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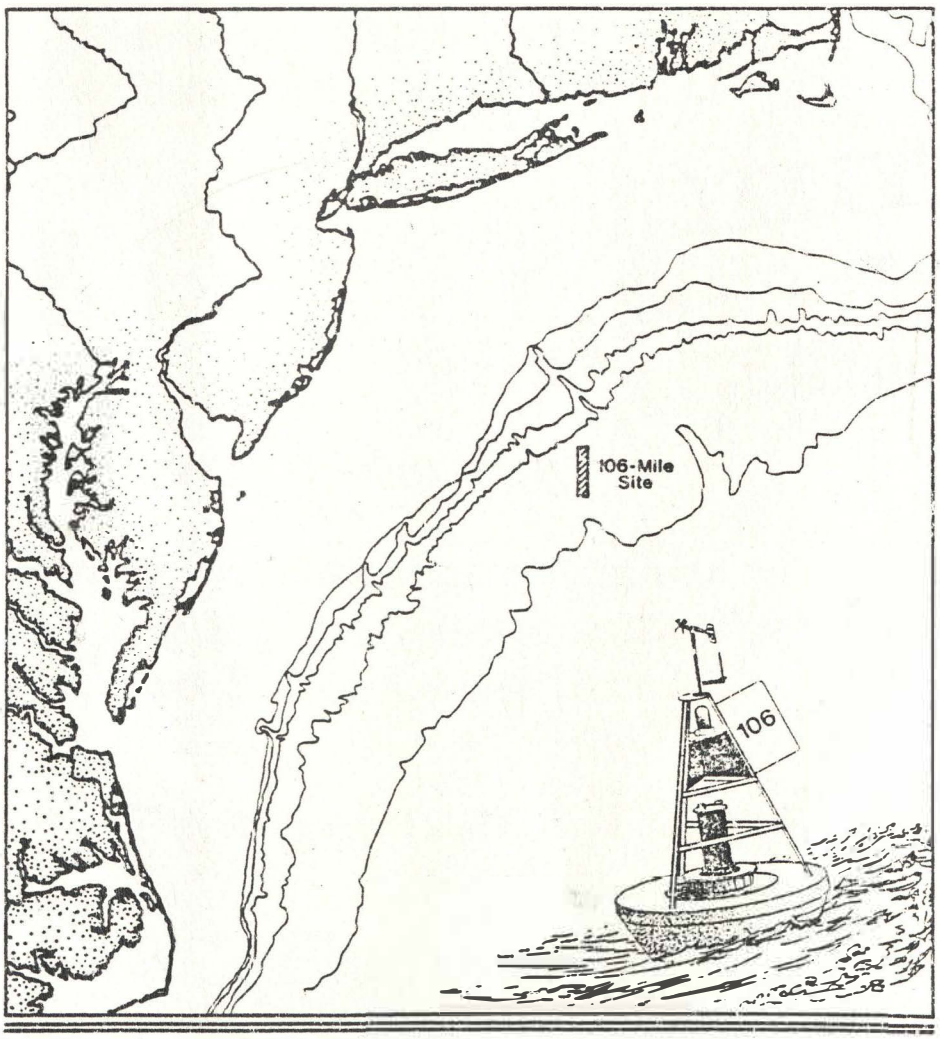
Monitoring, Research, And Surveillance Plan For The 106-Mile Deepwater Municipal Sludge Dump Site And Environs



FINAL

Monitoring, Research, and Surveillance Plan for the 106-Mile Deepwater Municipal Sludge Dump Site and Environs

Developed Jointly by

Environmental Protection Agency
National Oceanic and Atmospheric Administration
The United States Coast Guard

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NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

200 Years of Service

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EXECUTIVE SUMMARY

In 1972, the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA, Pub.L. 92-532) was passed to regulate the disposal of wastes in the ocean. As amended, MPRSA is the primary legislative authority directly related to ocean dumping. In 1988, Congress passed the Ocean Dumping Ban Act of 1988 (ODBA) to end the practice of ocean dumping of sewage sludge and industrial waste by December 31, 1991. OBDA also required that the Environmental Protection Agency (EPA), in cooperation with the National Oceanic and Atmospheric Administration (NOAA) and the United States Coast Guard (USCG), design a monitoring program for the 106-Mile Site and the environs that may be impacted by the dumping of sewage sludge. In addition to requiring increased monitoring of the area, the joint Monitoring Plan required by ODBA was to include (1) sampling of an appropriate number of fish and shellfish species and other organisms to assess the effects of environmental conditions on living marine organisms in the areas of interest and (2) use of satellite and other advanced technologies in conducting the program.

In responding to the ODBA requirements, EPA, NOAA, and the USCG convened a workshop in Ocean City, New Jersey, March 28 - 30, 1989, to address concerns about the potential impact on fisheries and about the human health risks of disposing sewage sludge at the 106-Mile Site, to assist in the process of identifying critical monitoring, research, and surveillance needs relative to the 106-Mile Site, and to develop recommendations for future research, monitoring, and surveillance activities at the 106-Mile Site.

Building on the previous EPA Monitoring Plan for the 106-Mile Site plus input from the 106-Mile Site Workshop, EPA/NOAA/USCG prepared the ODBA-required Monitoring Plan. This document summarizes the activities, hypotheses, and implementation schedule that the agencies have developed.

A key feature of the plan is the retention of the tiered monitoring approach of the previous EPA Monitoring Plan for the 106-Mile Site. In addition, many of the activities being conducted under the EPA Monitoring Plan have been retained. However, an expanded program to determine the transport and fate of sludge is presented. This expanded program will use state-of-the-art physical oceanographic techniques such as satellite-tracked surface drifters, satellite imagery of sea-surface temperature, expendable current profilers, and an extensive sediment-trap program to evaluate the movement of sludge away from the dump site. Also, a series of studies has been conceived to determine if sludge can be detected in sediments located both near the site and at potential depositional areas away from the site. Several studies of the potential effects of sludge disposal at the 106-Mile Site are also planned. These will include measurement of sludge-related contaminants in benthic organisms, assessment of shellfish populations for the prevalence of shell disease, and evaluation of midwater fish species for contaminants, plus other more specific studies.

Many of the activities to be conducted under this plan will be funded by fees and penalties generated under ODBA. However, EPA and the NOAA National Underseas Research Program (NURP) are supplying additional funds to support many of the planned activities.

