	1	5	1	5
<u>PARAMETER</u>								
Temperature (°C)	3.0	2.0	4.5	4.0	6.0	5.0	10.0	10.0
Dissolved Oxygen	10.3	11.6	14.5	14.3	11.9	11.6	9.8	9.8
pH (Standard Units)	7.9	7.9	8.1	8.0	8.1	8.1	7.9	7.9
Salinity ‰	30	31	28.5	28.0	31.0	30.5	22.0	22.0
BOD ₅	1.2	2.1	2.4	2.4	1.8	1.8	2.1	1.8
Suspended Solids	0.5	0.0	4.0	3.0	2.5	4.5	1.5	<1.0
Total Solids	34,000	36,000	34,000	35,000	34,000	34,000	34,900	33,500
Turbidity (NTU)	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.6
Specific Conductivity (µmhos)	27,000	27,500	27,500	27,000	31,000	30,500	25,000	25,000
Total Kjeldahl-Nitrogen	0.76	0.80	0.46	0.49	0.68	0.86	1.0	1.5
Ammonia-Nitrogen	0.07	0.04	<0.02	<0.02	0.02	<0.02	0.03	0.06
Total Phosphorus	0.11	0.09	0.08	0.06	0.09	0.10	0.09	0.08
Chloride	16,000	16,500	17,000	17,000	16,000	16,500	16,500	16,500
Total Coliform (colonies/100 ml)	490	790	<20	<20	10	<5	10	<5
Fecal Coliform (colonies/100 ml)	130	130	<10	<10	<5	<5	<5	<5
Tide (Incoming - I)	0	0	I	I	0	0	I	I
(Outgoing - O)								

TABLE 14 (CONTINUED)

STATION:	21		22	
DATE:	3/07	3/30	3/07	3/30
TIME (hours):	1234	1304	1215	1250
DEPTH (meters):	0.1	0.1	0.1	0.1
<u>PARAMETER</u>				
Temperature (°C)	5.5	7.0	5.0	7.0
Dissolved Oxygen	14.3	11.0	14.4	11.1
pH (Standard Units)	8.0	8.1	8.1	8.1
Salinity ‰	28.5	28.0	29.0	30.0
BOD ₅	2.4	1.8	1.8	1.2
Suspended Solids	2.0	5.5	2.0	20
Total Solids	34,000	31,000	35,000	33,000
Turbidity (NTU)	0.7	1.1	0.7	0.8
Specific Conductivity (µmhos)	27,500	28,500	28,000	30,000
Total Kjeldahl-Nitrogen	0.50	0.78	0.46	0.80
Ammonia-Nitrogen	<0.02	0.04	<0.02	0.03
Total Phosphorus	0.07	0.09	0.06	0.09
Chloride	17,000	15,500	17,000	15,500
Total Coliform (colonies/100 ml)	20	5	20	<5
Fecal Coliform (colonies/100 ml)	10	<5	<10	<5
Tide (Incoming - I)	I	0	I	0
(Outgoing - O)				

TABLE 15
1988 BEVERLY HARBOR SPECIAL WATER QUALITY SURVEY

SEDIMENT DATA*

(mg/kg dry weight)

STATION:	A	B	C	D	E
<u>PARAMETER</u>					
Total Metals:					
Iron	10,000	8,000	5,100	16,750	5,600
Aluminum	5,000	5,200	3,100	8,750	3,350
Copper	12	24	3.4	70	8.2
Zinc	47	100	28	21	35
Chromium	75	500	60	1,550	80
Cadmium	0.30	0.80	<0.20	4.2	0.20
Nickel	8.0	7.7	3.7	16	3.9
Silver	<0.20	<0.20	<0.20	0.60	<0.20
Arsenic	4.8	6.2	3.9	4.5	2.4
Mercury	0.16	0.65	0.08	1.3	0.12
Total Kjeldahl-Nitrogen	1,730	3,480	730	4,940	1,190
Total Phosphorus	700	1,080	460	1,690	600
% Volatile Solids	2.3	6.6	20	13	2.5
Oil and Grease	120	480	51	1,200	100
(mg/kg wet weight)					

* Samples collected May 4, 1988

TABLE 16

1988 BEVERLY HARBOR SPECIAL WATER QUALITY SURVEY
SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(Reported as $\mu\text{g/l}$)

<u>COMPOUNDS</u>	<u>STATION</u>				
	<u>A¹</u>	<u>B¹</u>	<u>C²</u>	<u>D²</u>	<u>E²</u>
Benzo(a) anthracene	ND	<2.4	ND	ND	ND
Benzo(b) fluoranthene	ND	<2.5	ND	ND	ND
Benzo(k) fluoranthene	ND	<0.80	ND	ND	ND
Chrysene	<1.5	<1.5	ND	ND	ND
Fluoranthene	<4.0	<4.0	ND	<4.0	<4.0
Fluorene	ND	<4.3	ND	ND	ND
Phenanthrene	<5.2	<5.2	ND	<5.2	<5.2
Pyrene	<3.0	<3.2	ND	<3.2	3.9

* Samples collected May 4, 1988

¹ Aqueous samples are extracted and analyzed according to EPA Method 625² Sample was analyzed by Gas Chromatography/Mass Spectrometry, EPA Method 8100

SALEM SOUND AND MARBLEHEAD HARBOR

DESCRIPTION OF STUDY AREA

The harbors of Salem and Beverly adjoin Salem Sound, a relatively shallow (<15 meters) area protected on the east from the direct force of the Atlantic by a chain of twenty-five small islands. These islands comprise a total of approximately 234 acres within the Sound. The largest of these (over 10 acres) include Cat, Bakers, House, and Great Misery Islands. The Sound is approximately ten square miles and is bordered on the north by Beverly and Manchester and in the south by Salem and Marblehead.

Marblehead Harbor is a small (0.56 square miles), well protected harbor with no major freshwater tributaries. The entire area supports a variety of recreational and commercial activities including pleasure boating, swimming, scuba diving and sport and commercial fishing. Salem sound also provides boat access to the developed Salem and Beverly Harbors via maintained navigational channels.

Sailing is popular in and around Marblehead Harbor with over 2100 boats moored here during the summer (MCZM, 1977). In addition several public boat ramps and beaches are found along the shoreline.

Within Salem Sound the major source of pollution is the South Essex Sewerage District (SESD) outfall which discharges primary treated sewerage at a site just east of Great Haste Island in approximately 10 meters of water. Up until 1978 raw wastewater was pumped directly into the harbor via this outfall. In 1986 the SESD submitted a revised application to EPA requesting that the Federal requirement to upgrade treatment facilities to secondary be waived. This request was subsequently denied by the EPA and studies for the location and construction of the secondary treatment plant and the location of the discharge outfall site have been initiated.

The location descriptions of the stations that were sampled in this portion of the survey are presented in Table 17. Figure 2 illustrates the locations of the sampling stations.

RESULTS

The water column chemical, physical and bacteriological data are presented in Tables 18 and 19. The results of the sediment analyses are presented in Tables 20 and 21.

TABLE 17

1987 SALEM SOUND AND MARBLEHEAD HARBOR WATER QUALITY SURVEY

SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>LOCATION DESCRIPTION</u>
SS01	Salem Sound - near South Essex Sewerage District outfall
SS02	Salem Sound - offshore from Mingo Beach at nun #14
SS03	Salem Sound - offshore from Allen Head
SS04	Salem Sound - east of Hardy Shoal at nun #8
MB01	Marblehead Harbor - mouth of harbor at nun #2
MB02	Marblehead Harbor - in inner harbor offshore from yacht club

TABLE 18

1987 SALEM SOUND AND MARBLEHEAD HARBOR SURVEY DATA

TIME - DEPTH - TEMPERATURE - SALINITY - DISSOLVED OXYGEN

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station SS01 (Salem Sound)					
6/24/87	1340	0.1	15.5	29.7	10.1
		2.0	15.4	30.8	10.1
		4.0	15.1	30.9	10.0
		6.0	14.8	30.8	9.7
		8.0	13.5	30.9	9.2
		10.0	13.2	31.0	9.2
7/20/87	1020	11.0	13.2	31.0	9.2
		0.2	17.4	30.0	9.3
		2.0	16.9	30.8	9.3
		4.0	16.0	30.8	9.2
		6.0	15.6	30.9	9.2
		8.0	15.5	30.9	9.2
7/21/87	0950	8.7	15.4	30.9	9.2
		0.2	16.1	29.9	9.3
		2.0	16.6	30.9	9.3
		4.0	16.2	31.1	9.2
		6.0	15.9	31.1	9.1
		8.0	13.5	31.1	9.2
8/18/87	1100	9.5	10.7	31.3	9.2
		0.2	16.3	29.7	9.1
		2.0	17.0	31.3	8.8
		4.0	12.6	31.4	9.0
		7.0	11.0	31.4	***
		9.0	10.6	31.4	***
8/19/87	1230	0.2	13.6	29.7	9.8
		2.0	13.8	31.5	9.7
		4.0	12.7	31.5	9.7
		6.0	12.0	31.5	9.6
		8.0	11.8	31.5	9.4
Station SS02 (Salem Sound)					
6/24/87	1320	0.1	16.8	30.4	10.6
8/18/87	1045	0.2	16.7	31.3	9.4
		2.0	15.3	31.2	***
8/19/87	1205	0.2	17.8	31.3	9.3
		2.0	14.4	31.3	9.5
		4.0	12.7	31.4	9.6
		6.0	11.9	31.5	9.3
		8.0	11.5	31.6	9.4
		9.9	9.8	31.7	8.7

* Data obtained with Hydrolab Surve,or II

*** Hydrolab malfunction

TABLE 18 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station SS03 (Salem Sound)					
6/24/87	1250	0.1	15.5	30.9	9.5
Station SS04 (Salem Sound)					
6/24/87	1230	0.1	15.6	30.8	9.8
		2.0	14.4	30.8	9.4
		4.0	13.6	30.8	9.2
		6.0	13.6	30.8	9.2
		8.0	13.5	30.9	9.1
		10.0	13.2	30.8	9.1
Station MB01 (Marblehead Harbor)					
6/24/87	1155	0.1	15.9	30.7	10.0
		2.0	15.6	30.8	9.7
		4.0	14.4	30.8	9.4
		6.0	13.7	30.8	9.1
7/20/87	0910	0.2	17.3	30.9	9.7
		2.0	16.8	30.8	9.4
		4.0	16.2	30.9	9.0
		4.6	16.1	30.9	9.0
7/21/87	0855	0.2	16.9	30.9	9.4
		2.0	16.8	31.0	9.3
		4.0	16.3	31.1	9.2
		6.0	14.7	31.1	9.1
		8.0	12.0	31.3	8.8
		10.0	11.1	31.3	9.1
Station MB02 (Marblehead Harbor)					
7/20/87	0925	0.2	17.5	31.0	10.1
		2.0	17.4	31.0	9.8
		4.0	16.3	31.0	9.3
		6.0	15.8	31.0	9.2
		8.0	15.4	31.0	9.1
		8.8	15.1	31.0	9.1
7/21/87	0910	0.2	16.6	31.0	9.6
		2.0	16.1	31.1	9.3
		4.0	15.5	31.1	9.1
		6.0	14.9	31.1	8.9
		8.0	14.0	31.2	8.3

* Data obtained with Hydrolab Surveyor II

TABLE 19

1987 SALEM SOUND AND MARBLEHEAD HARBOR SURVEY

WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER: DATE: TIME (hours): DEPTH (meters):	SS01									
	6/24		7/20		7/21		8/18		8/19	
	1340	1345	1020	1025	0950	0955	1100	1110	1230	1235
	1.0	10.0	1.0	8.0	1.0	8.0	1.0	8.0	1.0	8.0
<u>PARAMETER</u>										
Suspended Solids	2.5	2.0	2.5	3.5	9.0	2.5	3.0	2.0	4.5	1.0
Total Solids	31,400	32,340	31,500	31,100	32,090	32,750	32,400	33,400	32,000	33,000
Turbidity (NTU)	2.3	1.7	1.1	1.3	1.5	0.4	1.5	0.6	1.3	0.4
Total Kjeldahl-Nitrogen	1.4	1.4	2.0	2.0	4.3	0.71	1.1	0.82	4.8	0.48
Ammonia-Nitrogen	0.41	<0.02	0.2	0.51	0.41	<0.02	0.27	<0.02	<0.02	<0.02
Total Phosphorus	0.25	0.12	0.19	0.36	0.31	0.02	0.22	0.06	0.29	0.27
Orthophosphate	0.21	0.01	0.12	0.27	0.24	0.02	0.03	0.02	0.16	0.02
Chloride	16,500	17,500	16,500	16,750	17,750	17,000	16,250	17,250	16,500	16,750
Total Coliform (colonies/100 ml)	100	--	2,000	--	5,000	--	600	--	950,000	--
Fecal Coliform (colonies/100 ml)	<5	--	10	--	120	--	10	--	15,000	--
Enterococci (colonies/100 ml)	--	--	10	--	--	--	--	--	--	--
Chlorophyll <u>a</u> (mg/m ³)	11.76	--	--	--	1.50	--	2.88	--	--	--

TABLE 19 (CONTINUED)

STATION NUMBER:	SS02			SS03	SS04	MB01			MB02		
DATE:	6/24	8/18	8/19	6/24	6/24	6/24	7/20	7/21	7/20	7/20	7/21
TIME (hours):	1320	1045	1205	1250	1230	1155	0910	0855	0925	0945	0910
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0	1.0
PARAMETER											
Suspended Solids	1.0	2.0	0.0	2.5	1.6	2.0	0.5	2.0	5.0	0.5	3.5
Total Solids	32,310	33,300	33,000	32,050	32,530	32,230	32,400	32,540	32,200	32,300	32,520
Turbidity (NTU)	1.0	0.6	0.5	0.7	0.6	0.9	0.5	0.6	0.8	0.7	0.6
Total Kjeldahl-Nitrogen	1.5	0.70	0.38	1.4	1.2	0.87	0.49	1.1	0.40	1.3	1.2
Ammonia-Nitrogen	<0.02	0.60	<0.02	<0.02	<0.02	<0.02	<0.02	0.10	<0.02	1.1	0.02
Total Phosphorus	0.08	0.08	0.16	0.05	0.04	0.08	0.06	0.03	0.05	0.06	0.04
Orthophosphate	0.03	0.01	0.02	0.02	0.01	0.03	0.03	0.02	0.03	0.03	0.02
Chloride	17,000	17,250	17,000	16,750	16,500	17,250	17,060	16,750	16,500	16,750	16,750
Total Coliform (colonies/100 ml)	100	80	10	20	5	10	10	<5	5	--	5
Fecal Coliform (colonies/100 ml)	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Enterococci (colonies/100 ml)	--	--	--	--	--	--	<5	--	--	--	--
Chlorophyll <u>a</u> (mg/m ³)	--	1.9	--	--	5.32	10.08	1.11	--	1.14	--	--

TABLE 20

1987 SALEM SOUND AND MARBLEHEAD HARBOR SURVEY

SEDIMENT DATA*

TOTAL METALS, TOTAL KJELDAHL-NITROGEN, TOTAL PHOSPHORUS, % VOLATILE SOLIDS
AND OIL & GREASE

STATION NUMBER:	<u>SS01</u>	<u>MB02</u>
<u>PARAMETER</u> (mg/kg dry wt.)		
Metals:		
Iron	17,000	28,000
Aluminum	5,750	11,500
Copper	330	74
Zinc	770	170
Lead	660	160
Chromium	5,400	1,300
Cadmium	8.5	2.6
Nickel	44	22
Silver	0.70	<0.20
Arsenic	5.4	12
Mercury	4.2	1.1
Total Kjeldahl-Nitrogen	7,600	5,200
Total Phosphorus	9,420	1,670
% Volatile Solids	12.1	13.8
Oil & Grease (mg/kg wet weight)	0.41	0.21

* Samples collected July 21, 1987

TABLE 21

1987 SALEM SOUND AND MARBLEHEAD HARBOR SURVEY

SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(reported as $\mu\text{g/g}$ dry weight)

STATION NUMBER:	SS01	MB02
<u>COMPOUNDS</u>		
Acenaphthene	1.7	ND
Acenaphthylene	0.66	ND
Anthracene	2.7	ND
Benzo(a) anthracene	9.5	ND
Benzo(b) fluoranthene	ND	ND
Benzo(k) fluoranthene	7.2	ND
Benzo(g,h,i) perylene	ND	ND
Benzo(a) pyrene	8.1	ND
Chrysene	7.0	ND
Dibenzofuran	+	ND
Dimethyethylbenzene	+	ND
Dimethylnaphthalene	+	ND
Ethyl naphthalene	+	ND
Fluoranthene	19.0	ND
Fluorene	2.1	ND
Methylantracene	ND	ND
Methylethylbenzene	+	ND
Methylfluorene	ND	ND
Methyl indole	+	ND
Methyl naphthalene	ND	ND
Methyl phenanthrene	ND	ND
Methyl pyrene	ND	ND
Naphthalene	7.8	ND
Nitrosophyenyyl benzamine	+	ND
Phenanthrene	16.0	ND
Pyrene	12.0	ND
Trimethylbenzene	+	ND
Trimethylnaphthalene	+	ND
1,1 Biphenyl	+	ND
1H-indene, 1-ethylidene	+	ND
1-methyl-4 (1-methylethyl) benzene	+	ND
PCB A 1242	<0.16	<0.16
PCB A 1254	N.D.	ND
PCB A 1260	0.63	<0.17

+ No standard available for quantitation. Mass spectrum compared to Mass spectral database for identification

* Samples collected July 21, 1987

ND Not detected

MANCHESTER HARBOR

DESCRIPTION OF STUDY AREA

Manchester Harbor lies between Beverly and Gloucester and opens southward into Salem Sound. The harbor is very small (0.29 square miles) and must be maintained by frequent dredging. Several small freshwater tributaries drain into the harbor from a primarily residential and rural watershed area. Recreational and commercial vessels crowd this harbor. Several marinas, boat storage and repair yards, yacht clubs and mooring areas occupy much of the harbor area. There is one public boat ramp but no public beach inside the harbor.

The sewage treatment plant for the town of Manchester discharges 0.67 MGD of primary treated sewage via an outfall pipe to the outer harbor at a site approximately 4 meters deep near Halftide Rocks.

In the summer of 1986 the outfall pipe was broken during dredging operations and for a short time all of the sewage was being discharged into the inner harbor. The data presented in this report were collected to monitor the water quality conditions during the break.

Table 22 provides the location descriptions of the sampling stations and Figure 2 illustrates these locations.

RESULTS

Water column chemical, physical and bacteriological data are presented in Tables 23 and 24.

TABLE 22
1987 MANCHESTER HARBOR WATER QUALITY SURVEY
SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>LOCATION DESCRIPTION</u>
MH01	Manchester Harbor - inner harbor mid channel between Manchester Marine and jetty
MH02	Manchester Harbor - in channel at can #13
MH04	Manchester Harbor - in channel at nun #10
MH05	Manchester Harbor - in channel at can #7
MH06	Manchester Harbor - in channel at can #5

TABLE 23
MANCHESTER HARBOR WATER QUALITY SURVEY DATA
JULY 8, 1987

TIME - DEPTH - TEMPERATURE - SALINITY - DISSOLVED OXYGEN

STATION NUMBER	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
MH01	1100	0.1	20.3	29.8	10.4
		2.0	20.0	30.0	9.6
		3.0	19.8	30.2	9.3
MH02	1115	0.1	20.0	30.0	10.2
		2.0	19.8	30.1	9.3
		4.0	19.4	30.2	9.0
MH04	1245	0.1	19.9	30.1	10.2
		2.0	19.7	30.2	9.7
		3.5	19.6	30.3	9.1
MH05	1220	0.1	19.8	30.2	10.3
		1.5	19.2	30.4	10.8
MH06	1230	0.1	19.4	30.3	11.2
		2.0	19.2	30.4	11.2
		4.0	18.0	30.5	10.5

* Data obtained with Hydrolab Surveyor II

TABLE 24
MANCHESTER HARBOR SURVEY

JULY 8, 1987

WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER:	MH01	MH02		MH04		MH05	MH06
TIME (hours):	1100	1115	1120	1245	1250	1220	1230
DEPTH (meters):	1.0	1.0	4.0	1.0	3.0	1.0	1.0
<u>PARAMETER</u>							
Suspended Solids	4.5	5.7	5.5	5.2	3.3	2.7	2.8
Total Solids	36,000	32,000	32,000	32,000	32,000	32,000	32,000
Turbidity (NTU)	1.3	1.2	1.2	1.3	1.2	1.3	1.0
Total Kjeldahl-Nitrogen	1.1	0.98	0.96	0.75	1.2	1.0	0.94
Ammonia-Nitrogen	0.04	0.04	0.03	0.02	<0.02	<0.02	0.02
Total Phosphorus	0.11	0.50	0.08	0.09	0.09	0.09	0.08
Chloride	16,250	16,250	16,500	16,000	16,250	16,500	16,500
Total Coliform (colonies/100 ml)	300	1,800	--	2,200	--	280	5
Fecal Coliform (colonies/100 ml)	5	200	--	170	--	10	<5

GLOUCESTER HARBOR

DESCRIPTION OF STUDY AREA

Gloucester Harbor is located on Cape Ann between Rockport and Manchester. It is a well protected, natural harbor occupying approximately 2.24 square miles. The harbor's major tributary, the Annisquam River, flows into the northwest point of the harbor by way of Blynman Canal. According to the Massachusetts Coastal Zone Management Office (MCZM) this canal is the third most used waterway in Massachusetts (MCZM, 1977). The Annisquam is tidal for its entire reach from Ipswich Bay. This river receives freshwater from numerous tributaries that drain a large, predominately rural watershed. The extensive salt marshes that exist along its length support over 500 acres of shellfish flats. There are no major freshwater inputs directly to the harbor. Several small streams drain from the eastern and western portions of the watershed.

Gloucester and New Bedford Harbors are the two most important fishing ports in Massachusetts. Fish brought into the harbor by the large fishing fleet are stored, processed, and sold at the numerous facilities located along the inner harbor shoreline.

Both the inner and outer harbor have public facilities for mooring and launching recreational boats. The entire harbor is heavily used for recreational boating. Several beaches also exist around the shoreline of the outer harbor.

The city of Gloucester's sewage treatment facility discharges approximately 5 MGD of primary treated effluent from an outfall site in the center of the main harbor. Several combined sewer overflow pipes also discharge untreated sewage and runoff periodically from locations in the Inner Harbor, Blynman Canal, Annisquam River, and the main harbor near the mouth of the canal. The city has applied for and received a variance from secondary sewage treatment requirements for discharge to marine waters. As a provision of the variance, the city is planning to extend the outfall pipe to discharge effluent at a depth of 90 feet approximately 0.7 miles outside the harbor mouth.

The locations of the sampling stations are described in Table 25 and illustrated in Figure 4.

RESULTS

The results of the water quality analyses are presented in Tables 26 and 27. The results of the sediment analyses are presented in Tables 28, 29 and 30.

TABLE 25
1987 GLOUCESTER HARBOR WATER QUALITY SURVEY
SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>LOCATION DESCRIPTION</u>
GH01	Annisquam River - 100 yards south of can #45
GH02	Annisquam River - can #43
GH03	Annisquam River - nun #34
GH04	Gloucester Harbor - in front of Fisherman Statue
GH05	Inner Harbor - Harbor Cove
GH06	Inner Harbor - North Channel
GH07	Inner Harbor - South Channel
GH08	Inner Harbor - nun #2
GH09	Inner Harbor - Smith Cove
GH10	Gloucester Harbor - can #11
GH11	Gloucester Harbor - nun #8
GH12	Gloucester Harbor - sewage outfall "boil" area
GH13	Gloucester Harbor - off breakwater - R/B Buoy
GH14	Off southeast Harbor Beach
GH15	Freshwater Cove - off Dolliver Neck
GH16	Good Harbor Beach - tidal stream on west end, at footbridge

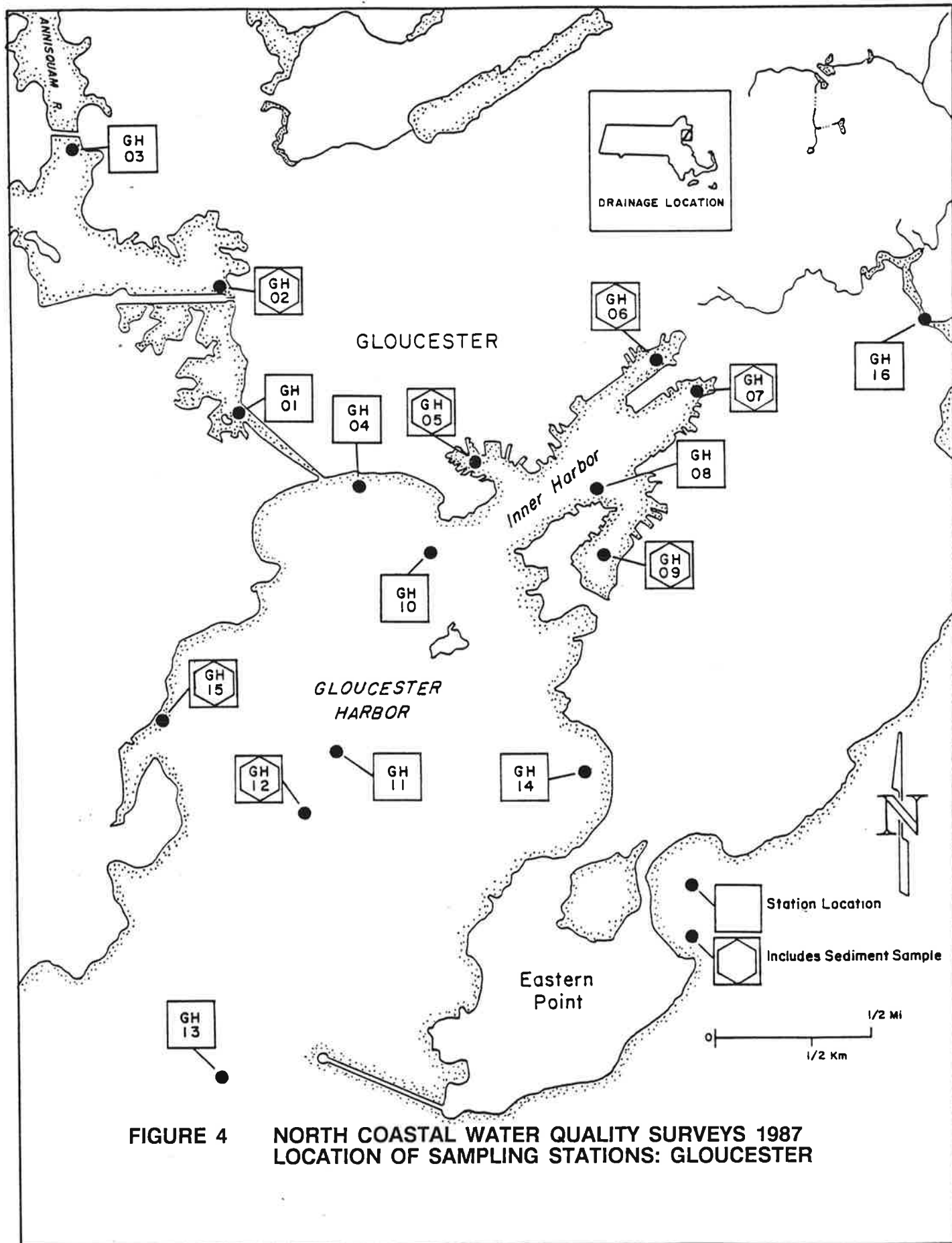


TABLE 26

1987 GLOUCESTER HARBOR WATER QUALITY SURVEY DATA

TIME - DEPTH - TEMPERATURE - SALINITY - DISSOLVED OXYGEN

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (‰)	DISSOLVED* OXYGEN (mg/l)
Station GH01 (Annisquam River)					
9/01/87	0815	0.2	16.9	31.0	7.8
9/02/87	0850	0.2	16.2	30.5	7.9
		2.0	16.2	31.2	7.8
9/03/87	1015	0.2	15.5	31.2	9.1
		2.0	15.4	31.2	8.9
Station GH02 (Annisquam River)					
9/01/87	0800	0.2	16.8	30.1	7.6
9/02/87	0830	0.2	16.0	30.4	7.8
9/03/87	1005	0.2	16.1	30.0	8.9
Station GH03 (Annisquam River)					
9/01/87	0740	0.2	16.6	30.9	7.7
		2.0	16.4	31.0	7.7
		3.4	15.6	31.1	7.9
9/02/87	0815	0.2	15.3	30.8	8.2
		2.0	15.4	31.0	8.2
		4.0	15.1	31.2	8.2
9/03/87	0950	0.2	15.9	30.6	9.5
		2.0	15.6	30.9	9.2
Station GH04 (Gloucester Harbor)					
9/01/87	0830	0.5	16.7	30.8	8.3
		2.0	16.6	31.0	7.9
9/02/87	0900	0.2	16.2	31.3	8.6
		2.0	16.2	31.3	8.4
9/03/87	1025	0.2	15.1	31.2	9.8
		2.0	14.4	31.2	9.4
Station GH05 (Inner Harbor - Harbor Cove)					
9/01/87	0855	0.2	16.8	30.6	6.6
		2.0	16.8	31.1	6.3
		4.0	16.8	31.2	5.9
		6.0	16.7	31.2	7.3

* Data obtained with Hydrolab Surveyor II

TABLE 26 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (°/‰)	DISSOLVED* OXYGEN (mg/l)
Station GH05 (continued)					
9/02/87	0920	0.2	16.6	31.1	6.9
		2.0	16.5	31.2	6.8
		4.0	15.7	31.3	6.6
		6.0	11.8	31.6	7.1
9/03/87	1035	0.2	15.0	31.2	8.2
		2.0	14.7	31.2	8.2
		4.0	13.8	31.4	7.7
		6.0	10.9	31.7	7.9
Station GH06 (Inner Harbor - North Channel)					
9/01/87	0906	0.2	15.9	30.6	7.3
		2.0	16.8	31.1	6.3
		4.0	16.8	31.2	7.1
9/02/87	0935	0.2	16.9	30.5	6.4
		2.0	16.8	31.5	6.2
		4.0	16.3	31.3	5.8
9/03/87	1050	0.2	16.0	31.0	7.4
		2.0	15.1	31.2	7.9
		4.0	14.1	31.3	6.9
Station GH07 (Inner Harbor - South Channel)					
9/01/87	0930	0.2	17.1	30.5	7.8
		2.0	17.1	31.1	7.3
9/02/87	0955	0.2	17.1	29.3	8.0
		2.0	17.1	31.0	7.8
9/03/87	1105	0.2	16.2	31.2	8.6
		2.0	15.0	31.2	8.7
Station GH08 (Inner Harbor)					
9/01/87	1000	0.2	16.9	31.1	8.1
		2.0	16.8	31.2	7.9
		4.0	16.7	31.2	7.6
		5.8	14.1	31.4	7.4
9/02/87	1015	0.2	16.9	31.1	8.1
		2.0	16.8	31.2	8.0
		4.0	15.2	31.5	7.2
		6.0	10.0	31.7	8.3
9/03/87	1135	0.2	16.1	31.1	9.1
		2.0	15.9	31.1	9.0
		4.0	14.0	31.4	8.6
		6.0	10.9	31.6	8.5

* Data obtained with Hydrolab Surveyor II

TABLE 26 (CONTINUED)

				DISSOLVED*
DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	OXYGEN (mg/l)
Station GH09 (Inner Harbor - Smith Cove)				
9/01/87	0950	0.2	16.9	26.1
9/02/87	1005	0.2	16.9	31.2
		2.0	16.7	31.2
9/03/87	1125	0.2	17.0	28.0
		2.0	16.1	31.3
Station GH10 (Gloucester Harbor)				
9/01/87	1015	0.2	16.6	31.2
		2.0	16.6	31.2
		4.0	16.6	31.2
		6.0	11.8	31.7
		8.0	9.1	31.8
9/02/87	1030	0.2	16.6	31.2
		2.0	16.6	31.3
		4.0	13.6	31.3
		6.0	9.1	31.8
		7.8	8.7	31.9
9/03/87	1150	0.2	15.5	31.2
		2.0	14.7	31.3
		4.0	14.3	31.4
		6.0	12.4	31.6
		7.8	10.3	31.7
Station GH11 (Gloucester Harbor)				
9/01/87	1030	0.2	16.7	31.1
		2.0	16.7	31.2
		4.0	16.7	31.3
		6.0	14.8	31.4
		8.0	8.2	31.8
9/02/87	1050	9.6	8.1	31.9
		0.2	16.1	31.3
		2.0	15.8	31.4
		4.0	14.6	31.5
		6.0	9.7	31.7
9/03/87	1200	8.0	8.8	31.8
		0.2	15.2	30.6
		2.0	14.9	31.0
		4.0	13.3	31.5
		6.0	12.2	31.7
		8.0	12.0	31.7

*Data obtained with Hydrolab Surveyor II

TABLE 26 (CONTINUED)

DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (°/‰)	DISSOLVED* OXYGEN (mg/l)
Station GH12 (Gloucester Harbor)					
9/01/87	1120	0.2	17.0	31.1	8.7
		2.0	16.7	31.2	8.6
		4.0	16.6	31.2	8.5
		6.0	12.9	31.4	8.5
		8.0	10.9	31.5	8.8
		10.7	8.3	31.7	8.9
9/02/87	1100	0.2	16.0	31.2	8.9
		2.0	16.0	31.3	8.7
		4.0	15.5	31.3	8.7
		6.0	10.1	31.7	9.0
		8.0	9.0	31.8	8.9
9/03/87	1210	0.2	14.9	31.3	10.0
		2.0	13.9	31.3	9.9
		4.0	13.0	31.4	9.8
		6.0	12.2	31.6	9.9
		8.0	11.6	31.6	9.9
Station GH13 (Gloucester Harbor)					
9/01/87	1050	0.2	16.6	31.2	8.7
		2.0	16.4	31.3	8.6
		4.0	16.3	31.3	8.5
		6.0	15.5	31.4	8.2
		8.0	13.9	31.5	8.4
		9.5	10.7	31.7	9.0
9/03/87	1300	0.2	14.1	31.4	10.2
		2.0	13.8	31.4	10.1
		4.0	13.6	31.5	10.1
		6.0	13.5	31.5	10.1
		8.0	13.0	31.5	10.1
Station GH14 (Southeast Harbor Beach)					
9/01/87	1146	0.2	17.1	30.9	8.6
		2.0	16.8	31.1	8.4
		4.0	16.6	31.2	8.4
		6.0	10.8	31.6	8.7
9/02/87	1130	0.2	16.8	30.6	8.4
		2.0	16.8	31.1	8.2
		4.0	16.5	31.3	8.5
9/03/87	1310	0.2	15.5	30.9	10.1
		2.0	14.0	31.5	10.0
		4.0	13.6	31.5	10.0

* Data obtained with Hydrolab Surveyor II

TABLE 26 (CONTINUED)

					DISSOLVED*
DATE	TIME (hr/min)	DEPTH* (m)	TEMPERATURE* (°C)	SALINITY* (°/‰)	OXYGEN (mg/l)
Station GH15 (Freshwater Cove)					
9/01/87	1134	0.2	16.9	31.0	8.5
		2.0	16.6	31.2	8.1
9/02/87	1115	0.2	14.4	28.9	8.6
		2.0	12.9	31.0	8.7
9/03/87	1235	0.2	15.0	31.3	8.9

* Data obtained with Hydrolab Surveyor II

TABLE 27

1987 GLOUCESTER HARBOR SURVEY

SEPTEMBER WATER QUALITY DATA

(Values reported as mg/l unless noted)

STATION NUMBER:	GH01			GH02			GH03		
DATE:	9/01	9/02	9/03	9/01	9/02	9/03	9/01	9/02	9/03
TIME (hours):	0815	0850	1015	0800	0830	1005	0740	0815	0950
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>									
Suspended Solids	23.0	20.0	5.5	18.0	15.0	12.0	16.0	15.0	5.5
Total Solids	33,000	33,000	32,000	32,000	33,000	32,000	33,000	33,000	31,000
Turbidity (NTU)	0.6	0.7	0.5	0.7	0.8	0.7	0.7	0.6	0.6
Total Kjeldahl-Nitrogen	0.90	0.68	1.1	0.72	0.60	0.90	0.84	0.52	0.60
Ammonia-Nitrogen	<0.02	0.02	0.02	0.02	0.20	<0.02	<0.02	0.02	0.03
Total Phosphorus	0.10	0.09	0.14	0.08	0.08	0.10	0.08	0.07	0.10
Orthophosphate	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Chloride	17,000	18,000	16,750	16,500	17,000	17,000	17,000	16,750	17,000
Total Coliform (colonies/100 ml)	180	20	40	1,100	20	40	20	240	<10
Fecal Coliform (colonies/100 ml)	30	20	<10	40	<20	<10	<5	<20	<10
Chlorophyll <u>a</u> (mg/m ³)	--	--	--	1.8	--	--	--	--	--