Section 1 of this plan summarizes the history of disposal at the 106-Mile Site, establishes the regulatory basis for monitoring the site, reviews the hypotheses and monitoring activities proposed under the EPA Monitoring Plan that preceded this plan, and discusses activities occurring since the passage of ODBA that have resulted in the this joint EPA/NOAA/ USCG Monitoring, Research, and Surveillance Plan for the 106-Mile Site and Environs. Results of monitoring under the original EPA plan are summarized in Section 2 to provide a perspective on the activities that will be conducted as part of the joint Monitoring Plan (discussed in Section 3). Schedules for planned activities, communication and reports, and planned data usage are given in Section 4.

Prior to finalizing the plan, a Federal Blue Ribbon Panel was convened by EPA/NOAA/ USCG to receive comments from a peer review of the draft plan. The comments received by the panel have been incorporated in to this final plan.

ACKNOWLEDGMENTS

This joint Monitoring Plan was prepared under the guidance of a working group composed of scientists from the Environmental Protection Agency, National Oceanic and Atmospheric Administration, and United States Coast Guard. Working group participants included

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LIST OF ACRONYMS AND ABBREVIATIONS

AVHRR	advanced very high resolution radiometer
CPUE	catch per unit effort
CTD	conductivity/temperature/depth
DDT	dichloro-diphenyl-trichloroethane
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FY90	fiscal year 1990
FY91	fiscal year 1991
LC_{50}	lethal concentration for 50 percent of test organisms
LFM	limited-area, fine-mesh
LPC	limiting permissible concentration
MARMAP	Marine Resources Monitoring, Assessment, and Prediction [program]
MASAR	Middle Atlantic Slope and Rise [program]
MPRSA	Marine Protection, Research, and Sanctuaries Act of 1972
MOU	memorandum of understanding
NESDIS	National Environmental Satellite, Data, and Information Service
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODC	National Ocean Data Center
NOS	National Ocean Service
NRC	National Research Council of Canada
NS&T	National Status and Trends
NURP	National Undersea Research Program
NWS	National Weather Service
ODBA	Ocean Dumping Ban Act of 1988
ODES	Ocean Data Evaluation System
ODNF	Ocean Dumping Notification Form
ODSS	Ocean Dumping Surveillance System
PAH	polynuclear aromatic hydrocarbon
PC	personal computer
PCB	polychlorinated biphenyl
SEEP	Shelf Edge Exchange Processes [program]
SST	sea-surface temperature
USCG	United States Coast Guard
UV	ultraviolet
WQC	water quality criteria
XBT	expendable bathythermograph
XCP	expendable current profiler

1.0 INTRODUCTION

The only ocean disposal site in the United States designated for dumping of sewage sludge is the 106-Mile Deepwater Municipal Sludge Dump Site (106-Mile Site). In 1984, the Environmental Protection Agency (EPA) designated the 106-Mile Site to receive municipal sewage sludge. The site designation expires in March 1991. Currently, sludge from the New York/New Jersey Metropolitan area is dumped at the site. Disposal operations were transferred from the 12-Mile Site, located in the New York Bight, beginning in 1986. By late 1987, all authorities permitted to conduct ocean disposal of sewage sludge were using the 106-Mile Site.

During 1986 and 1987, EPA developed a draft Monitoring Plan for the 106-Mile Site (Battelle 1988a,b). This joint Monitoring Plan was designed to develop information on potential adverse effects of sludge on marine life and human health and to gain information regarding continued site management and permitting. Under this plan, EPA conducted baseline studies plus several surveys designed to evaluate nearfield fate and short-term effects.

In November 1988, Congress passed the Ocean Dumping Ban Act of 1988 (ODBA) that ends ocean dumping of sewage sludge and industrial waste by 1991, or as soon after as possible. One of the requirements of ODBA is that EPA, the National Oceanic and Atmospheric Administration (NOAA), and the United States Coast Guard (USCG) design a monitoring program for the 12-Mile Site, the 106-Mile Site, the industrial-waste sites, and other areas that might be impacted by dumping. The required monitoring program is to include (1) sampling an appropriate number of fish and shellfish species and other organisms to assess the effects of environmental conditions on living marine organisms in these areas and (2) use of satellite and other advanced technologies in conducting the program. ODBA also requires the payment of fees and penalties by those holding permits to dispose of sludge at the 106-Mile Site. A portion of these fees goes to EPA and NOAA to conduct monitoring and research, and to the USCG to conduct surveillance operations.

This document responds to the ODBA requirement for increased monitoring by presenting a joint EPA, NOAA, and USCG Monitoring, Research, and Surveillance Plan for the 106-Mile Site (joint Monitoring Plan). Activities to be conducted under this plan will be funded in part by fees and penalties generated under ODBA. However, the EPA and NOAA

National Underseas Research Program (NURP) are supplying additional funds to support many of the activities proposed in this plan.

The plan is presented in four sections. Section 1 develops the history of disposal at the 106-Mile Site, establishes the regulatory basis for monitoring the site, reviews the previous EPA Monitoring Plan, and discusses activities since the passage of ODBA that have resulted in the joint Monitoring Plan for the 106-Mile Site. A summary of results gathered under the EPA 106-Mile Site Monitoring Plan is presented in Section 2 to provide a perspective on the activities that will be conducted as part of the joint Monitoring Plan, discussed in Section 3. Schedules for planned activities, communication, reports, and planned data usage are presented in Section 4.

1.1 HISTORY OF WASTE DISPOSAL AT THE 106-MILE SITE

Designation of the 106-Mile Site resulted from the EPA decision to end municipal sludge disposal at the 12-Mile Site, located within the apex of the New York Bight. The 12-Mile Site had been used for disposal of municipal sludges since 1924. From 1981 until the 106-Mile Site was designated in 1984, sludge was dumped at the 12-Mile Site under a court order resulting from *City of New York v. EPA*, 543 Supp. 1084 (S.D.N.Y. 1981).

When the 106-Mile Site was designated, the sewerage authorities involved negotiated a court-ordered schedule to shift operations offshore. Phasing out the use of the 12-Mile Site and phasing in the use of the 106-Mile Site took place during 1986-1987. The nine sewerage authorities that use the site are

- Westchester County Department of Environmental Facilities, New York
- Bergen County Utilities Authority, New Jersey
- Joint Meeting of Essex and Union County, New Jersey
- Linden Roselle Sewerage Authority, New Jersey
- Rahway Valley Sewerage Authority, New Jersey
- Middlesex County Utilities Authority, New Jersey
- Passaic Valley Sewerage Authority, New Jersey
- Nassau County Department of Public Works, New York
- New York City Department of Environmental Protection, New York

Although the 106-Mile Site was not designated until 1984, it had been used for past disposal. Originally, it was part of a larger disposal site. Approximately 500 nmi^2 ($\approx$1715 km^2) in area, that site had been used since 1961 for disposal of chemical wastes and other materials. The original large site came under EPA regulation in 1978, and in 1982 EPA published its

intention of formal designation. However, concern that mixed dumping of municipal sludges and industrial wastes would complicate monitoring efforts led to a decision to designate two smaller sites within the larger one. The resulting 106-Mile Site is approximately 100 nmi^2 (≈343 km^2), with boundaries at 38°40′00″ to 39°00′00″ north latitude and 72°00′00″ to 72°05′00″ west longitude. Its location is approximately 120 nmi southeast of Ambrose Light, New York, and 115 nmi (≈213 km) from Atlantic City, New Jersey (Figure 1-1).

The Deepwater Industrial Waste Site was also designated within the original larger site in 1984. The Deepwater Industrial Waste Site is circular, with a radius of 3 nmi and a center at 38°40′00″ north latitude and 72°20′00″ west longitude. The area of the site is approximately 28 nmi^2. It is located 120 nmi southeast from Ambrose Light and 105 nmi from Atlantic City, New Jersey. Although the site was used during the late 1970s and early 1980s, no dumping now occurs at the Deepwater Industrial Waste Site. Any effects of waste disposal at the site are thought to have been transient and short-lived, because concentrations of wastes disposed at the site were reduced to very low levels within 2 h after dumping, and waste plumes were small (O'Connor and Park, 1982).

Sludge disposal at the 106-Mile Site now proceeds according to permits issued in 1989. An estimated 8 to 9 million wet tons of sewage sludge is dumped at the site annually. Although the general characteristics of the sludge will vary from plant to plant, the material being dumped at the site is primarily biological sludge. Biological sludge may contain small amounts of debris, such as grit, paper, and fibers. The sludges disposed at the site are somewhat buoyant, comprising 2 to 4 percent solid material. The sludge contains trace levels of organic contaminants, such as aldrin, dieldrin, chlordane, heptachlor epoxide, DDT and its degradation products, and polychlorinated biphenyls (PCB). Metals, including cadmium, copper, chromium, and mercury, are also present at trace levels. The sludges are not permitted to contain any floatable materials. EPA is requiring the permittees to sample quarterly for floatables.

1.2 THE REGULATORY BASIS FOR MONITORING

The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 presents the U.S. policy to regulate the dumping of all types of materials into ocean waters and to prevent

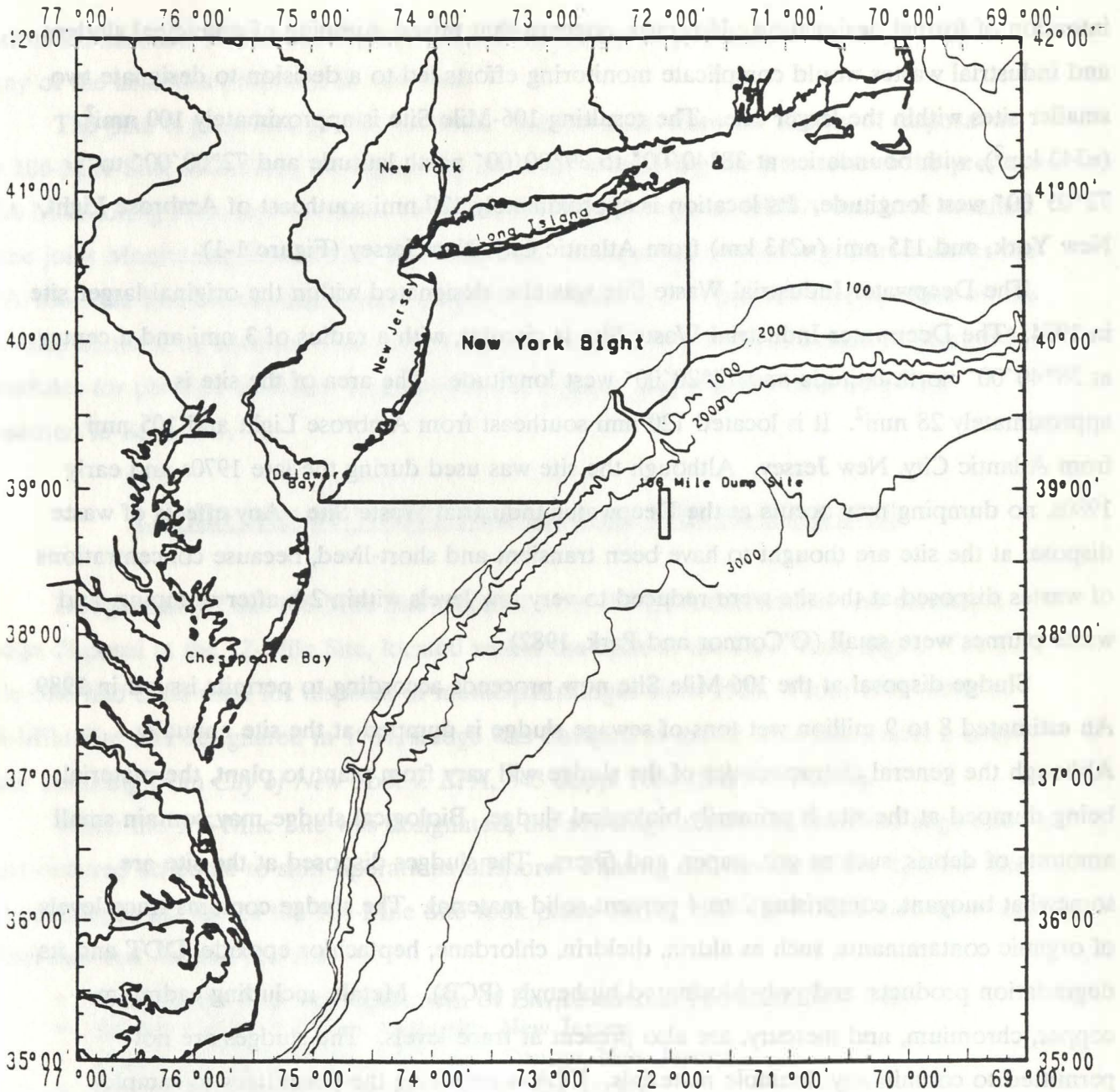


FIGURE 1-1. LOCATION OF THE 106-MILE DEEPWATER MUNICIPAL SLUDGE DUMP SITE

or strictly limit the dumping of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. Acting under the MPRSA, EPA has published regulations and criteria for ocean dumping. The most recent revisions to these regulations were published in 1977 (40 CFR Parts 220-229).