TABLE 27 (CONTINUED)

STATION NUMBER:	GH04			GH05			GH06		
DATE:	9/01	9/02	9/03	9/01	9/02	9/03	9/01	9/02	9/03
TIME (hours)	0830	0900	1025	0855	0920	1035	0906	0935	1050
DEPTH (meters)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>									
Suspended Solids	9.0	15.0	8.0	23.0	11.0	8.0	15.0	12.0	10.0
Total Solids	32,000	33,000	32,000	33,000	34,000	32,000	33,000	33,000	32,000
Turbidity (NTU)	0.5	0.5	0.6	1.1	0.9	0.5	1.0	0.9	0.6
Total Kjeldahl-Nitrogen	0.64	0.60	1.0	0.78	0.46	1.1	0.70	0.90	0.89
Ammonia-Nitrogen	<0.02	<0.02	<0.02	0.08	0.09	0.03	0.07	0.07	0.06
Total Phosphorus	0.08	0.08	0.07	0.10	0.08	0.09	0.18	0.10	0.11
Orthophosphate	0.02	0.01	0.02	0.04	0.02	0.03	0.03	0.03	0.03
Chloride	17,250	16,750	17,000	17,000	17,000	17,000	17,000	16,750	17,000
Total Coliform (colonies/100 ml)	12,000	80	30	1,700	200	180	740	280	120
Fecal Coliform (colonies/100 ml)	1,000	<20	<10	450	60	<10	160	<20	10
Chlorophyll <u>a</u> (mg/m ³)	--	--	--	--	--	--	4.68	--	--
Oil and Grease	--	--	--	--	--	1.5(0.9)*	68	--	--

* Sample taken at surface

TABLE 27 (CONTINUED)

STATION NUMBER:	GH07			GH08			GH09		
DATE:	9/01	9/02	9/03	9/01	9/02	9/03	9/01	9/02	9/03
TIME (hours):	0930	0955	1105	1000	1015	1135	0950	1005	1125
DEPTH (meters):	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>									
Suspended Solids	12.0	11.0	6.5	7.5	7.5	6.0	19.0	9.5	5.5
Total Solids	32,000	33,000	32,000	32,000	33,000	32,000	32,000	33,000	32,000
Turbidity (NTU)	0.8	0.7	0.5	0.6	0.7	0.6	0.9	0.07	0.7
Total Kjeldahl-Nitrogen	0.50	0.68	1.6	0.60	0.44	0.84	0.86	0.60	1.1
Ammonia-Nitrogen	<0.02	0.03	0.02	<0.02	0.04	0.05	<0.02	0.19	<0.02
Total Phosphorus	0.08	0.08	0.09	0.06	0.07	0.16	0.07	0.06	0.09
Orthophosphate	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02
Chloride	16,500	16,750	17,000	17,000	17,000	16,750	17,250	16,750	16,750
Total Coliform (colonies/100 ml)	620	1,900	<10	1,300	80	20	--	20	60
Fecal Coliform (colonies/100 ml)	80	20	<10	100	<20	120	--	<20	<10
Chlorophyll <u>a</u> (mg/m ³)	3.78	--	--	--	--	--	4.86	--	--

TABLE 27 (CONTINUED)

STATION NUMBER: DATE: TIME (hours): DEPTH (meters):	GH10			GH11		
	9/01	9/02	9/03	9/01	9/02	9/03
	1015	1030	1150	1030	1050	1200
	1.0	1.0	1.0	1.0	1.0	1.0
<u>PARAMETER</u>						
Suspended Solids	3.5	8.0	6.5	19	7.5	3.5
Total Solids	32,000	33,000	33,000	33,000	33,000	32,000
Turbidity (NTU)	0.6	0.5	0.5	0.6	0.3	0.3
Total Kjeldahl-Nitrogen	0.55	0.84	0.88	0.75	1.4	1.4
Ammonia-Nitrogen	<0.02	<0.02	0.35	<0.02	<0.02	0.22
Total Phosphorus	0.06	0.06	0.09	0.09	0.06	0.08
Orthophosphate	0.02	0.02	0.01	0.02	0.01	0.01
Chloride	17,000	16,750	17,750	17,250	15,750	17,250
Total Coliform (colonies/100 ml)	2,500	40	<10	400	<20	<10
Fecal Coliform (colonies/100 ml)	110	<20	<10	20	<20	<10
Chlorophyll <u>a</u> (mg/m ³)	2.16	--	--	--	--	--

TABLE 27 (CONTINUED)

STATION NUMBER:	GH12						GH13	
	9/01	9/01	9/02	9/02	9/03	9/03	9/01	9/03
DATE:	9/01	9/01	9/02	9/02	9/03	9/03	9/01	9/03
TIME (hours)	1120	1125	1100	1105	1210	1215	1050	1300
DEPTH (meters)	1.0	8.0	1.0	8.0	1.0	8.0	1.0	1.0
<u>PARAMETER</u>								
Suspended Solids	5.5	8.5	12.0	8.0	12.0	12.0	5.5	10
Total Solids	33,000	33,000	33,000	34,000	32,000	32,000	32,000	32,000
Turbidity (NTU)	0.5	0.2	0.4	0.1	0.4	0.1	0.5	0.2
Total Kjeldahl-Nitrogen	0.80	0.79	0.88	0.98	1.4	1.1	0.49	1.1
Ammonia-Nitrogen	<0.02	<0.02	0.02	0.03	0.02	0.04	<0.02	<0.02
Total Phosphorus	0.07	0.06	0.08	0.08	0.10	0.07	0.06	0.06
Orthophosphate	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01
Chloride	17,000	17,500	16,000	16,750	17,750	17,250	17,250	17,750
Total Coliform (colonies/100 ml)	10	--	20	--	1,800	--	10	<10
Fecal Coliform (colonies/100 ml)	<5	--	<20	--	10	--	<5	<10
Chlorophyll <u>a</u> (mg/m ³)	4.86	--	--	--	--	--	2.57	--

TABLE 27 (CONTINUED)

STATION NUMBER:

DATE:

TIME (hours):

DEPTH (meters):

GH14			GH15			GH16	
9/01	9/02	9/03	9/01	9/02	9/03	9/02	9/03
1146	1130	1310	1130	1115	1235	1230	1420
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

PARAMETER

Suspended Solids	12.0	7.0	15.0	12.0	12.0	14.0	8.5	56
Total Solids	32,000	33,000	32,000	33,000	33,000	32,000	24,400	24,000
Turbidity (NTU)	0.4	0.4	0.3	0.6	0.3	0.04	1.5	0.09
Total Kjeldahl-Nitrogen	0.50	0.79	0.93	0.96	1.9	0.92	0.89	1.1
Ammonia-Nitrogen	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	0.09	0.09
Total Phosphorus	0.11	0.08	0.07	0.08	0.08	0.07	0.10	0.10
Orthophosphate	0.02	0.02	0.01	0.02	0.02	0.02	0.05	0.05
Chloride	16,750	17,000	17,250	17,000	17,500	17,250	12,000	12,750
Total Coliform (colonies/100 ml)	10	<20	<10	5	20	<10	200	20
Fecal Coliform (colonies/100 ml)	5	<20	<10	<5	<20	<10	20	<10
Enterococci (colonies/100 ml)	--	<10	--	--	--	--	--	--
Chlorophyll <u>a</u> (mg/m ³)	--	--	--	2.8	--	--	--	--

TABLE 28

1987 GLOUCESTER HARBOR SURVEY

SEDIMENT DATA*

TOTAL KJELDAHL-NITROGEN (TKN), TOTAL PHOSPHORUS, % VOLATILE SOLIDS,
OIL & GREASE

STATION NUMBER	TKN ¹	TOTAL PHOSPHORUS ¹	% VOLATILE SOLIDS	OIL AND GREASE ²
GH02	1,320	470	2.18	0.14
GH05	4,730	6,430	13.8	0.67
GH06	3,530	2,060	11.8	0.23
GH07	4,430	1,630	15.6	0.3
GH09	4,190	1,910	13.4	0.35
GH12	1,050	640	2.86	0.11
GH15	1,980	570	4.42	0.11

* Samples collected September 2 and 3, 1987

¹ mg/kg dry weight² mg/kg wet weight

TABLE 29
1987 GLOUCESTER HARBOR SURVEY
SEDIMENT DATA*
TOTAL METALS (mg/kg dry weight)

STATION NUMBER	Fe	Al	Zn	Pb	Cr	Cd	Ni	Ag	As
GH02	5,900	3,420	35	18	15	0.30	7.3	<0.20	1.21
GH05	3,800	10,500	730	480	64	2.7	24	0.80	21
GH06	23,000	10,300	430	250	38	2.0	16	0.50	20
GH07	55,000	9,800	550	400	43	2.5	15	0.50	8.5
GH09	65,000	11,700	480	330	68	1.1	17	0.50	7.7
GH12	7,600	4,000	48	19	21	0.30	7.6	0.20	17
GH15	6,600	3,270	64	34	20	0.50	5.8	0.30	2.7

* Samples collected September 2 and 3, 1987

TABLE 30

1987 GLOUCESTER HARBOR SURVEY

SEDIMENT DATA*

POLYCYCLIC AROMATIC HYDROCARBONS AND POLYCHLORINATED BIPHENYLS

(reported as $\mu\text{g/g}$ dry weight)

STATION NUMBER:	GH02	GH05	GH06	GH07	GH09	GH12	GH15
<u>COMPOUNDS</u>							
Acenaphthene	ND	ND	0.16	0.19	ND	ND	ND
Acenaphthylene	ND	0.26	0.23	0.32	ND	ND	ND
Anthracene	ND	ND	1.6	1.3	ND	ND	ND
Benzo(a) anthracene	ND	1.8	3.4	4.0	ND	ND	ND
Benzo(b) fluoranthene	ND	ND	+	+	ND	ND	ND
Benzo(k) fluoranthene	ND	ND	3.5	4.6	ND	ND	ND
Benzo(g,h,i) perylene	ND	ND	ND	ND	ND	ND	ND
Benzo(a) pyrene	ND	ND	2.4	5.9	ND	ND	ND
Chrysene	ND	2.2	2.9	3.9	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND
Dimethyl naphthalene	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	2.9	6.8	6.4	1.1	ND	ND
Fluorene	ND	0.41	0.71	0.77	ND	ND	ND
Methyl anthracene	ND	ND	ND	ND	ND	ND	ND
Methyl fluorene	ND	ND	ND	ND	ND	ND	ND
Methyl phenanthrene	ND	ND	ND	ND	ND	ND	ND
Methyl pyrene	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	1.3	3.0	3.1	ND	ND	ND
Pyrene	ND	2.5	4.7	5.6	1.0	ND	ND
1,1 Biphenyl	ND	ND	ND	ND	ND	ND	ND
PCB A 1242	<0.16	<0.16	<0.16	ND	<0.16	<0.16	ND
PCB A 1254	<0.56	9.0	<0.56	ND	ND	<0.56	<0.56
PCB A 1260	ND	0.49	ND	0.20	0.28	--	ND

+ No standard available for quantitation. Mass spectrum compared to mass spectral database for identification

* Samples collected September 2 and 3, 1987

ND Not detected

EFFLUENT MONITORING

Effluent monitoring was performed on selected wastewater facilities and industries with NPDES permitted discharges in the study areas. The sampling was conducted to aid in the evaluation of water quality conditions in the receiving water, and to compare effluent quality data to NPDES permit limits.

The following tables present the results from samples collected from the wastewater treatment facilities of the South Essex Sewerage District (SESD), Manchester, and Gloucester, and from the New England Power electric generating facility in Salem (NEPCO). Grab samples or twenty-four hour composite samples were taken from the effluent of these facilities, as appropriate.

Sampling methodology and water quality analyses for compliance monitoring is described in the materials and methods section of this report.

SOUTH ESSEX SEWERAGE DISTRICT WASTEWATER TREATMENT FACILITY

LOCATION: Salem

DRAINAGE: North Coastal

RECEIVING WATER: Salem Sound

N.P.D.E.S PERMIT NO.: MA0100501

DESIGN FLOW: 41 MGD

DATE AND SAMPLE TYPE: June 23, 1987 - grab sample
July 21, 1987 - 24 hour composite

COMMENTS:

Several of the maximum daily limits imposed by the NPDES permit were exceeded during both of the sampling periods. Specifically the BOD was much higher than the allowable limit of 50 mg/l (153 mg/l and 1,100 mg/l, respectively). Fecal coliform counts were in violation of the permit maximum daily limits on both dates with exceedingly high counts of 2.4×10^5 .

TABLE 31

SOUTH ESSEX SEWERAGE DISTRICT WASTEWATER TREATMENT PLANT
RESULTS OF LABORATORY ANALYSES

(All results in mg/l unless otherwise noted)

PARAMETER	EFFLUENT	
	6/23/87 (grab sample)	7/21/87 (24 hour composite)
Flow (MGD)	23.2	22.12
COD	500	1,600
BOD ₅	153	1,100
pH (Standard Units)	6.8	7.0
Total Alkalinity	170	227
Suspended Solids	24	85
Total Solids	2,700	3,380
Settleable Solids (ml/l)	1.9	0.05
Total Kjeldahl-Nitrogen	32	172
Ammonia-Nitrogen	18	27
Nitrate-Nitrogen	<0.1	0.3
Total Phosphorus	9.1	9.6
Chloride	1,110	990
Aluminum	2.9	<0.10
Cadmium	<0.01	<0.001
Chromium	0.16	0.05
Copper	0.06	0.10
Iron	0.89	0.82
Lead	0.06	0.005
Manganese	0.18	0.22
Nickel	0.06	<0.015
Silver	<0.02	0.004
Zinc	0.19	0.15
Hexavalent Chromium	0.00	--
Total Chlorine Residual (in situ)	0.25	2.5
Free Chlorine	1.8	1.8
Total Coliform (colonies/100 ml)	2.4×10^6	2.4×10^7 *
Fecal Coliform (colonies/100 ml)	2.4×10^5	2.4×10^5 *

* Grab sample

TABLE 32

SOUTH ESSEX SEWERAGE DISTRICT WASTEWATER TREATMENT PLANT
PURGEABLE ORGANICS*

(All results in mg/l unless otherwise noted)

<u>COMPOUND</u>	<u>EFFLUENT</u>	
	<u>6/23/87</u> <u>(grab sample)</u>	<u>7/21/87</u> <u>(24 hour composite)</u>
Acetone	220	--
1, 2-dichloroethylene	2.3	1.3
Chloroform	7.5	6.9
1, 1, 1-trichloroethane	5.6	1.4
Methyl tert. butyl ether	2.7	--
Trichloroethylene	<1.0	<1.0
Benzene	1.9	1.1
Tetrachloroethylene	10	--
Toluene	21	14
Ethyl benzene	2.1	--
Xylenes	16	11
Methyl chloride	--	1.1

* gas chromatography - mass spectrometry analysis
of 30 ml sample aliquot

NEW ENGLAND POWER PLANT, SALEM

LOCATION: Salem
DRAINAGE: North Coastal
RECEIVING WATER: Salem Harbor
N.P.D.E.S PERMIT NO.: MA0005096
DATE AND SAMPLE TYPE: June 23, 1987 - 2 hour composite
July 21, 1987 - grab sample

COMMENTS:

Samples were collected from outfall 006 which discharges water collected from the ash settling pond, seal water, floor drains, equipment drain, demineralized regeneration wastes, and equipment wash water streams. No violations of the maximum daily discharge limitations listed in the NPDES permit were observed. All values were well within the required maximum except for pH. On July 21 the grab sample collected had a pH of 9.45. The weekly maximum limit is 9.0.

TABLE 33

NEW ENGLAND POWER PLANT, SALEM
RESULTS OF LABORATORY ANALYSES

(All results in mg/l unless otherwise noted)

PARAMETER	EFFLUENT	
	(outfall 006) 6/23/87 (2 hour composite)*	(outfall 006) 7/21/87 (grab sample)
Flow (MGD)	0.001	0.04 (on 7/20)
BOD ₅	3.6	6.6
pH (Standard Units)	8.8	9.45
Total Alkalinity	220	86
Suspended Solids	2.5	19
Total Solids	4,900	3,020
Settleable Solids (ml/l)	<0.05	<0.05
Chloride	170	380
Aluminum	<0.10	<0.10
Cadmium	<0.01	<0.001
Chromium	0.19	0.02
Copper	<0.02	0.031
Iron	0.10	0.11
Lead	<0.05	<0.002
Manganese	0.02	<0.02
Nickel	0.23	0.038
Silver	<0.02	0.001
Zinc	0.06	0.02
Total Chlorine Residual (in situ)	0.25	--
Oil and Grease	2.3	1.5
Phth Alkalinity	78	29
Purgeable Organics:	ug/l	ND
Acetone	78	--
Chloroform	1.6	--
Toluene	<1.0	--
Base/Neutral Extractables:	ND	--
Hexanone	+	--
Hexanol	+	--

* total discharge for 24 hours

+ No standard available for quantitation. The mass spectrum was compared to a mass spectral data base for identification.

ND Not detected

MANCHESTER MUNICIPAL WASTEWATER TREATMENT FACILITY

LOCATION: Manchester

RECEIVING WATER: Manchester Harbor

N.P.D.E.S PERMIT NO.: MA0100871

DESIGN FLOW: 0.67 MGD

DATE AND SAMPLE TYPE: June 23, 1987 - 24 hour composite
July 8, 1987 - grab sample

COMMENTS:

Comparison of discharge limitations imposed by the permit show that the fecal coliform limit (400 CFU/100 ml) was greatly exceeded during the June survey (9.3×10^4 CFU) but was well within limits on July 8. Chlorine residual was low (0.1) at the time of the June sampling indicating that chlorination was not effective on that date.

TABLE 34

MANCHESTER MUNICIPAL WASTEWATER TREATMENT FACILITY
RESULTS OF LABORATORY ANALYSES

(All results in mg/l unless otherwise noted)

PARAMETER	EFFLUENT	
	6/23/87 (24 hour sample)	7/8/87 (grab sample)
Flow (MGD)	0.401	--
COD	95	--
BOD ₅	23	--
pH (Standard Units)	6.3	--
Total Alkalinity	45	--
Suspended Solids	12	22
Turbidity (NTU)	--	1.2
Total Solids	500	640
Settleable Solids (ml/l)	1.0	--
Total Kjeldahl-Nitrogen	7.2	11
Ammonia-Nitrogen	3.3	6.6
Nitrate-Nitrogen	7.3	--
Total Phosphorus	4.2	1.7
Chloride	170	250
Aluminum	0.24	--
Cadmium	<0.01	--
Chromium	0.10	--
Copper	0.08	--
Iron	0.66	--
Lead	0.53	--
Manganese	0.22	--
Nickel	0.64	--
Silver	<0.02	--
Zinc	1.5	--
Total Chlorine Residual (in situ)	0.1	--
Free Chlorine	0.05	--
Total Coliform (colonies/100 ml)	2.4 X 10 ⁶ *	2,000
Fecal Coliform (colonies/100 ml)	9.3 X 10 ⁴ *	140

* Grab sample

GLOUCESTER MUNICIPAL WASTEWATER TREATMENT FACILITY

LOCATION: Gloucester
DRAINAGE: North Coastal
RECEIVING WATER: Gloucester Harbor
N.P.D.E.S PERMIT NO.: MA0100625
DESIGN FLOW: 5.15 MGD
DATE AND SAMPLE TYPE: September 2, 1987 - 24 hour composite
September 3, 1987 - 24 hour composite

COMMENTS:

Comparison of the water quality analysis from the treatment plant on the above dates to the discharge limitations imposed by the NPDES permit indicate that the plant was not effectively chlorinating the effluent. The permitted maximum daily fecal coliform count allowed is 400 CFU/100 ml. On both days the fecal coliform counts greatly exceeded this value (2,400 and 240,000, respectively). Settleable solids were exceeded on September 2nd but were well within limits on September 3rd. All other parameters were within the maximum daily discharge limitation of the permit during these dates.

TABLE 35

GLOUCESTER MUNICIPAL WASTEWATER TREATMENT FACILITY
RESULTS OF LABORATORY ANALYSES

(All results in mg/l unless otherwise noted)

EFFLUENT**

<u>PARAMETER</u>	<u>9/2/87</u>	<u>9/3/87</u>
Flow (MGD)	2.982	2.050
COD	323	448
BOD ₅	190	240
Total Alkalinity	127	165
Suspended Solids	65	67
Hardness	477	512
Total Solids	2,840	3,100
Specific Conductivity (umhos)	4,280	4,550
Settleable Solids (ml/l)	1.6	<0.05
Total Kjeldahl-Nitrogen	21	32
Ammonia-Nitrogen	15	14
Nitrate-Nitrogen	***	***
Total Phosphorus	5.5	3.3
Chloride	1,250	1,275
Aluminum	--	0.76
Cadmium	--	<0.02
Chromium	--	<0.02
Copper	--	0.03
Iron	--	0.37
Lead	--	<0.05
Manganese	--	1.5
Nickel	--	<0.03
Silver	--	<0.02
Zinc	--	0.07
Oil and Grease	1.7	15
Total Chlorine Residual (in situ)	0.43	0.40
Total Coliform (colonies/100 ml)	46,000*	430,000*
Fecal Coliform (colonies/100 ml)	2,400*	240,000*

* Grab sample

** 24 hour composite samples

*** Interference during analyses

DISCUSSION OF SIGNIFICANT FINDINGS

Introduction

Figures 5 through 18 illustrate significant levels of contaminants found at stations sampled during the 1987 North Coastal surveys. These graphics enable areawide comparisons to be made between some of the most prevalent contaminants and immediately illustrate sites where significant contamination is occurring or in the case of sediments, has occurred.

The most important parameters related to water quality of the areas are presented in the graphics and will be discussed in this section. They include dissolved oxygen, total and fecal coliform bacteria, nutrients, and sediment quality, including heavy metals, PCB's and PAH's. Dissolved oxygen concentrations and bacteria densities are compared to the levels set by the current Massachusetts Water Quality Standards for each area. Since there are no standards for heavy metals, PAH or PCB concentration in sediments the data were compared to the state's criteria established for categorizing dredge spoils and fill material for use and/or disposal (MDWPC, 1983a). These regulations classify dredge or fill material by chemical constituents into Categories I, II, or III. (See Tables 36 and 37).

Category I materials contain the lowest levels of the chemical constituents used in this classification system (i.e., selected heavy metals and PCBs). The dredging, handling, and disposal options for this material is least restrictive under these regulations. Category II material contains moderate levels of one or more of these constituents, and high levels of one or more of the chemicals classifies the material into Category III. Category III sediment requires specific restrictive methods of disposal and placement.

Ranges of concentrations of PCBs, PAHs, Cr, Hg and Pb from North Coastal sediment stations were also compared to ranges for these parameters found in sediment sampled by this office from other Massachusetts coastal areas (Table 38).

In addition, the low molecular weight PAHs (LPAH) and high molecular weight PAHs (HPAH) were grouped and summed. This method of comparison has been done before and was considered appropriate since the LPAH are believed to be from petroleum wastes and the HPAH are associated with combustion products (Chapman, et al. 1986). The toxicity of the individual aromatic hydrocarbon compounds varies substantially. This information is lost when the compounds are grouped; however, for the purpose of comparing the level of contamination at each station this method proved to be adequate.

Salem Harbor and Tributaries

Physical and Chemical

Data from Salem Harbor and tributary stations are illustrated in figures 5-7.

Dissolved oxygen concentrations in the tributaries of Salem Harbor dropped below the Water Quality Standard of 6.0 mg/l on several occasions (Figure 5). Station

SB03 in the South River had the lowest readings with three (3) of the four (4) measurements made during the summer at low tide well below the D.O. standard. Open water harbor stations had high dissolved oxygen concentrations throughout the water column. Several of the deeper harbor stations exhibited slight water column stratification during July. Station SH24 in front of New England Power exhibited the most defined thermal stratification. The lowest D.O. measurement in the harbor, still above the minimum required, was taken at this station at 10m in July.

Biological

Coliform bacteria concentrations were very high at the tributary stations (Figure 5). Station SB01 violated the Water Quality Standard but SB02, which was downstream did not. Since all samples were collected on an outgoing or low tide this indicates that no new sources existed between SB01 and SB02 on the Forest River. Station SB03 had consistently high counts of total and fecal coliform indicative of a raw sewage input. Coliform counts violated the SB Water Quality Standard of 700 MPN on all survey dates. Open water stations exhibited low coliform counts (well within the standard) throughout the summer.

Chlorophyll a was always relatively low ($<5.0 \text{ mg/m}^3$) at the stations evaluated in the open water. As expected, all nutrients were higher at the tributaries than at the open water stations. Values for nutrients fell within the ranges measured in the 1985 survey at Stations SB01, SB02, SB03 and similar open water stations. For each of these survey years SB03 exhibited consistently higher ammonia concentrations than the other tidal tributary stations, supporting the possibility of a raw sewage input upstream.

Sediments

There were five sediment samples collected from Salem Harbor and its tributaries. (See Figure 1). Lead, chromium, arsenic, and mercury were all measured in moderately high or very high concentrations at all of the harbor stations (SH23, SH24, and SH25). (See Figures 7, 9 and 17). Comparatively, the tributary stations tended to be slightly less contaminated with heavy metals. Station SH25 at the mouth of the South River channel in Salem Harbor exceeded Category III dredge spoils classification for arsenic, chromium, and lead. At stations SH23 (in the harbor mooring area) and SH24 (in front of New England Power) chromium levels were 3-6 times higher than the limit established for Category III. (1,800 and 1,100 mg/kg dry weight, respectively). See Table 37 for a summary of these results. There were no PCB's detected in sediments at these five stations.

It is reported that sediment that contains a higher percentage of volatile organics has a greater affinity for contaminant adsorption than sediment with lower percent organic content. This being the case, sediment with a higher percentage of combustible organic material (as measured by % volatile solids), would be expected to contain higher levels of PAHs than relatively non-organic sediment if PAH exposure levels were the same at each site. Figure 18 illustrates the percent volatile solids in the sediment at each station and the PAH concentrations measured there. However, the relationship between these two parameters is not directly quantifiable. Other measurements (not taken in these surveys) such as grain size or total organic carbon would provide information

that could be used to normalize the sediment data and enable a more quantitative method of comparison between stations. It appears that the tributary stations have lower % volatile solids than the harbor stations, presumably because they receive more flushing from river flow. However, the PAH concentrations are higher in these tributary stations. One possible explanation for this is simply that these tributary stations receive a far greater amount of PAH exposure than the open water stations. Where PAHs were detected, all of the stations contained proportionately higher levels of high molecular weight PAH compounds (HPAH) (also illustrated in Figure 18) than the low molecular weight PAHs (LPAH). The source of the HPAH compounds is reported to be from combustion products (Chapman, et al 1986). Hoffman et al (1984) reports that these HPAHs are mostly associated with particulates in urban runoff. This may explain where these PAHs are coming from and why they are usually so much higher in the tributaries than at the Salem Harbor stations which are farther away from direct runoff sources.

Overall the PAH levels observed at these five sediment stations were lower than those measured at several Boston Harbor stations (DWPC, 1985), but higher than levels found in Buzzards Bay sediment (DWPC 1985-1986). (See Table 38.)

Beverly Harbor and Tributaries

Physical and Chemical

Dissolved oxygen concentrations in Goldthwait Brook (Stations SB05, SB05A, and SB06A) were very low, consistently below the Massachusetts Water Quality Standard of 6.0 mg/l (see Figure 5). Occasionally, Station SB10 on the North River also went below this level. The remaining river stations and all of the open water stations contained at least 6.0 mg/l dissolved oxygen during the survey. The deeper harbor stations; BH25, BH24, and BH23 exhibited very slight thermal stratification during August (generally less than 5 degrees from top to bottom). At all of these stations dissolved oxygen was higher nearer the bottom than at the top.

Biological

One of the most obvious problems exhibited by the data is the degree of coliform contamination noted at several of the stations (see Figure 5). On the North River during both days of the June and August surveys Stations SB09 and SB10 had extremely high bacteria counts. In August Station SB06A on the North River had the highest total and fecal coliform for any station recorded on any date for the North Coastal surveys. These data indicate that somewhere between Station SB05A on Goldthwait Brook and Station SB06A there is a raw sewage discharge. This is also supported by the fact that all samples were collected on a low, outgoing tide. Stations upstream of SB05A contain elevated bacteria counts but they are several orders of magnitude less than at SB06A. Fifteen of the total nineteen water quality stations contained levels of bacteria that exceeded the Massachusetts Water Quality Coliform Standards for class SB waters at least once during the summer surveys. Exceptions to this were stations SB21 (Danvers River at the Liberty Hill Avenue Bridge in Salem), SB22 (Danvers River at Rte. 1A), BH24 (Beverly Harbor), and BH25 (Beverly Harbor).

Chlorophyll a values tended to be higher during the June surveys at the stations sampled. Diatoms were the dominant algae group on all occasions. The highest

chlorophyll a values were observed at Stations SB22 and SB23 (Danvers and Bass Rivers, respectively).

Sediments

Fourteen stations were also sampled for sediment quality (See Figure 1). Stations SB06A and BH21 on the North River were by far the most contaminated sites based on heavy metals concentration. In particular, the level for chromium was 6,800 mg/kg dry weight and 4,700 mg/kg dry weight, respectively, at these stations, greatly exceeding chromium values at all North Coastal sediment stations except the SESD outfall where the values were comparable (see Figures 5, 9 and 10). Levels of lead, zinc and mercury were also high enough to classify the sediment as Category III at Stations BH21, and SB06A (See Figures 7, 9, 11 and 17).

Six of the fourteen sediment stations had elevated chromium levels that placed the sediment into Category III. Six stations also contained mercury levels high enough to classify that sediment as Category III also (Figure 6). Arsenic and zinc were found at two of the stations at Category III levels. A total of eight of the fourteen sediment stations contained one or more of the heavy metals (used by the state to assess sediment disposal and handling) in concentrations at or greatly exceeding the minimum level for Category III material. Please refer to Table 37 for a summary of these results.

The highest levels of zinc, lead, chromium, and mercury found at these stations was much higher than the maximum concentrations observed at any Boston Harbor sediment station in 1985, 1986, 1987 or 1988 (DWPC, 1985, 1986, 1987 and 1988).

PCB concentrations were low or below levels of detection at all stations except SB10 where the value would place the sediment into Category II. PAH concentrations exhibited similar trends to Salem Harbor in that the tributary stations tended to have more PAHs than the open water river and harbor stations. Goldthwait Brook and the North River stations (SB05A, SB06A, SB09, SB10, and BH21) contained the highest PAH levels (Figure 18). Again, the high molecular weight compounds dominated, suggesting that the source of the majority of the PAH contamination was from combustion products and urban runoff. Station SB05A on Goldthwait Brook contained, by far the highest level of PAH compounds found at any of the North Coastal sediment stations, including the SESD outfall site (Station SS01). Total PAH concentration at this station exceeded maximum concentrations measured by DWPC in Boston Harbor Sediments (DWPC, 1985, 1986, 1987 and 1988).

Salem Sound and Marblehead Harbor

Physical and Chemical

All of the sampling stations in this area are located in open water. Dissolved oxygen concentrations were always high, even at the bottom depths. All of the stations exhibited slight thermal stratification during the summer.

Nutrient levels in the open water tended to be lower than at inshore stations with the exception of the outfall station. Here all nutrient parameters were higher than usually seen at all open water sites but not as high as observed at most of the tributary stations of Beverly and Salem Harbors.

Biological

Except for Station SS01 at the SESD outfall "boil," all of these open water stations had low total and fecal bacteria counts during every survey. At station SS01 high counts of total coliform bacteria were observed in the surface samples on three occasions (Figure 6). On August 19th counts of total and fecal coliforms were very high (950,000 CPU and 15,000 CPU, respectively) indicating a possible operational problem occurring at the treatment plant that day.

The highest chlorophyll a values were observed in June, although these values did not indicate the presence of an algae bloom. The cell counts revealed diatoms as the dominant algal group.

Sediments

Sediment samples were collected from Stations SS01 and MB02. (See Table 37 for summary.) Station SS01 had high (Category III) levels of chromium, lead, mercury, and zinc in the sediments. The levels found here place this North Coastal site as the second most contaminated with heavy metals. Station SB06A on the North River contained the highest concentration of most of the heavy metals measured. Figures 7 - 12 illustrate the relative concentrations of zinc, lead, and chromium at all of the sediment stations in the Salem/Beverly area. Station MB02 in the inner Marblehead Harbor had high chromium (Category III) levels and moderate levels of arsenic, lead, and mercury (Figures 8 and 17).

Polycyclic aromatic hydrocarbons and PCBs were not found in Marblehead Harbor sediments, however many PAH compounds were present at Station SS01. PCB levels at SS01 fell within Category II limits.

At Station SS01 the total PAH concentration was second only to the level measured at Station SB05A on Goldthwait Brook (a North River tributary); however, the highest number of compounds were identified at Station SS01 (Figure 18). Similar to all of the other stations where PAHs were found, the heavy molecular weight compounds predominated, suggesting that the source of most of the compounds was from combustion products. Many of the same PAH compounds were found at stations SS01, SB05A, SB06A, SB09, SB10, and BH21.

Manchester Harbor

Physical and Chemical

The one day Manchester Harbor survey was conducted in response to a sewer pipe break in the inner harbor. Water samples were collected at five stations along a transect from inner to outer harbor.

On the sampling date of July 8, 1987 the dissolved oxygen concentrations at all stations throughout the water column were high. None of the stations exhibited thermal stratification.

Phosphorus was high at Station MH02 in the surface sample, but all other nutrient values at every station fell within the range measured at other open water stations along the North Coast including those in Beverly Harbor sampled after a sewer pipe rupture occurred there.

Biological

The only significant water quality trend indicated by the data was the elevated coliform bacteria densities observed at the two stations closest downcurrent of the pipe rupture (See Figure 6). Samples were collected on an outgoing tide; consequently stations MH02 and MH04 showed total and fecal coliform densities higher than the Massachusetts Water Quality Standard set for this harbor (Class SB). MH01 was upcurrent of the rupture, and Stations MH05 and MH06 were located in the outer channel most likely far enough from the break that the coliform bacteria died off before being carried by the current to these stations.

Gloucester Harbor

Physical and Chemical

For the most part dissolved oxygen concentrations throughout the harbor were well above 6.0 mg/l. Only at stations GH05 and GH06, two inner harbor cove stations that most likely receive reduced flushing, did dissolved oxygen concentrations fall slightly below (5.8 mg/l) this minimum standard level near the bottom of the water column on one sampling day. (See Figure 13).

Nutrient concentrations were relatively low compared to levels measured at some of the stations in Beverly and Salem harbors and their tributaries.

Biological

Coliform counts were elevated and exceeded water quality standards for Class SB waters at many of the stations (See Figure 13). Almost all of these violations occurred on September 1. During the survey on this date the weather was rainy and windy. Debris were observed floating all about the inner harbor. Flow was observed from the CSO that discharges to Western Harbor. The highest bacteria densities measured during the survey were found at this station (GH04) on September 1. This was most likely due to the CSO discharge.

As in the other North Coastal areas described in this report, coliform bacteria counts were very low at the open water stations except for Station GH12, near the sewage outfall "boil." This elevated count was observed on only one of three survey days.

Chlorophyll a and respective algae cell counts were low at all stations sampled. Diatoms were the dominant algal group but no bloom conditions were observed even at the inner harbor stations.

Sediments

Sediments were sampled at seven stations throughout the harbor (Figure 4). As expected, the highest levels of contaminants were found at the stations located within coves of the inner harbor where flushing and circulation is minimal and commercial and industrial use is heavy.

Lead and zinc levels at all of the Inner Harbor Cove stations (GH05, GH06, GH07, and GH09) were within the Category III class for sediments (Figures 14 and 15). Arsenic was also elevated at Stations GH05 and GH06 (Figure 17). A high (9.49 µg/g) PCB value was obtained from Station GH05 sediments but other stations exhibited low or below detection levels of PCBs (Figure 16). Refer to Table 37 for a listing of category classifications.

Compared to certain stations sampled in Salem and Beverly waters, the PAH concentrations detected at the Gloucester sites were relatively low (Figure 18). Again, Stations GH05, GH06, and GH07 displayed the highest levels of LPAH and HPAH found in Gloucester. The higher molecular weight compounds dominated at all three of these locations indicating the source to be from combustion products and urban runoff rather than petroleum products.

Stations GH05, GH06, and GH07, located at the head of three narrow Inner Harbor coves or channels, most likely receive a considerable degree of urban runoff from the surrounding developed area. Station GH07, where the highest total PAH level was measured is located in a cove that receives storm drainage and runoff from a rather steeply sloped, highly developed area. Station GH06 is located in an somewhat similar area with similar characteristics and the PAH compounds found here were identical to those found at Station GH07 at only slightly lesser concentrations.