Under the MPRSA, EPA is responsible for (1) site designation—conducting disposal site evaluation and designation studies and recommending modifications in site use or designation; (2) permits—regulating times, rates, and methods of disposal and quantities and types of materials that can be disposed; and (3) monitoring—developing and maintaining effective monitoring programs. These three functions are interrelated and are intended to prevent unreasonable degradation of the environment. The MPRSA also directs NOAA to conduct monitoring and long-range research on the effects of ocean dumping. The MPRSA assigns the USCG responsibility for surveillance of ocean dumping activities in conjunction with EPA.

1.3 PREVIOUS MONITORING OF THE 106-MILE SITE: DEVELOPMENT AND IMPLEMENTATION OF EPA'S MONITORING PLAN

Acting under the MPRSA and the ocean dumping regulations, EPA developed and initiated implementation of a Monitoring Plan [most recently updated in March 1988 (Battelle, 1988a,b)] to determine whether (1) conditions of permits to dump sludge were met and (2) sludge dumping at the site adversely affected the environment or human health. Although permit conditions are set to protect the environment, EPA's monitoring efforts have assessed not only whether those conditions are being met, but also whether the conditions are sufficiently protective.

EPA's Monitoring Plan considered characteristics of the site and the sludge to predict possible impacts of sludge disposal and to formulate the null hypotheses that these predictions suggest. The following impact categories itemized in the ocean dumping regulations were used to develop predictions of possible impacts:

- Impingement of sludge onto shorelines
- Movement of sludge into marine sanctuaries or shellfishery or fishery areas
- Effects of sludge on commercial fisheries
- Accumulation of sludge constituents in biota
- Progressive changes in water quality related to sludge disposal

- Progressive changes in sediment composition related to sludge disposal
- Impacts on pollution-sensitive species or life-cycle stages as a result of sludge disposal
- Impacts on endangered species as a result of sludge disposal
- Progressive changes in pelagic, demersal, or benthic biological communities as a result of sludge disposal

The predictions developed for each of these impact categories are summarized in Figure 1-2. These predictions served as the conceptual foundation for formulating testable null hypotheses. The hypotheses addressed assessment of permit compliance as well as assessment of potential impacts.

EPA's Monitoring Plan presented an overview of the implementation of the monitoring program, including a description of how questions about the impacts of monitoring were organized into a framework of tiers. The tiered approach organized the null hypotheses into a hierarchy, whereby data collected in each tier were used as the foundation for the design and extent of monitoring activities in the next tier. Such an approach ensured that only information needed for making decisions would be collected (Zeller and Wastler, 1986).

The four tiers included in the 106-Mile Site monitoring program were as follows:

- Tier 1: Sludge Characteristics and Disposal Operations
- Tier 2: Nearfield Fate and Short-Term Effects
- Tier 3: Farfield Fate
- Tier 4: Long-Term Effects

Activities planned under these tiers assessed permit compliance and impacts (Figure 1-3).

1.4 DEVELOPMENT OF A NEW STRATEGY FOR MONITORING, RESEARCH, AND SURVEILLANCE

In 1988, the Congress passed the Ocean Dumping Ban Act (ODBA), legislation that amended the MPRSA and was aimed at ending ocean dumping of municipal sludges and industrial wastes by December 31, 1991. One requirement of ODBA was to develop a monitoring program for the 106-Mile Site and the region that could be affected by sludge disposal at the site.

In response to the ODBA requirements, EPA, NOAA, and the USCG held a workshop in March 1989 to solicit recommendations for monitoring, research, and surveillance of the 106-Mile Site. Discussions at the workshop focused on four questions:

Impingement of sludge onto shorelines.

P-1: Sewage sludges dumped at the 106-Mile Site will probably not impact any shorelines in detectable quantities.

Movement of sludge into marine sanctuaries or shellfishery or fishery areas.

P-2: Marine sanctuaries and shellfishery areas will probably not be impacted by shoreward movements of sludge.

P-3: Sewage sludge may be transported to the continental slope and shelf where fisheries activities exist.

Effects of sludge on commercial fisheries.

P-4: The impact of sludge dumping on commercial fisheries, expressed as direct decrease in fish stocks or decrease in eggs or larvae, will probably not be detected, and the use of any area for fishing will not be reduced.

Accumulation of sludge constituents in biota.

P-5: Bioaccumulation of low levels of contaminants associated with sewage sludge from the 106-Mile site will occur, from time to time, at the site or directly adjacent to the site, by migrating fishes or invertebrates, but may be difficult to distinguish from other potential sources.

P-6: Bioaccumulation of low levels of contaminants by resident continental shelf/slope fishes or invertebrates may occur, depending on direction and extent of transport of sludge to these areas, but may be difficult to distinguish from bioaccumulation from other potential sources.

Progressive changes in water quality.

P-7: Sewage sludge movement and transport beyond the site boundaries may result in significant impact on the water quality beyond the site.

P-8: Sludge constituents may be found in significant quantities within the site at all times and may persist beyond four hours after disposal. Chronic effects on marine biota are possible.

P-9: Though certain sludge constituents may be detectable well outside the site, these levels are not expected to have significant effect on marine biota.

Progressive changes in sediment composition.

P-10: Sludge particles may settle outside the disposal site boundaries. However, this settling will occur over a very large and as yet undefined area. The resultant changes in sediment composition, the destruction of habitat, and/or the accumulation of sludge constituents in surficial sediments will probably be nil to minimal.

Impacts on pollution-sensitive species.

P-11: The disposal of sewage sludge probably will not cause long-term impacts on pollution-sensitive species or life-cycle stages in the water column or the sediments of the 106-Mile Site region. Effects may be detectable, but local and short-lived.

P-12: The sea-surface microlayer in the disposal site and in an undefined area adjacent to the site and the sensitive life stages of marine biota within may be affected by the surface-active components and nonpolar pollutant compounds present in sludges.

Impacts on endangered species.

P-13: Endangered species of mammals or reptiles will probably not be impacted by sewage sludge disposal at the 106-Mile Site.

Progressive changes in biological communities.

P-14: Due to nutrient enrichment in the upper water column, there may be a localized increase in primary productivity related to individual sewage plumes.

P-15: There will probably be no long-term or large-scale impact on the plankton community as a result of sludge disposal at the 106-Mile Site.

P-16: Due to the expected absence of sewage sludge particles in the demersal or benthic environment, no effects on the benthic or demersal community structures are likely.