Harbor Cove, where station GH05 is located, is crowded with commercial fishing boats and surrounded by fishing-related industries. PAHs from urban runoff, although undoubtedly entering Harbor Cove, do not seem to be as serious a problem here as at Stations GH06 and GH07. Rather the data indicate that arsenic, lead, zinc, and PCBs are the contaminants of concern in this area. (See summary Table 37).

Summary

These water quality surveys identified several areas of considerable contamination in the North Coastal region, the types and degree of which varied from site to site.

Major problems identified from a large proportion of the water samples were high coliform bacteria densities and low dissolved oxygen in some areas. At sites such as those identified along the North River which contained counts of bacteria indicative of raw sewage, steps should be taken to pinpoint and terminate the discharge.

Although it is difficult to identify specific sources of coliform contamination from broad based water quality surveys such as these, elevated bacteria levels should signal a need for concern and more specific investigative work. Point sources of coliform bacteria contamination were also verified from samples taken at all of the treatment plant outfalls and near a combined sewer overflow in Gloucester.

The extremely high heavy metals (particularly chromium) found in the sediments at some of the sites in Salem/Beverly reflect the historic prevalence of the tanning industry in the area. Other heavy metals and organic contaminants found in these sediments and elsewhere along the North Coast are no doubt products of the highly urbanized and industrial nature of the region.

Table 38 compares ranges of several heavy metals and PCBs and PAHs measured recently in sediments sampled by this office from the North Coast, Buzzards Bay and Boston Harbor. Several stations in the Salem/Beverly area contained the highest concentrations of Cr, Hg, Pb, and total PAHs in the sediments than even those measured at any DWPC Boston Harbor station. The highest PCB concentration

measured in these areas by DWPC was at a station in Gloucester. (For comparison, the extremely high PCB concentration measured in New Bedford Harbor [by a consultant] was included).

Specific sources of past sediment contamination are usually very difficult to identify. These contaminated sediments however, may also provide a potential non-point source of water quality contamination via mechanical (i.e., resuspension) or biochemical pathways.

TABLE 36
CLASSIFICATION OF DREDGE OR FILL MATERIAL
BY CHEMICAL CONSTITUENTS*
(mg/kg dry weight)

<u>METAL</u>	<u>CATEGORY I</u>	<u>CATEGORY II</u>	<u>CATEGORY III</u>
As	<10	10 - 20	>20
Cd	<5	5 - 10	>10
Cr	<100	100 - 300	>300
Cu	<200	200 - 400	>400
Pb	<100	100 - 200	>200
Hg	<0.5	0.5 - 1.5	>1.5
Nl	<50	50 - 100	>100
V	<75	75 - 125	>125
Zn	<200	200 - 400	>400
PCB	<0.5	0.5 - 1.0	>1.0

Category I Materials - those which contain no chemicals listed in the above table in concentrations exceeding those listed in the first column.

Category II Materials - those which contain any one or more of the chemicals listed in the above table in the concentration range shown in the second column.

Category III Materials - those which contain any chemical listed in the above table in a concentration greater than shown in the third column.

*Commonwealth of Massachusetts, Division of Water Pollution Control, 1983a.

TABLE 37

CLASSIFICATION OF SEDIMENT QUALITY IN NORTH COASTAL BASED ON CATEGORIES
ESTABLISHED IN CERTIFICATION FOR DREDGING, DREDGED MATERIAL DISPOSAL
AND FILLING IN WATERS.*

<u>Location</u>	<u>Station</u>	<u>Parameter</u>								
		As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	PCB
Salem Harbor & Tributaries	SB02	1	1	2	1	3	2	1	1	1
	SB03	1	1	2	1	2	2	1	1	1
	SH23	2	1	3	1	3	2	1	1	1
	SH24	2	1	3	1	2	2	1	1	1
	SH25	3	1	3	1	3	2	1	1	1
Beverly Harbor & Tributaries	SB05A	1	1	1	1	2	1	1	1	1
	SB06A	2	2	3	1	3	3	1	3	1
	SB09	1	1	3	1	3	3	1	2	1
	SB10	2	1	3	1	3	3	1	2	2
	SB12	1	1	2	1	2	2	1	1	1
	SB15	2	1	2	1	2	3	1	1	1
	SB17	1	1	2	1	2	2	1	1	1
	SB20	2	1	3	1	2	3	1	2	1
	SB21	1	1	2	1	2	2	1	1	1
	BH20	3	1	3	1	2	2	1	1	1
	BH21	3	2	3	1	3	3	1	3	1
	BH22	2	1	3	1	2	2	1	1	1
	BH23	1	1	2	1	1	2	1	1	1
	BH24	1	1	2	1	1	1	1	1	1
Salem Sound	SS01	1	2	3	2	3	3	1	3	2
	MB02	2	1	3	1	2	2	1	1	1
Gloucester Harbor	GH02	1	1	1	**	1	**	1	1	1
	GH05	3	1	1	**	3	**	1	3	3
	GH06	2	1	1	**	3	**	1	3	1
	GH07	1	1	1	**	3	**	1	3	1
	GH09	1	1	1	**	3	**	1	3	1
	GH12	2	1	1	**	1	**	1	1	1
	GH15	1	1	1	**	1	**	1	1	1

* Refer to Table 36 for ranges of concentrations for chemical parameters which define Categories I, II and III (MDWPC, 1983a).

** Not Analyzed

TABLE 38

RANGES OF SELECTED PARAMETERS MEASURED IN SEDIMENT AT SAMPLING STATIONS
IN FOUR MASSACHUSETTS COASTAL AREAS

<u>Parameter</u>	<u>Location</u>			
	<u>Salem/Beverly¹ and Tributaries</u>	<u>Gloucester¹</u>	<u>Buzzards Bay²</u>	<u>Boston Harbor³</u>
Cr mg/kg dry wt.	40 - 6,800	15 - 68	2.5 - 30	40 - 245
Hg mg/kg dry wt.	0.37 - 5.0	-	0.03 - 2.6	0.128 - 3.01
Pb mg/kg dry wt.	52 - 950	18 - 480	5.2 - 72	55 - 560
Total PCB µg/g dry wt.	ND - 2.03	ND - 9.49	ND - 0.89*	ND - 7.0
Total PAH µg/g dry wt.	ND - 125.7	ND - 36.08	ND - 2.18	ND - 67.5

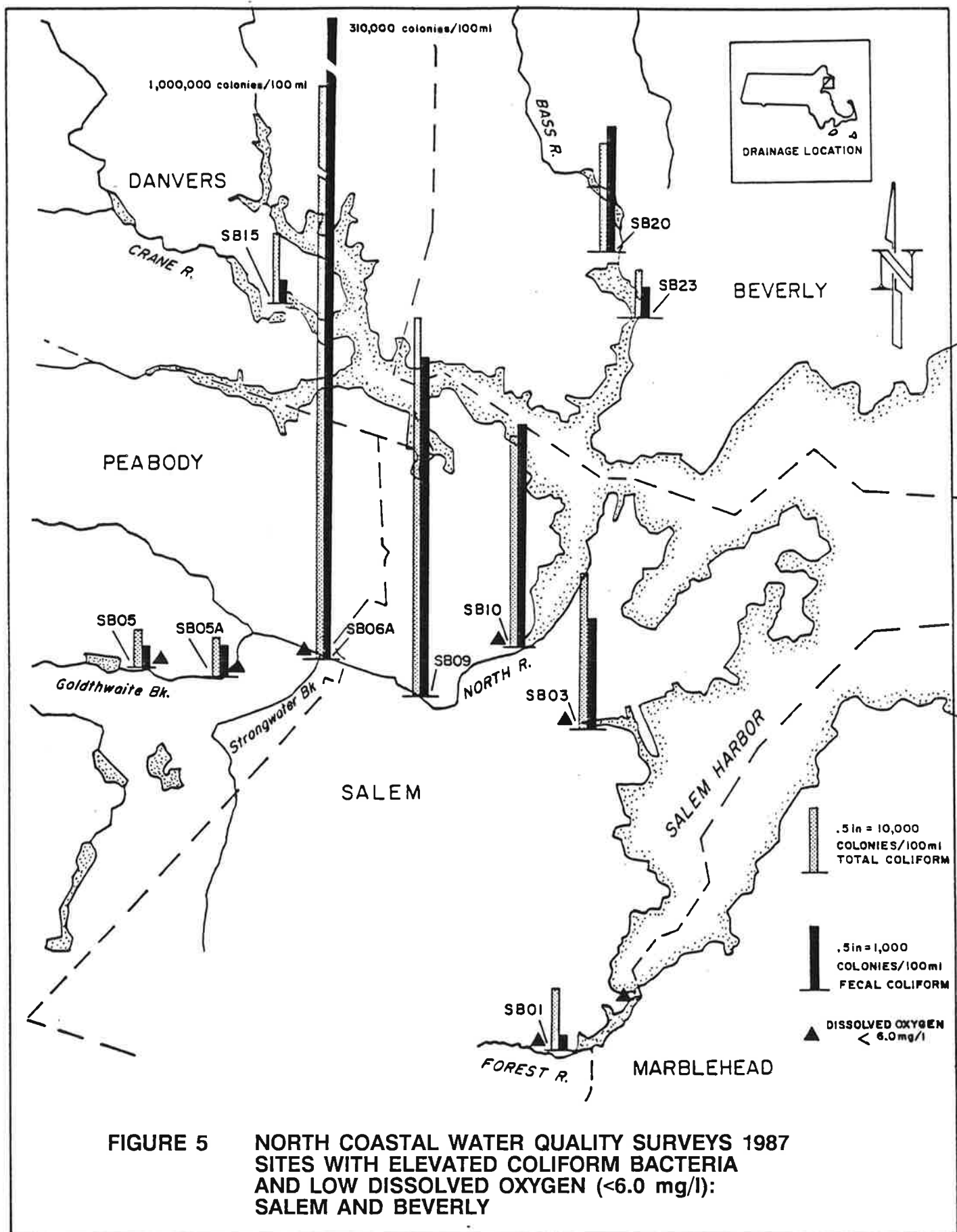
ND Not detected

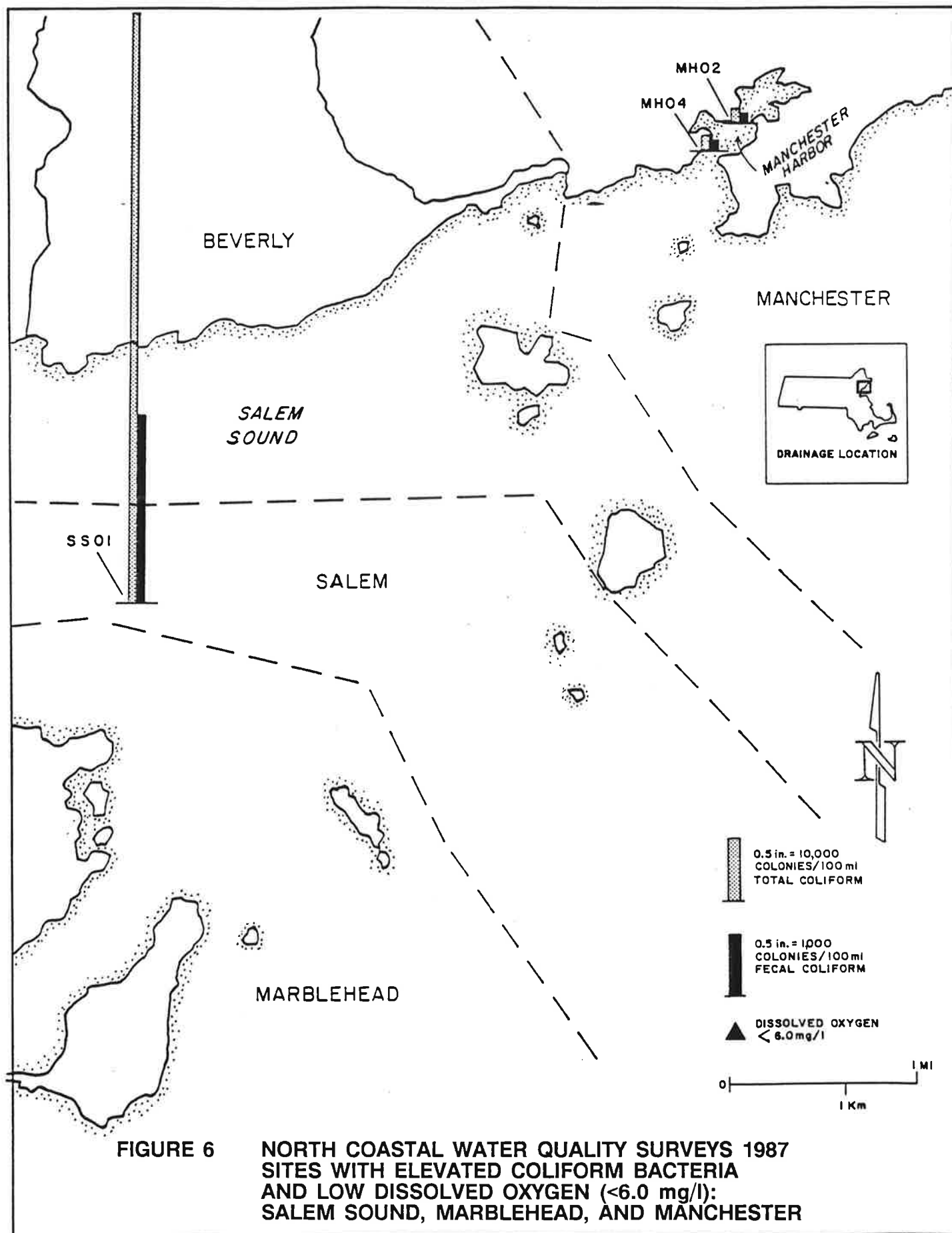
* Sediments from certain areas in New Bedford contain PCB concentrations exceeding 100,000 ppm. (Weaver, 1984)

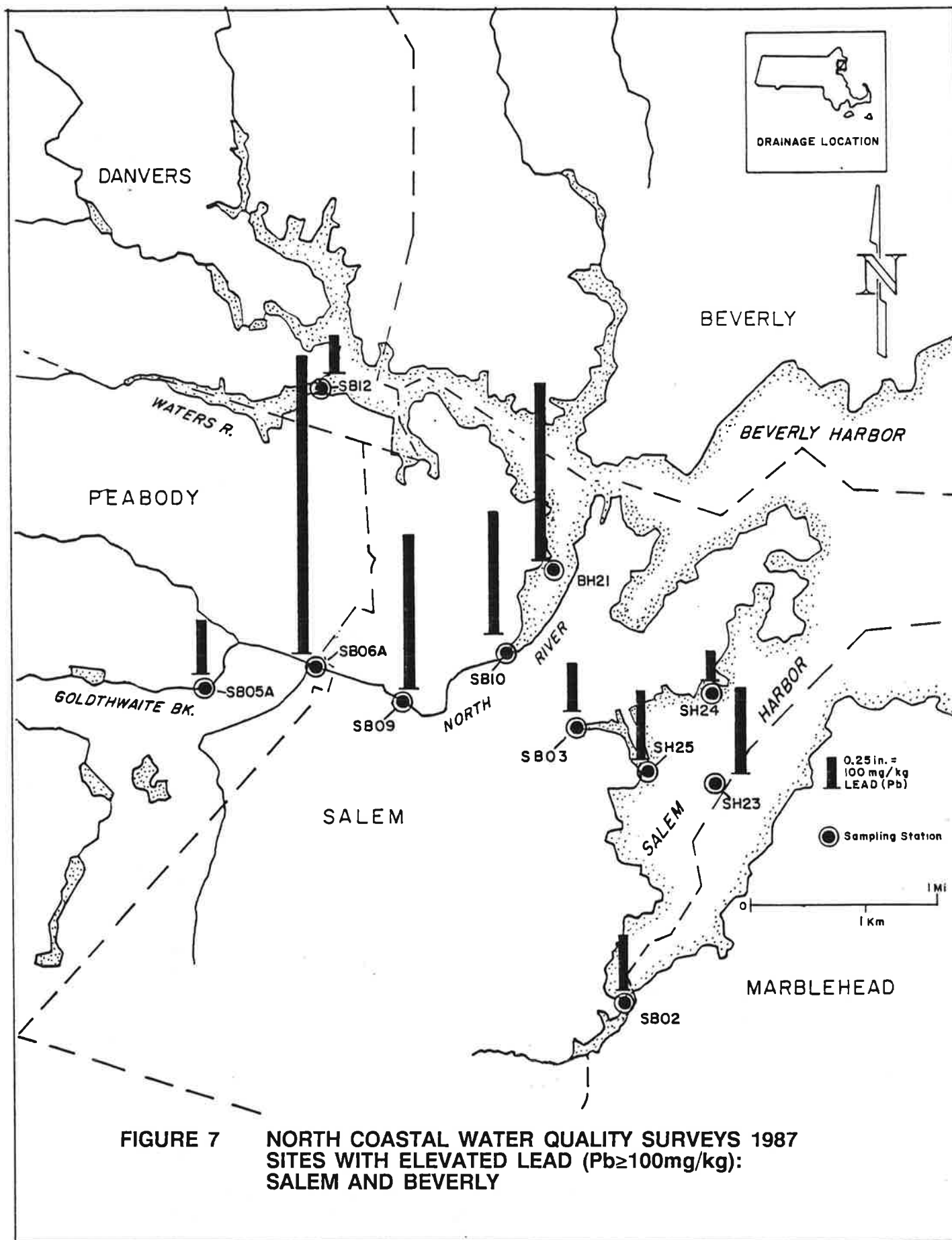
¹ Data from: North Coastal 1987 Water Quality Surveys, MDWPC.