FIGURE 1-2. PREDICTIONS INCLUDED IN THE 1988 EPA MONITORING PLAN (Battelle, 1988a)

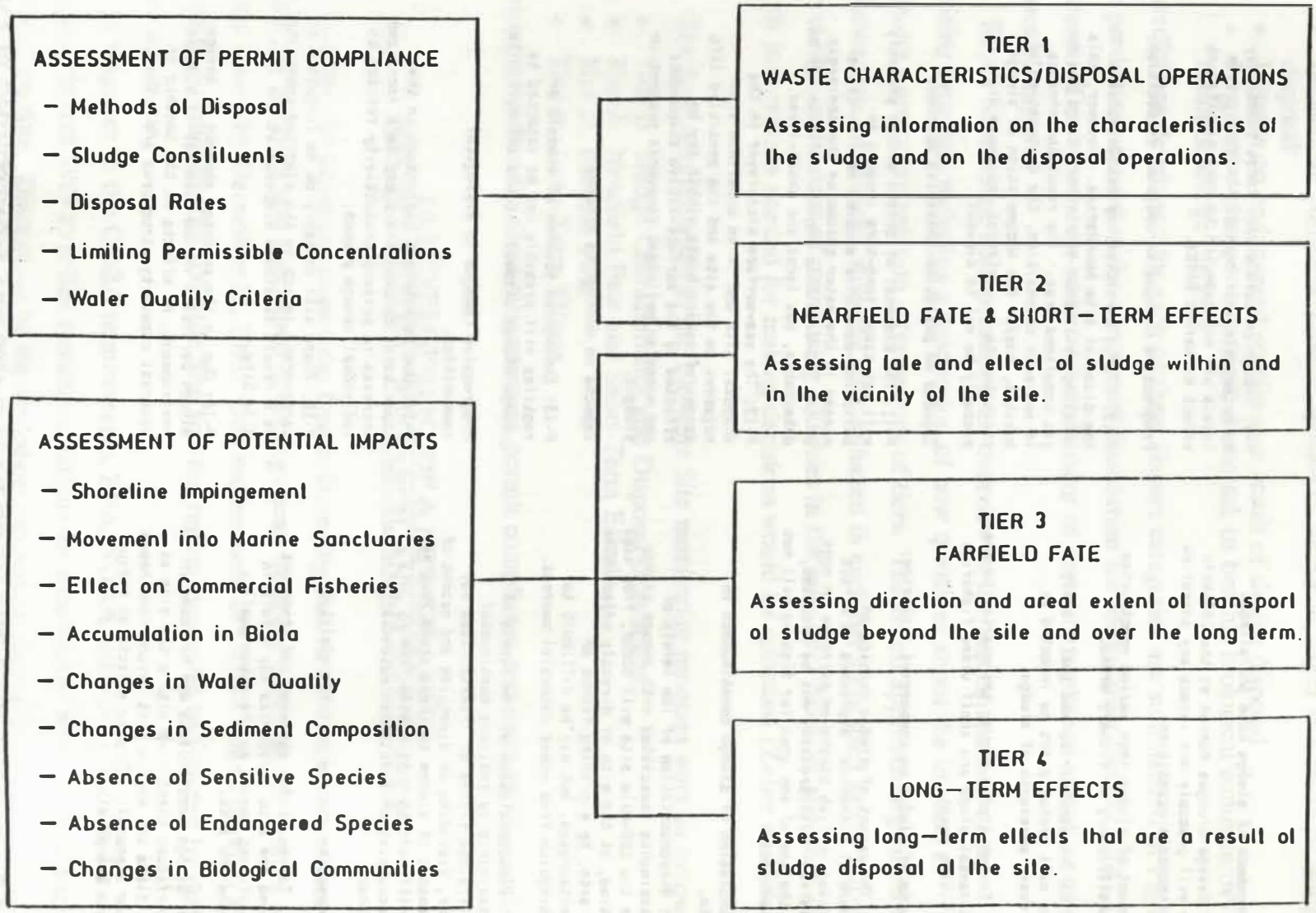


FIGURE 1-3. MONITORING TIERS ADDRESS PERMIT COMPLIANCE AND IMPACT ASSESSMENT

(1) What is the physical and chemical fate of the sewage sludge dumped at the 106-Mile Site?

(2) What is the effect of sludge dumping at the 106-Mile Site on living marine resources?

(3) What is the effect of sludge dumping at the 106-Mile Site on human health?

(4) Are there changes in site designation, permits, or surveillance that can provide better protection of the environment, living marine resources, or human health?

During the workshop, participants assessed available information concerning the 106-Mile Site and the dumping activities. Because EPA's monitoring program already focused on the issues described in ODBA, EPA's Monitoring Plan provided the focus for many of the discussions. Participants examined the potential effects on marine life and the risks to human health associated with sludge dumping at the site. They discussed whether changes in the existing monitoring, research, and surveillance efforts were needed, and they provided recommendations for refining EPA's Monitoring Plan. The workshop also identified research needs. The proceedings of the workshop are detailed in EPA (1989).

NOAA, EPA, and USCG used the recommendations and findings from the workshop to develop a joint strategy (attached as Appendix A) for monitoring, research, and surveillance (EPA, NOAA, and USCG, 1989). The agencies considered priorities and available resources as well as recommendations from the workshop in developing the strategy.

Implementation of the strategy is being accomplished through close cooperation among NOAA, EPA, and USCG. A Memorandum of Understanding (MOU) defines the roles of each agency (attached as Appendix B), and an interagency agreement administers the MOU. Interagency coordination will include conducting joint ocean surveys, planning, and data interpretation. The joint monitoring, research, and surveillance plan described in Section 3 is based on the strategy developed by the agencies. The joint Monitoring Plan supersedes all previous plans, including EPA's Monitoring Plan. However, because many of the monitoring needs for the 106-Mile Site have already been provided by EPA's monitoring program, Section 2 of this plan describes those results.

2.0 PAST MONITORING OF THE 106-MILE SITE: RESULTS FROM EPA'S MONITORING PLAN

Several programs conducted in the vicinity of the 106-Mile Site have already provided information to meet the requirement of ODBA to monitor the effects of dumping at the site. EPA's 106-Mile Site monitoring program, already in place when ODBA was passed, provided much of the necessary information. Therefore, the results from that program are summarized in this section.

Other relevant monitoring and research programs include NOAA's Northeast Monitoring Program and Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP) and EPA's baseline evaluation of a potential ocean incineration site that would have been contiguous to the southern border of the site. Results from these programs were used in EPA's monitoring program and are included in this section's discussion of baseline studies. Complete reviews of these and other programs have been prepared by Battelle (1986, 1988c, 1989a).

EPA's plan is now superseded by the joint EPA/NOAA/USCG monitoring, research, and surveillance plan that is presented in Section 3. The remainder of Section 2 presents the framework of EPA's plan and results that have been obtained from baseline studies and monitoring.

2.1 BACKGROUND INFORMATION AND BASELINE STUDIES

A wealth of information on chemical and physical characteristics and baseline biological conditions at the 106-Mile Site is available from studies performed during the past decade. This information was used to develop the framework of EPA's 106-Mile Site Monitoring Plan (Battelle, 1988a). It will also be used as the baseline information against which monitoring results are being compared.

Information available on the physiography, physical oceanography, and baseline chemical and biological characteristics of the 106-Mile Site and surrounding regions was summarized in EPA's Monitoring Plan. An extensive review is also found in NOAA (1983), which updated information summarized in the Environmental Impact Statement (EIS) prepared as part of the process to designate the site.

2.1.1 Dissolved Oxygen

Atmospheric gases such as oxygen dissolve in seawater. At a given temperature and salinity and in the absence of biological activity, the concentration of dissolved gases in seawater in contact with the atmosphere will reach an equilibrium value. This value is known as the saturation value. Because the amount of oxygen that can dissolve in seawater varies inversely with temperature, the saturation value of oxygen for warmer surface waters is lower than for colder water. Thus, during the winter months, oxygen concentrations are expected to be higher than during the summer months. Saturation values for oxygen in seawater with salinity near 32 °/oo are 7.3, 6.4, 5.9, and 5.1 mL/L for temperatures of 4°, 10°, 15°, and 20°C.

In addition to the dependence on temperature, oxygen concentration in seawater is affected by biological processes that can either produce or consume oxygen. The former may increase the oxygen concentration; the later will decrease the oxygen concentration, especially in water that is isolated from atmospheric exchange processes. Thus, biological processes may cause the oxygen content of the seawater in the open ocean to be above or below the saturation value expected from equilibration with the atmosphere. Generally, these processes result in a gradual lowering of dissolved-oxygen concentrations with depth within the upper 500 m of water.

At the 106-Mile Site, the average monthly dissolved-oxygen levels in the surface water range from 4.9 mL/L in August to 7.5 mL/L in April (Warsh, 1975). These values reflect typical saturation values for surface waters. Similar dissolved-oxygen concentrations were observed in surface waters during 1986 and 1988 surveys of the site (Battelle, 1988d, 1989b). The oxygen-minimum zone is located between 200 and 300 m, with oxygen values ranging from 3.0 mL/L in February to 3.5 mL/L in September. These values reflect oxygen consumption typically occurring at these depths in the ocean. An oxygen-maximum zone develops over several months, ranging from 7.0 mL/L at 30 m during August to 8.2 mL/L at 10 m during February.

2.1.2 Trace Metals

Results of studies of trace elements in the water column at the 106-Mile Site (Hausknecht, 1977; EPA, 1980; Battelle, 1987a) indicated that levels of mercury and zinc were comparable to those found in the open ocean and on the continental shelf. Background concentrations of cadmium, copper, and lead in the water column at the site were considered comparable to other oceanic regions (Battelle 1988c-e, 1989b).

Concentrations of trace metals in the sediments in the vicinity of the site vary considerably, depending on local topography, depth, and sediment grain size. Baseline sediment samples collected by NOAA in the vicinity of the site contained higher levels of trace elements than sediments on the adjacent continental shelf (Pearce et al., 1975). These concentrations may be higher than values found in other studies because of the proximity of sampling stations to the Hudson Canyon. NOAA (1977) analyzed five trace elements at the site, EPA analyzed eight trace elements at the site (Battelle, 1987a), and Bothner et al. (1987a,b) analyzed 12 trace elements southwest and northeast of the site. The metal concentrations in the surface sediments from these baseline studies were found comparable and are characteristic of uncontaminated natural sediments of similar mineral composition.

2.1.3 Organic Compounds

Concentrations of polynuclear aromatic hydrocarbons (PAH), pesticides, and polychlorinated biphenyls (PCB) in sediments collected in the vicinity of the site are low (low parts per billion) and appear comparable to those found in sediments from remote continental slope areas. In addition, baseline hydrocarbon levels in sediments at the site were lower than those found at other dumpsites in shallower waters (Greig and Wenzloff, 1977).

2.1.4 Benthic Organisms

Benthic invertebrate samples collected and analyzed by Pearce et al. (1975, 1977) showed no significant differences in numbers of individuals, numbers and types of species present, or diversity between stations at similar depths inside and outside the site. More recently, Battelle found infaunal densities and species compositions at the site similar to slope

areas of similar depths north and south of the site (Maciolek, 1987). The latter studies recorded densities of 3567 to 5361 individuals per square meter at depths of 2000 to 2500 m.

2.1.5 Plankton and Pelagic Organisms

Although there is considerable information about the plankton and pelagic organisms that inhabit the continental slope and shelf waters directly inshore from the site, little information is available on the flora and fauna that inhabit the immediate vicinity of the 106-Mile Site. Most of the information available indicates a patchy and highly variable community of plankton and higher organisms. The annual cycle of phytoplankton biomass in the area of the 106-Mile Site tends to be bimodal, with peaks occurring in March and November/December (NOAA, 1983). The spring bloom is dominated by netplankton (size greater than 20 μm) at depths of 60 to 2000 m. The fall bloom tends to be dominated equally by netplankton and nanoplankton (size less than 20 μm). During cooler months of the year, standing stocks of zooplankton in the site region are as high as at inshore areas (NOAA, 1983). However, peaks are reached earlier in the year at offshore regions than at inshore regions. Larval fishes collected at and surrounding the 106-Mile Site by MARMAP include 209 taxa representing 73 families (NOAA, 1983). Most of these are slope-water and oceanic species, along with some shelf species that are transported offshore via the Gulf Stream from the Mid-Atlantic Bight and south of Cape Hatteras.

Midwater finfishes found within the 106-Mile Site are mainly slope-water species and species transported to the area by Gulf Stream eddies. Many of these fishes, such as lantern and hatchet fishes (Families Myctophidae and Sternopychidae) migrate vertically in the area, from depths of several hundred meters in the daytime to 0 to 200 m at night (NOAA, 1977).

Two species of squid, long-finned *(Loligo pealei)* and short-finned *(Illex illecebrosus),* are found in the vicinity of the site. Thirty-one species of open-ocean predators have been observed and identified as they moved through the site, including sharks, swordfish, and tunas; however, these predators do not appear to be long-term residents of the site.

Cohen and Pawson (1977) observed 55 species of bottom fishes near the site. Most of these were rarely encountered and included the eel *Synaphobranchus kaupi,* the morid *Antimora rostrata,* the rattails *Nematonurus armatus* and *Lionurus carapinus,* the halosaur *Halosauropsis macrochir,* and the lizard fish *Bathysaurus ferox.* Tilefish, *Lopholatilus*

chamaeleonticeps, are fished commercially in continental shelf areas inshore of the site. Tilefish and the red crab, *Geryon quinquedens,* have been identified as relatively nonmobile and commercial species that may be suitable for bioaccumulation studies (Battelle, 1987b). Although the two species are not resident within the 106-Mile Site or in deep water south of the site, they are resident in shallow areas of the slope immediately north and west of the site and are suitable for study.