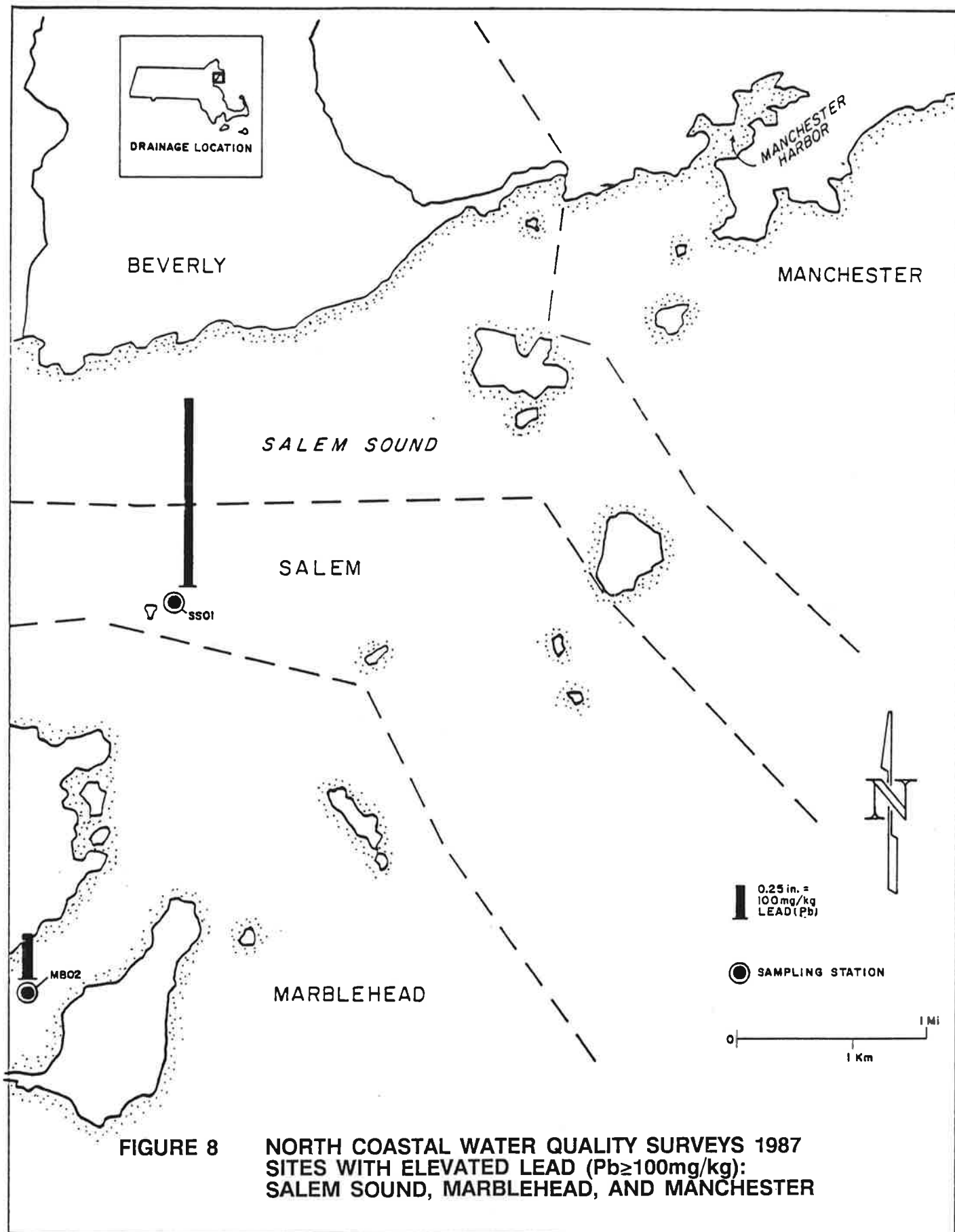
² Data from: 1985-86 Buzzards Bay Sediment Data Report, MDWPC.

³ Data from: - Boston Harbor 1985 Water Quality and Wastewater Discharge Data, MDWPC.
- Boston Harbor 1986 Discharge Data and Wastewater Discharge Data, MDWPC.
- Boston Harbor 1987, 1988 Water Quality and Wastewater Discharge Data. (In preparation, MDWPC).









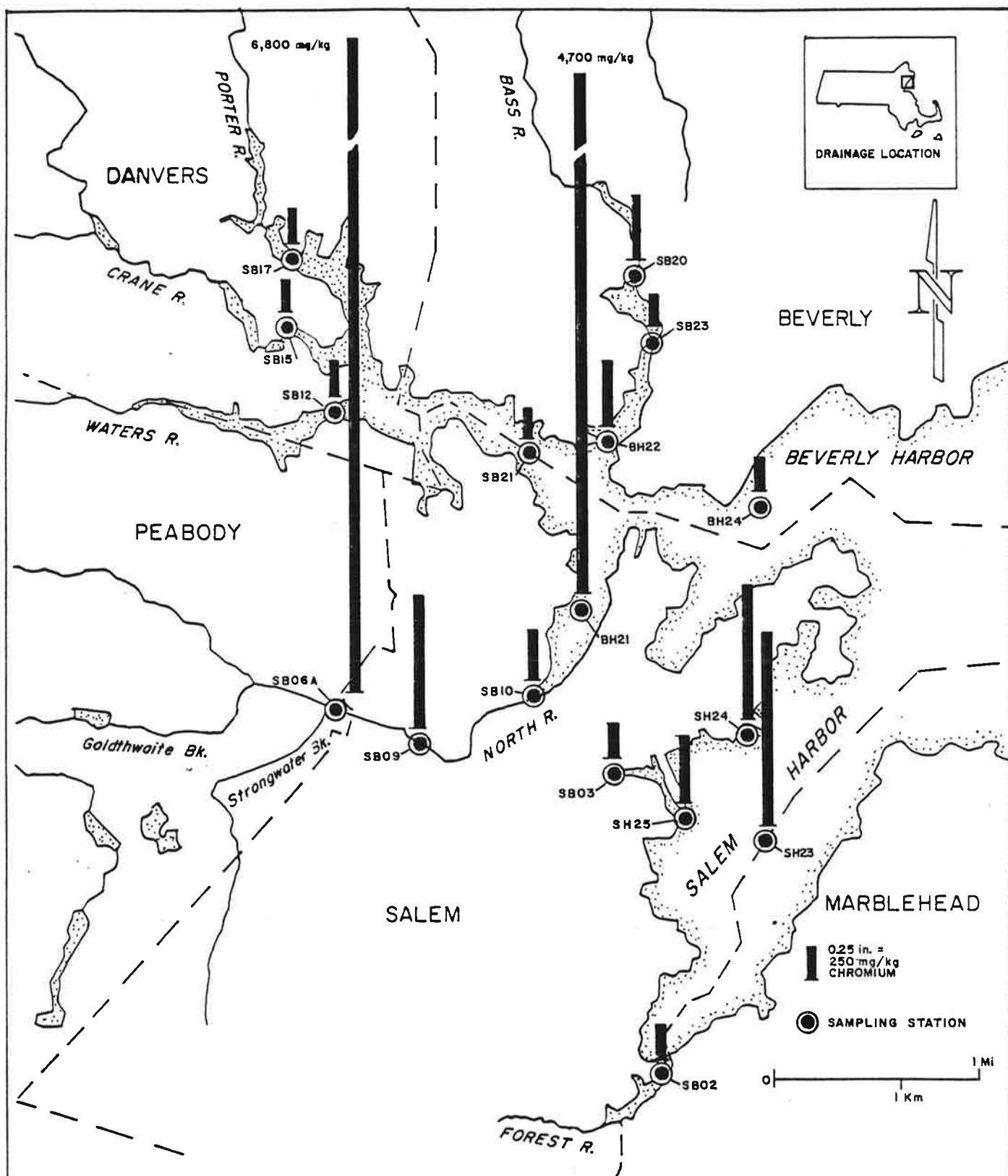
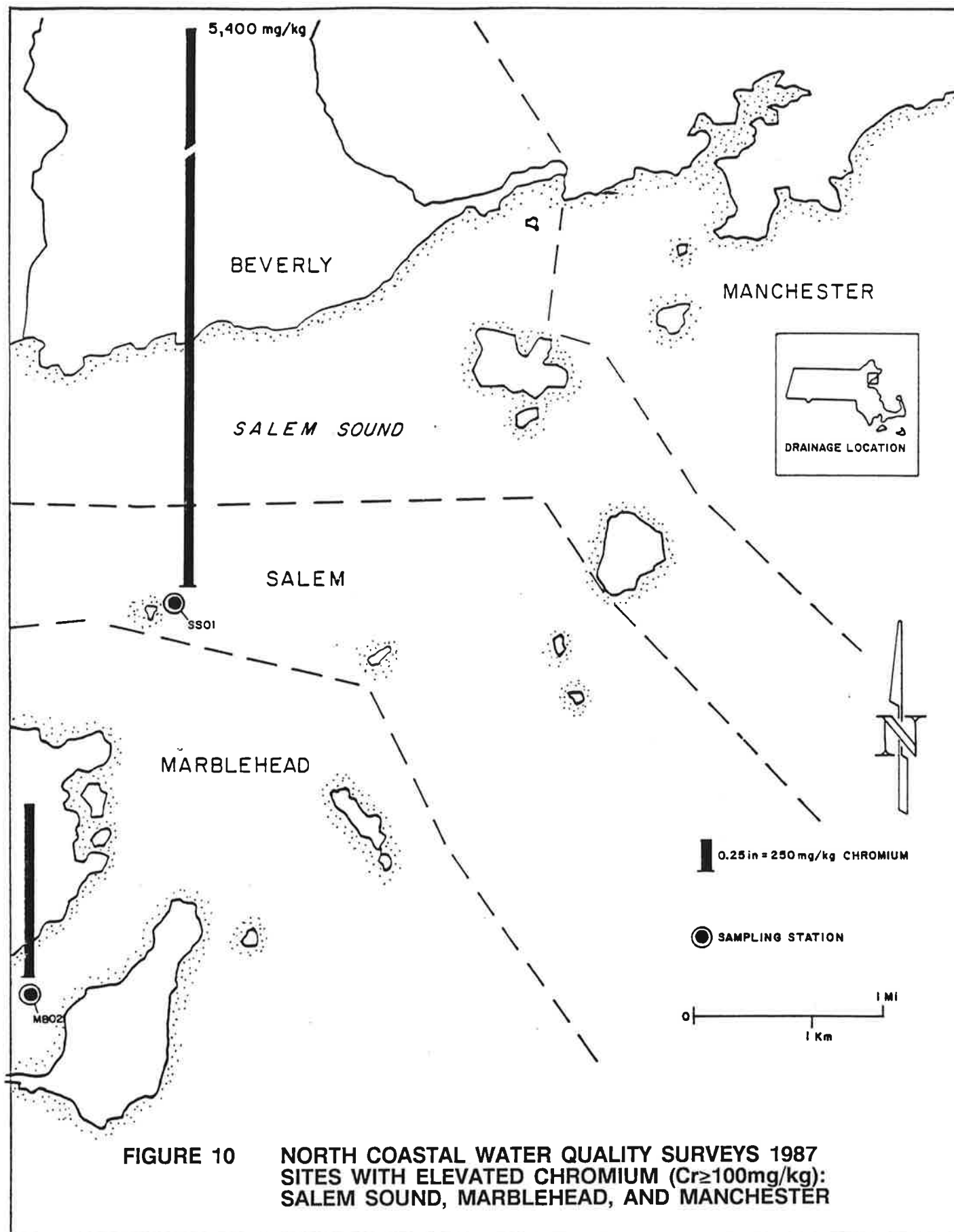
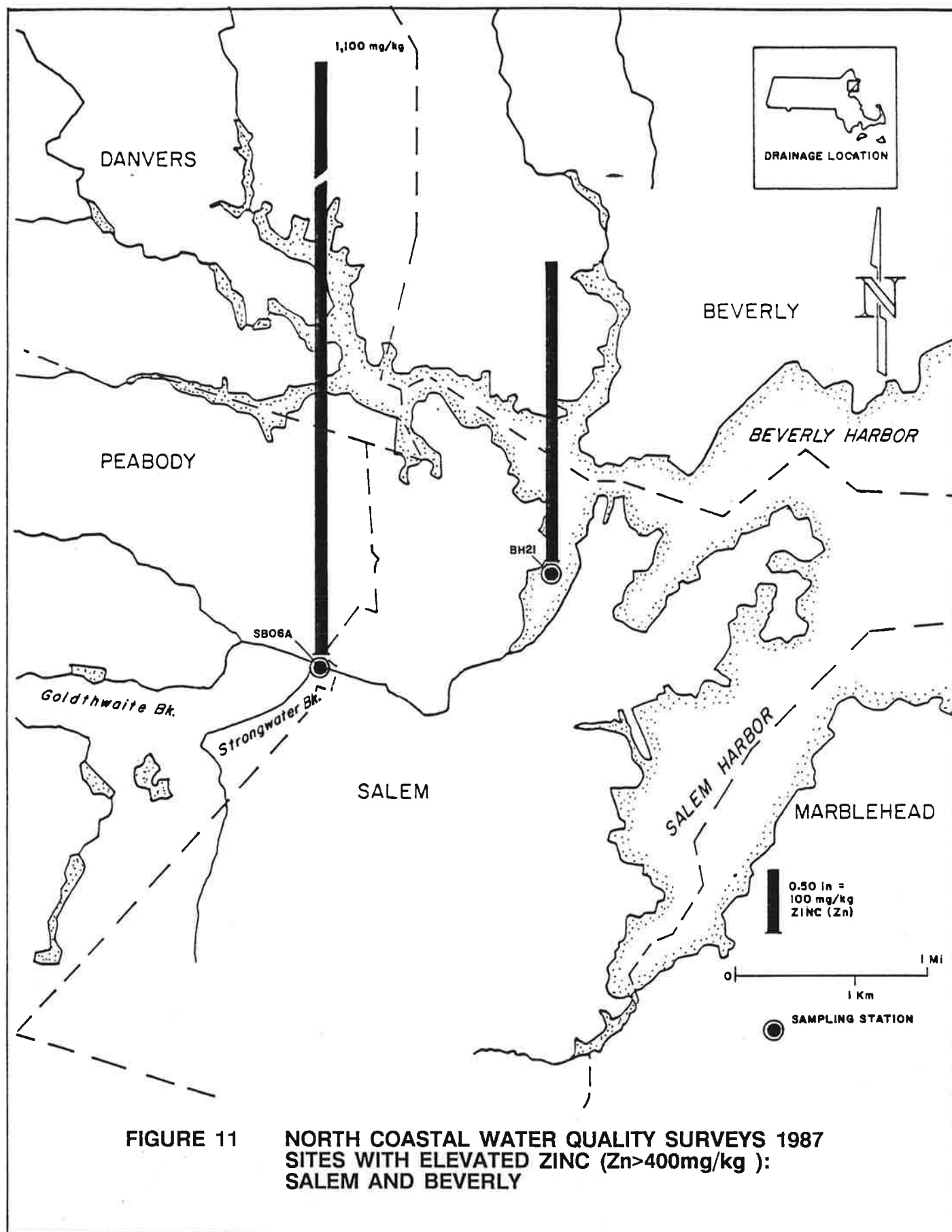
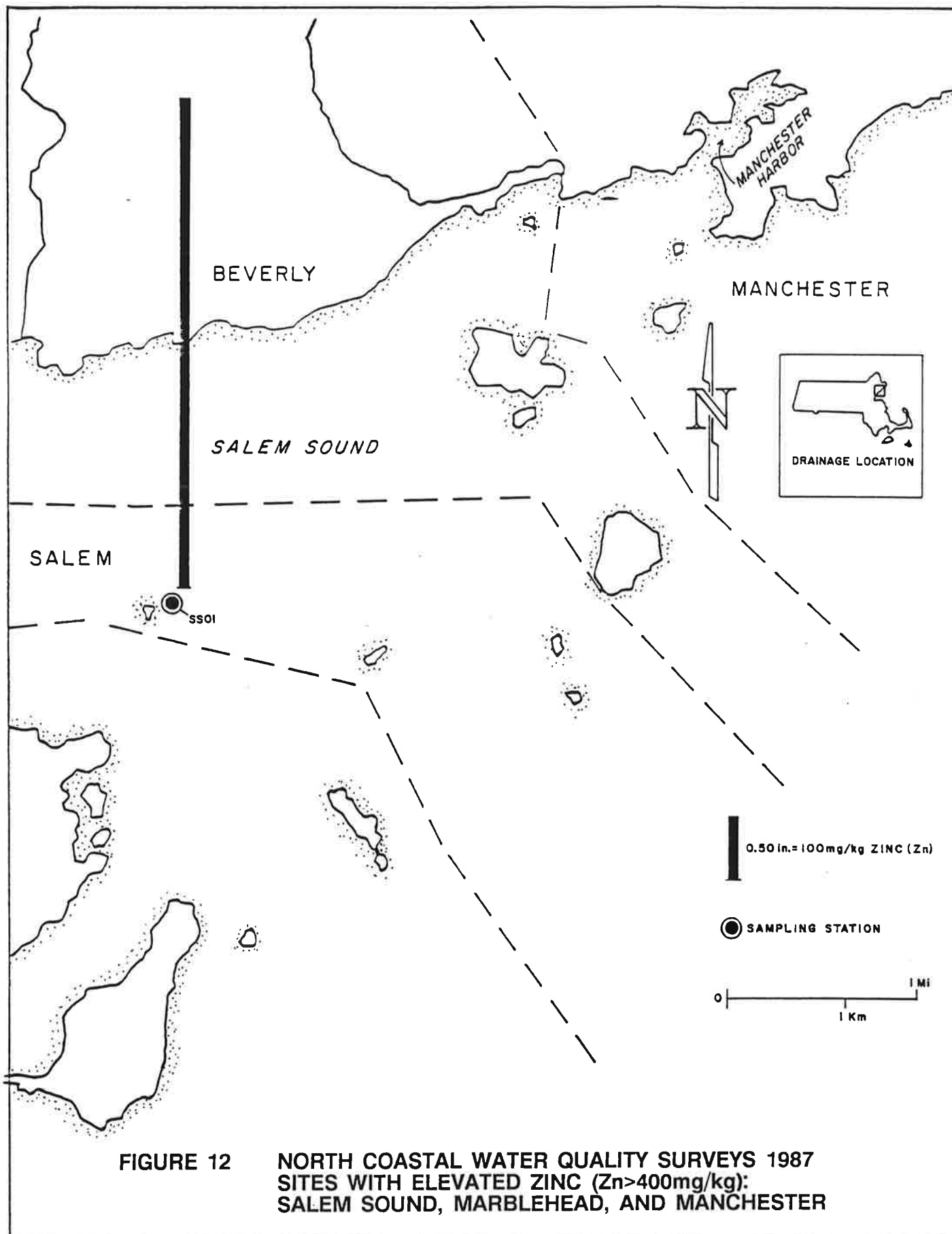
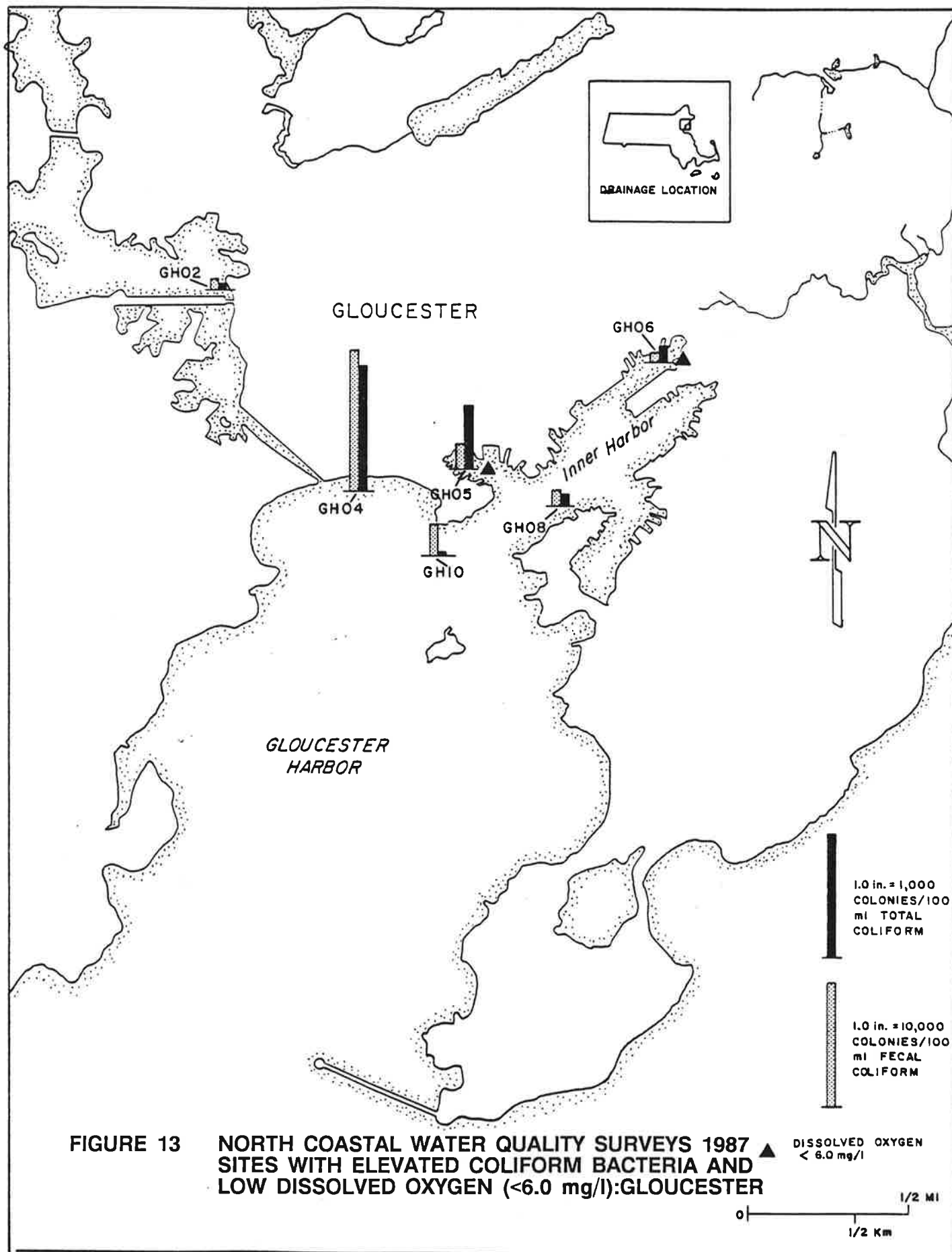


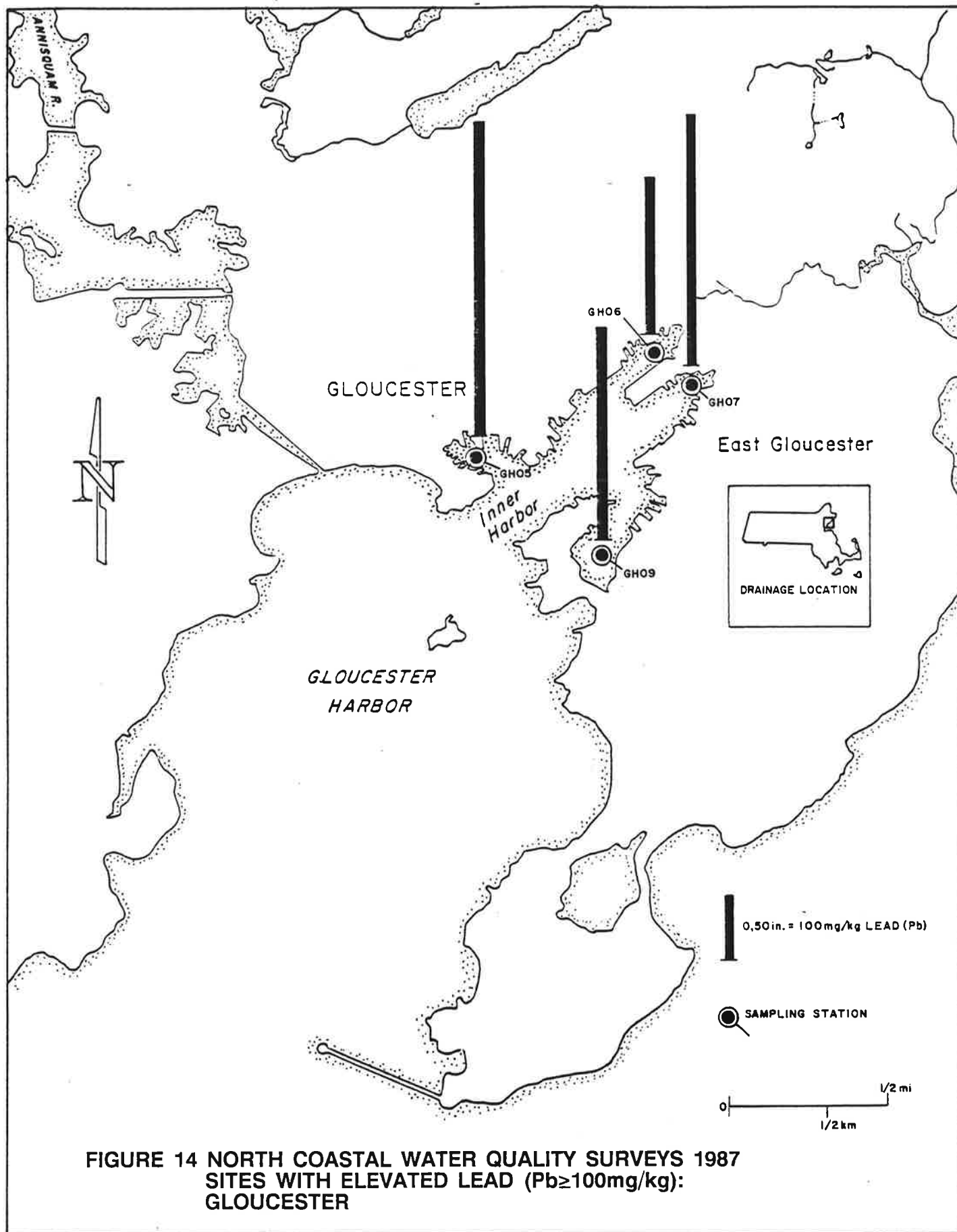
**FIGURE 9 NORTH COASTAL WATER QUALITY SURVEYS 1987
SITES WITH ELEVATED CHROMIUM ($\text{Cr} \geq 100 \text{ mg/kg}$):
SALEM AND BEVERLY**

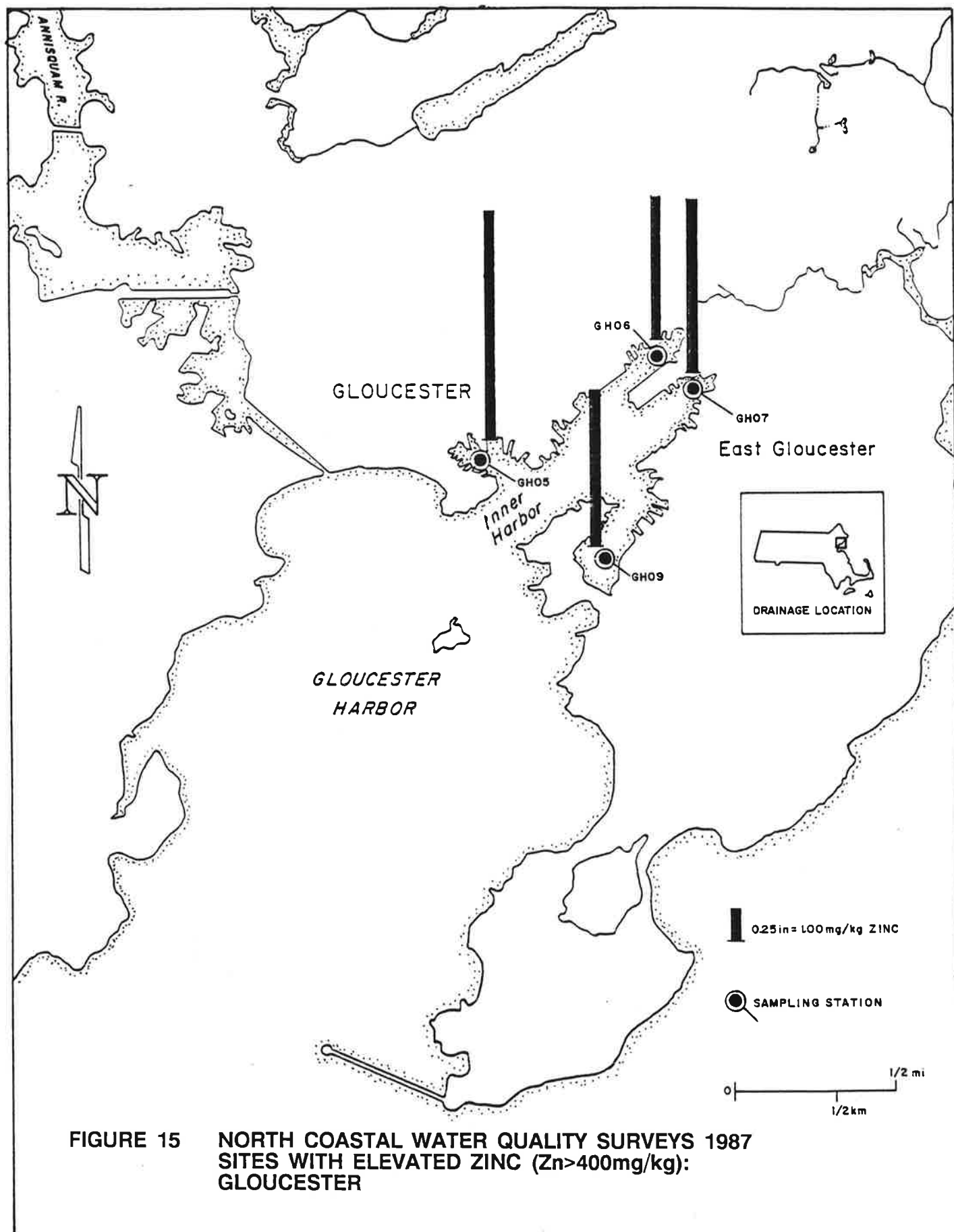












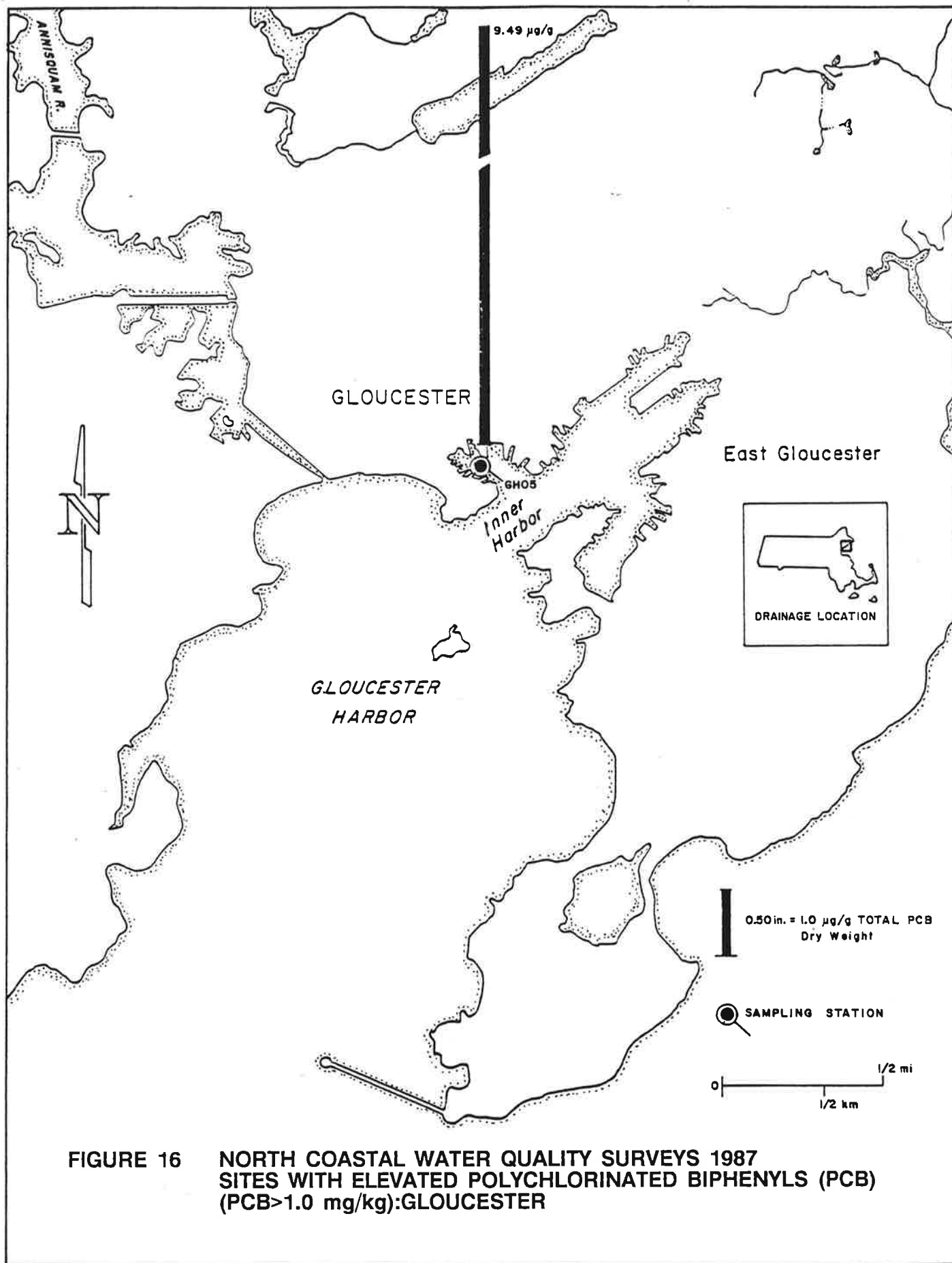


**FIGURE 17 NORTH COASTAL WATER QUALITY SURVEYS 1987
SEDIMENT ARSENIC AND MERCURY CONCENTRATIONS
FOR NORTH COASTAL SURVEY STATIONS**