2.1.6 Endangered Species

The potential effect of dumping operations on the distributions of endangered species at the 106-Mile Site is of public concern. Endangered species that occur in the 106-Mile Site or within a broadly defined area that could be influenced by dumping include the right whale, *Eubalena glacialis,* humpback whale, *Megaptera novaenangliae,* sei whale, *Balaenoptera borealis,* fin whale, *Balaenoptera phasalus,* sperm whale, *Physeter macrocephalus,* loggerhead turtle, *Caretta caretta,* leatherback turtle, *Dermochelys coriacea,* and Kemp's ridley turtle, *Lepidochelys kempii* (NOAA, 1988). Sitings of endangered species during baseline monitoring are depicted in Figure 2-1.

2.2 TIER 1: WASTE CHARACTERISTICS AND DISPOSAL OPERATIONS

The objectives of Tier 1 were to assess sludge characteristics and disposal operations to determine whether the assumptions made in setting permit conditions continued to be true throughout the period that the 106-Mile Site was used. Monitoring and surveillance of sludge characteristics and disposal operations were necessary for assessing the characteristics of individual sludge plumes and total loading of sludge to the site.

2.2.1 Waste Characteristics

Sewage sludge disposed at the 106-Mile Site has varying physical, chemical, and microbial characteristics, because sewage treatment plants receive wastes from a variety of sources. Sludges from each plant may also vary significantly over time. Permit conditions

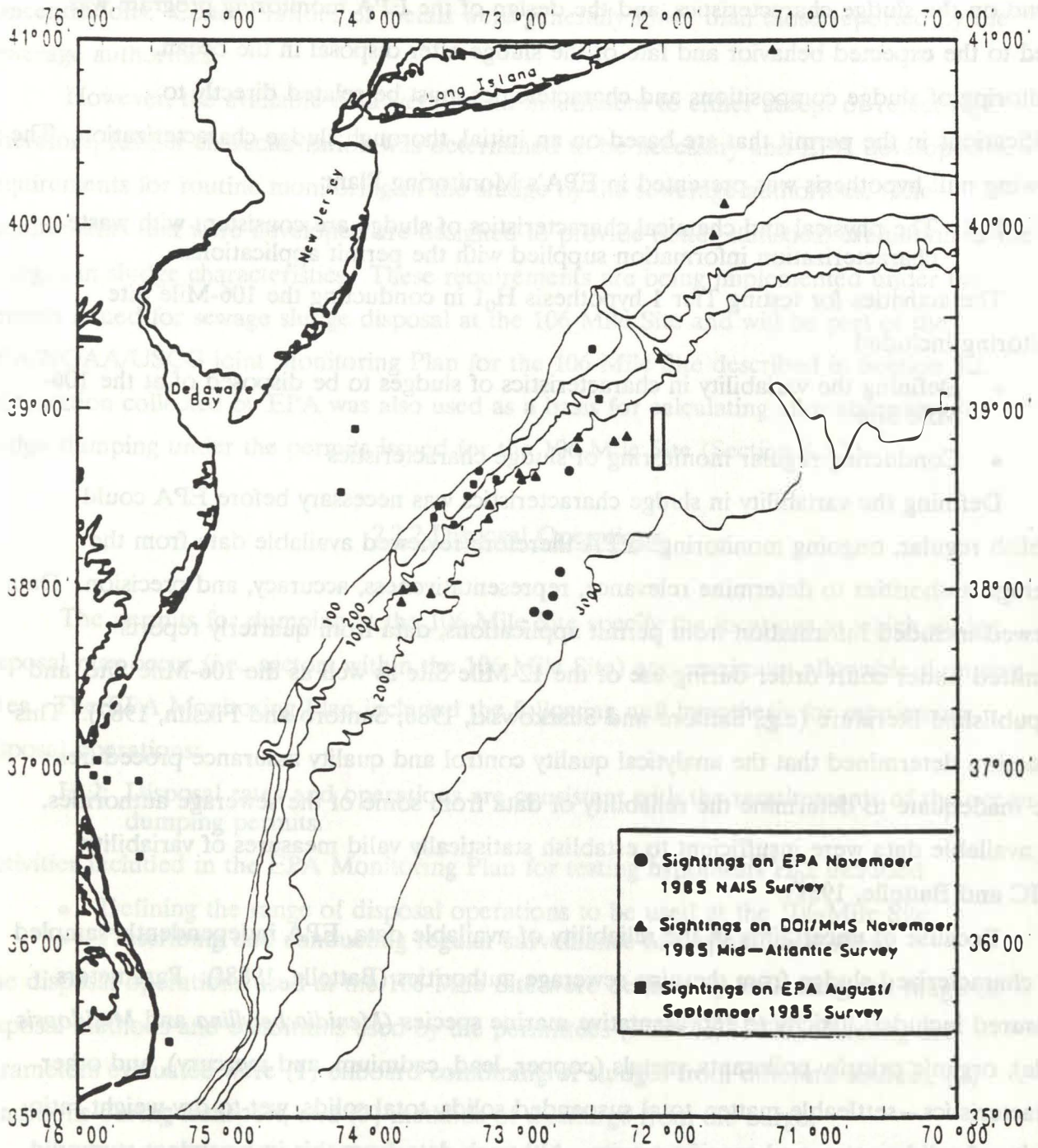


FIGURE 2-1. SIGHTINGS OF ENDANGERED SPECIES DURING BASELINE MONITORING

depend on the sludge characteristics, and the design of the EPA monitoring program was linked to the expected behavior and fate of the sludge after disposal in the ocean. Monitoring of sludge compositions and characteristics must be related directly to specifications in the permit that are based on an initial, thorough sludge characterization. The following null hypothesis was presented in EPA's Monitoring Plan:

> $H_0$1: The physical and chemical characteristics of sludge are consistent with waste characterization information supplied with the permit applications.

The activities for testing Tier 1 hypothesis $H_0$1 in conducting the 106-Mile Site monitoring included

- Defining the variability in characteristics of sludges to be disposed of at the 106-Mile Site
- Conducting regular monitoring of sludge characteristics

Defining the variability in sludge characteristics was necessary before EPA could establish regular, ongoing monitoring. EPA therefore reviewed available data from the sewerage authorities to determine relevance, representativeness, accuracy, and precision. Data reviewed included information from permit applications, data from quarterly reports submitted under court order during use of the 12-Mile Site as well as the 106-Mile Site, and the published literature (e.g., Santoro and Suszkowski, 1986; Santoro and Fikslin, 1987). This evaluation determined that the analytical quality control and quality assurance procedures were inadequate to determine the reliability of data from some of the sewerage authorities. The available data were insufficient to establish statistically valid measures of variability (SAIC and Battelle, 1989).