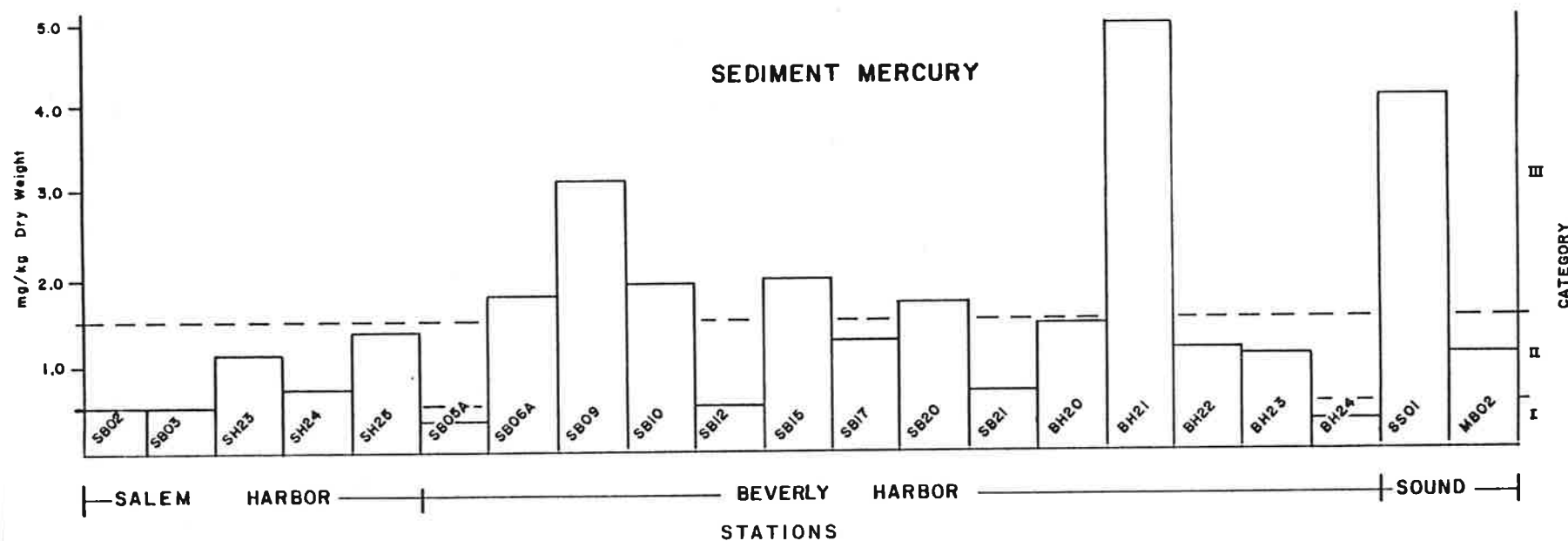
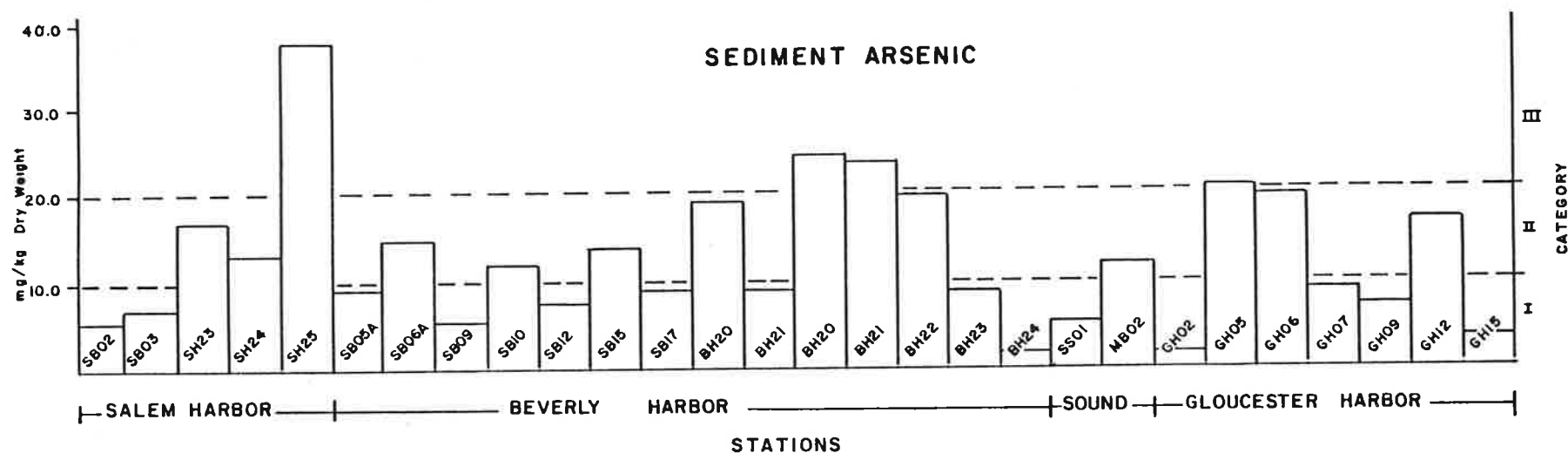
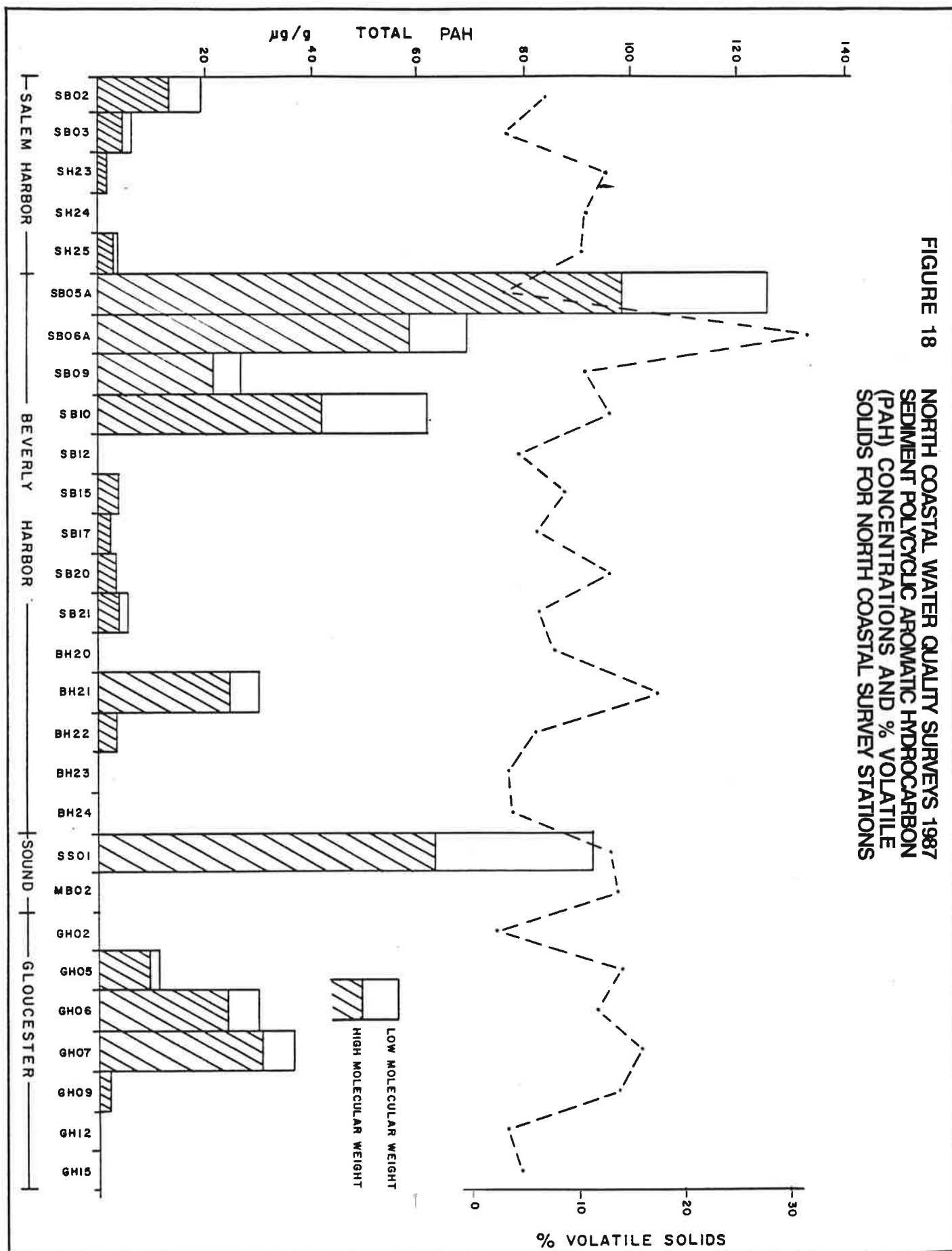


FIGURE 18
NORTH COASTAL WATER QUALITY SURVEYS 1987
SEDIMENT POLYCYCLIC AROMATIC HYDROCARBON
(PAH) CONCENTRATIONS AND % VOLATILE
SOLIDS FOR NORTH COASTAL SURVEY STATIONS



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APPENDIX A

TABLE A-1

1987 TIDAL CONDITIONS DURING NORTH COASTAL SURVEYS¹

DAY	MONTH	HIGH		LOW		SURVEY LOCATION
		a.m.	p.m.	a.m.	p.m.	
22	June	0921	0935	0308	0313	Salem/Beverly
23	June	1015	1021	0402	0402	Salem/Beverly
24	June	1104	1104	0450	0449	Salem/Beverly
8	July	0913	0925	0305	0313	Manchester
20	July	0757	0811	0143	0148	Salem/Beverly
21	July	0856	0906	0242	0243	Salem/Beverly
18	August	0727	0741	0109	0117	Salem/Beverly
19	August	0828	0837	0213	0215	Salem/Beverly
1	September	0524	0549	1127	--	Gloucester
2	September	0625	0641	1215	1227	Gloucester
3	September	0729	0747	0117	0130	Gloucester

¹ From: P. White, Robert Eldridge, 1987. Eldridge Tide and Pilot Book, 1987. Boston, MA 02110.

APPENDIX B

ANALYTICAL METHODS

TABLE B-1
COMMON SAMPLE TREATMENT METHODS

PARAMETER	SAMPLE VOLUME	SAMPLE CONTAINER ¹	IMMEDIATE SHIPBOARD PROCESSING AND STORAGE
Dissolved Oxygen	300 ml (2)	G (1)	MnSO ₄ ; KI: no sunlight/or (5) "in situ."
Temperature	---	- (1)	In situ recorded to nearest 0.1°C/F or (4), (5).
COD	1 l (2)	P/G (1)	H ₂ SO ₄ , pH ≤2.0, cool 4°C.
BOD ₅	1 l (2)	G (1)	Cool 4°C.
pH (Standard Units)	---	- (1)	"In situ" reading with meter (3) Record to nearest 0.1/or transport on ice to LES.
Total Alkalinity	1 l (2)	P/G (1)	Cool 4°C.
Specific Conductance	1 l (2)	P/G (1)	"In situ" reading/or cool 4°C (4)(5).
Total Hardness	300 ml (2)	P/G (1)	HNO ₃ , pH ≤ 2.0 cool 4°C.
Total Solids	1 l (2)	P/G (1)	Cool 4°C.
Suspended Solids	1 l (2)	P/G (1)	Cool 4°C.
Settleable Solids	1 l (2)	P/G (1)	Cool 4°C.
Chloride	1 l (2)	P/G (1)	Cool 4°C.
Total Kjeldahl-Nitrogen	500 ml (2)	G (1)	H ₂ SO ₄ , pH ≤2.0, cool 4°C.
Ammonia-Nitrogen	500 ml (2)	G (1)	H ₂ SO ₄ , pH ≤2.0, cool 4°C.
Total Phosphorus	500 ml (2)	G (1)	H ₂ SO ₄ , pH ≤2.0, cool 4°C.
Orthophosphate	500 ml (2)	G (1)	H ₂ SO ₄ , pH ≤2.0, cool 4°C.
Bacteria	200 ml (2)	G (1)	Cool 4°C.
Turbidity	1 l (2)	G (1)	Cool 4°C.
Chlorophyll <u>a</u> / Phytoplankton	200 ml	P/G (1)	Cool 4°C. (6)

¹ (G) Glass
(1) & (2) see footnotes on last page
P/G Polypropylene or glass

FOOTNOTES (TABLES B-1)

1. Required containers, preservation techniques, and holding time, per Table II 40 CFR Part 136.
2. Massachusetts Division of Water Pollution Control, Technical Services Branch, Engineering Section, Standard Operating Procedures.
3. Service and Calibration Manual Model 211 Orion Field pH meter. Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA. 02319
4. Yellow Springs Instrument, Model 33 S-C-T meter and probe. Yellow Springs Instrument Co., Inc. Yellow Springs, Ohio 45387.
5. Hydrolab Surveyor II, Model SVR2-SU sonde unit, Model SVR2-DV Digital read out. Hydrolab Corp., P.O. Box 50116, Austin TX 78763.
6. Massachusetts Division of Water Pollution Control, Technical Services Branch, Biomonitoring Program 1988, Standard Operating Procedures.

*River Temp
Salinity
Machine Temp
Salinity*

TABLE B-2

PARAMETER AND COLLECTION METHODS EMPLOYED AT SEDIMENT STATIONS

PARAMETER	SAMPLE VOLUME (liters)	SAMPLE CONTAINER	IMMEDIATE FIELD PROCESSING & STORAGE
PCB 1016/1242 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1248 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1254 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1260 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PAHs Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
Metals Sediment	25-100 g	G/Teflon Septum or Plastic Wrap Septum	Cool to 4°C

G = Glass

TABLE B-3

SAMPLING PARAMETERS AND ANALYTICAL METHODS

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
BOD ₅	5-day oxygen depletion at 20°C	mg/l BOD	2 mg/l	<u>Standard Methods</u> 16th ed. sec. 412B, p418,	48 hours
COD	Dichromate Reflux	mg/l COD	---	<u>Standard Methods</u> 16th ed. sec. 508, p532.	28 days
Dissolved Oxygen	Azide modification of Winkler method. 0.0375 N sodium thio- sulfate titrant, 300 ml sample	mg/l D.O.	+0.05 mg/l	<u>Standard Methods</u> 15th ed. sec. 421B	8 hours
pH	Electrometric, glass indicator, silver chloride reference	pH Logarithmic Units	+0.1 Standard Units	<u>Standard Methods</u> 16th ed., sec. 423, p249	Analyze immediately
Turbidity	Nephelometric. Hach Turbidi- meter. Model 2100A	Nephelometric Turbidity Units	---	<u>Standard Methods</u> 15th ed., sec. 214A	48 hours
Total Alkalinity	0.02 N sulfuric acid potentio- metric titration to pH 4.5, Orion Model 701, Digital pH meter	mg/l CaCO ₃	---	<u>Standard Methods</u> 16th ed., sec. 403, p269	14 days
Suspended Solids	Filtration through standard glass fiber filter paper. Residue dried at 103-105°C. Gravimetric	mg/l S.S.	10 mg/l	<u>Standard Methods</u> 16th ed., sec. 403, p269	48 hours
Total Solids	Evaporation to dryness at 103- 105°C. Gravimetric	mg/l T.S.	5 mg/l	<u>Standard Methods</u> 16th ed., sec. 209C, p96	7 days
Settleable Solids	Gravimetric settling using an Imhoff cone	ml/l sett. solid	0.1 ml/l	<u>Standard Methods</u> 15th ed., sec. 209F	48 hours

TABLE B-3 (CONTINUED)

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
Total Dissolved Solids	Filtration through standard glass fiber filter paper. Residue dried at 180°C	mg/l T.D.S.	---	<u>Standard Methods</u>	48 hours
Total Kjeldahl-Nitrogen	Acid digestion using Technical BD-40 Block Digester. Colorimetric analysis (reaction of ammonia, sodium salicylate, sodium nitroprusside, and sodium hypochlorite in buffered alkaline medium) using Technicon Auto Analyzer II	mg/l TKN	0.05 mg/l	EPA 1979, p351.2	28 days
126 Ammonia-Nitrogen	Phenate method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NH ₃ -N	0.02 mg/l	<u>Standard Methods</u> 15th ed., sec. 417F	28 days
Nitrate-Nitrogen	Hydrazine reduction method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NO ₃ -N	0.1 mg/l	EPA 1983, p353.1	48 hours
Total Phosphorus	Acid digestion using Technicon BD-40 Block Digester. Ascorbic acid reduction colorimetric method using Technicon Auto Analyzer II	mg/l P	0.02 mg/l	EPA 1979, p365.4	28 days
Total Coliform	Membrane filter technique	Total coliforms/ 100 ml	<10	<u>Standard Methods</u> 15th ed., sec. 908C	6 hours
Fecal Coliform	Membrane filter technique	Fecal coliforms/ 100 ml	<5	<u>Standard Methods</u> 15th ed., sec. 908C 1984 p943	6 hours

TABLE B-3 (CONTINUED)

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
Conductivity	Wheatstone Bridge type meter. Yellow springs Instrument conductivity bridge, Model 31	$\mu\text{mhos/cm}$	---	Standard Methods 15th ed., sec. 205	28 days
Color	Visual comparison of sample with known concentrations of colored solutions	Color Units	N/A	Standard Methods 15th ed., sec. 204A	48 hours
Chloride	Argentometric (titration with silver nitrate)	mg/l Cl	0.5 mg/l	Standard Methods 15th ed., sec. 407A, p287	28 days
Temperature	"In situ" reading	C°/°F	+0.05	Omega dial temp. thermo- meter models K-79-8, K-79-7. Omega Engineering Inc. Stamford, CT.	Analyze immediately
Orthophosphorus	Ascorbic acid method	mg/l as P	0.01 mg/l	Standard Methods 16th ed., sec. 424F, p448	48 hours
Hardness	Hardness by calculation	mg, equivalent	---	Standard Methods 15th ed., sec. 314A	6 months
Flow	Wading Rod Pygmy Current Meter	CFS	---	Gurly No. 625 Pygmy Current Meter, Troy, NY 12181	---
Depth	Hydrolab Surveyor II	meter	0.1 meters	Hydrolab Surveyor II, Model SVR2-SU Sonde Unit, Model SVR2-DV Digital readout	N/A

TABLE B-4

SEDIMENT SAMPLING PARAMETERS AND ANALYTICAL METHODS

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
<u>Metals Analysis</u>					
Cadmium - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 213.1	6 months
Total Chromium - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 218.1	6 months
Total Copper - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.2	EPA Method 220.1	6 months
Total Lead - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.5	EPA Method 239.1	6 months
Total Mercury - Sediment	Manual Cold Vapor Technique	mg/kg (d.w.)*	0.0002	EPA Method 245.5	6 months
Total Nickel - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.3	EPA Method 249.1	6 months
Total Silver - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 272.1	6 months
Total Zinc - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.2	EPA Method 289.1	6 months
Total Iron - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	<0.04	EPA Method 236.2	6 months
Total Aluminum - Sediment	ICAP	mg/kg (d.w.)*	0.10	EPA Method 200.7	6 months
Arsenic - Sediment	AA graphite furnace	mg/kg (d.w.)*	<0.001	EPA Method 206.2	6 months

TABLE B-4 (CONTINUED)

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
PAHs - Sediment	Gas chromatography/Mass Spectrometry	$\mu\text{g/g}$ (d.w.)*	(1)	EPA Method 3510 (2) EPA Method 8100 (2)	7 days to extraction, analysis.
<u>Polychlorinated Biphenyl Analysis</u>					
PCB 1016/1242 - Sediment	Gas chromatography	$\mu\text{g/g}$	0.16	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
PCB 1248 - Sediment	Gas chromatography	$\mu\text{g/g}$	0.084	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
129 PCB 1254 - Sediment	Gas chromatography	$\mu\text{g/g}$	0.56	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
PCB 1260 - Sediment	Gas chromatography	$\mu\text{g/g}$	0.17	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.

(1) No standard available for quantitation. The Mass Spectrum obtained was compared to a Mass spectral data base for identification.

(2) U.S. EPA 1984 40 CFR Part 136. Guidelines Establishing Test Procedure for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule.

(3) U.S. EPA. Environmental Monitoring and Support Laboratory. Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. 1980 Oct. Cincinnati, OH.

* Dry weight

TABLE B-5

SUMMARY OF RATED ACCURACY OF FIELD METERS AND UNIT OF MEASURE FOR EACH PARAMETER

PARAMETER	UNIT OF MEASURE	RATED ACCURACY	METER
Temperature	Degrees Centigrade	$\pm 0.6^{\circ}\text{C}$	YSI Model 57 Dissolved Oxygen Meter
	Degrees Centigrade	$\pm 0.6^{\circ}\text{C}$	YSI Model 33 SCT
	Degrees Centigrade	$\pm 0.1^{\circ}\text{C}$	Hydrolab Surveyor II
Dissolved Oxygen	mg/l	$\pm 3\%$ of D.O. reading over entire temperature range of probe (-5 to $+45^{\circ}\text{C}$)	YSI Model 57 D.O. Meter
	mg/l	± 0.2 with temperature and salinity compen- sation	Hydrolab Surveyor II
Specific Conductivity	$\mu\text{mhos/cm}$	$\pm 2.5\% - \pm 3.0\%$	YSI Model 33 SCT
	$\mu\text{mhos/cm}$	range from ± 0.015 to ± 1.5 with 25°C temperature compensation	Hydrolab Surveyor II
Salinity	parts per thousand ($^{\circ}/\text{‰}$)	± 0.7	Hydrolab Surveyor II
	parts per thousand ($^{\circ}/\text{‰}$)	$\pm 0.7 - \pm 0.9$	YSI Model 33 SCT
Depth	meters	± 1	Hydrolab Surveyor II