Because of uncertainty in the reliability of available data, EPA independently sampled and characterized sludge from the nine sewerage authorities (Battelle, 1988f). Parameters measured included toxicity to representative marine species *(Menidia beryllina* and *Mysidopsis bahia),* organic priority pollutants, metals (copper, lead, cadmium, and mercury), and other characteristics—settleable matter, total suspended solids, total solids, wet-to-dry-weight ratio, density of solid matter, and specific gravity. Although data from this independent study did not provide a statistical representation of the characteristics of sludges through time, they were used to evaluate the representativeness and accuracy of data submitted by the sewerage authorities.

The data generated by the EPA study were generally comparable to those provided by the sewerage authorities (Battelle, 1988f). Organic compounds were found at notably low

concentrations. Concentrations of metals were generally lower than those reported by the sewerage authorities.

However, the available data were found insufficient to either accept or reject $H_0$1. Therefore, further characterization was determined to be necessary and EPA developed new requirements for routine monitoring of the sludge by the sewerage authorities. The requirements that were developed are designed to provide better statistical evaluation of the changes in sludge characteristics. These requirements are being implemented under the permits issued for sewage sludge disposal at the 106-Mile Site and will be part of the EPA/NOAA/USCG joint Monitoring Plan for the 106-Mile Site described in Section 3.2. Information collected by EPA was also used as a basis for calculating allowable rates for sludge dumping under the permits issued for the 106-Mile Site (Section 4.3.2).

2.2.2 Disposal Operations

The permits for dumping at the 106-Mile Site specify the locations at which sludge disposal may occur (i.e., sectors within the 106-Mile Site) and maximum allowable dumping rates. The EPA Monitoring Plan included the following null hypothesis for monitoring disposal operations:

> $H_0$2: Disposal rates and operations are consistent with the requirements of the ocean dumping permits.

Activities included in the EPA Monitoring Plan for testing hypothesis $H_0$2 included

- Defining the range of disposal operations to be used at the 106-Mile Site
- Prescribing and conducting regular surveillance of disposal operations

The disposal operations used at the 106-Mile Site were defined by evaluating the range of disposal methods and conditions used by the permittees (Battelle, 1989c). Among the parameters evaluated were (1) onboard combining of sludges from different sources, (2) conditions during transport, and (3) methods of discharge from the barge.

Under the EPA Monitoring Plan, ongoing surveillance of dumping operations was the responsibility of the USCG in cooperation with EPA. To conduct surveillance of disposal operations, the USCG developed the Ocean Dumping Surveillance System (ODSS), which electronically observes barge location and dumping rate. In addition, EPA instituted a sludge manifest system to control in-port transfers of sludge. This program also utilizes ship riders

to monitor the at-sea disposal operations. This continuing, regular surveillance program is described in Section 3.2.

Based on results from 106-Mile Site nearfield surveys (Battelle, 1988e, 1989b) EPA found that disposal rates were often too high to allow sludge concentrations to reach limiting permissible concentrations 4 h after disposal. These results were sufficient to determine that $H_0 2$ was false. Therefore, new dumping rates (Battelle, 1989d) were established based on the results of the nearfield studies and sludge characterization studies discussed under Section 2.2.1.

2.3 TIER 2: NEARFIELD FATE AND SHORT-TERM EFFECTS

The overall objective of Tier 2 monitoring was to assess the short-term behavior, transport, and impact of sludge within the 106-Mile Site and in the immediate area surrounding the site. Short-term biological effects were defined as those effects occurring within 1 day of sludge disposal.

2.3.1 Nearfield Fate

Measurements of nearfield fate of sludge disposed at the site have focused on issues related to compliance with permit conditions and possible effects from sludge disposal. EPA's Monitoring Plan presented the following hypotheses about nearfield fate.

Permit Compliance

- $H_0 3$: Concentrations of sludge and sludge constituents are below the permitted limiting permissible concentrations (LPC), including water quality criteria (WQC), outside the site at all times.
- $H_0 4$: Concentrations of sludge and sludge constituents are below the permitted LPC and WQC within the site 4 h after disposal.
- $H_0 5$: Pathogen levels do not exceed ambient levels 4 h after disposal.

$H_0$6: Sludge particles do not settle in significant quantities beneath the seasonal pycnocline (50 m) or to the 50-m depth at any time, within the site boundaries or in an area adjacent to the site.

$H_0$7: The concentration of sludge constituents within the site does not exceed the LPC or WQC 4 h after disposal and is not detectable in the site 1 day after disposal.

$H_0$8: The concentrations of sludge constituents at the site boundary or in the area adjacent to the site do not exceed the LPC or WQC at any time and is not detectable 1 day after disposal.

$H_0$9: The disposal of sludge does not cause a significant depletion in the dissolved oxygen content of the water nor a significant change in the pH of the seawater in the area.

Beginning in 1987, EPA tested these hypotheses by studying the short-term, nearfield fate of sludges disposed at the site. These activities included direct studies of sludge plumes under varied oceanographic and meteorological conditions. Specifically, Tier 2 activities included

- Measuring sludge constituents in the water column in and near the 106-Mile Site to determine fate of sludge constituents with respect to permit conditions and ambient conditions.
- Conducting sludge-plume observations to define dilution characteristics of the sludge and any seasonal patterns of sludge dispersion at the 106-Mile Site.
- Studying rapid settling of sludge particles from plumes.
- Measuring surface currents and water-column structure to allow estimation of sludge dispersion and transport.

Measuring various sludge constituents in the sludge plumes provided the only direct measurement of regulatory parameters in Tier 2. Because the physical characteristics of the 106-Mile Site are different in the summer from those in the winter, these measurements were made during both seasons. During the summer, a seasonal pycnocline is formed in the surface waters. The shallow depth of the summer pycnocline was hypothesized to be a barrier to sludge settling and was thought to limit dispersion of the sludge plumes. In the winter, the surface mixed layer extends down to the more diffuse main pycnocline at about 300 m. Thus, the volume of water available for mixing and dilution of sludge plumes was expected to be much greater in the winter than in the summer. Parameters measured in Tier 2 included chemicals that (1) occurred in municipal sludges, (2) were readily measurable in the receiving water, and (3) for which there are water quality criteria. Spores of the microbe *Clostridium perfringens,* a tracer of pathogens, were also enumerated.

Plume-tracking measurements provided direct measurements of the fate of sludge plumes, thereby guiding sampling efforts and also providing some information on transport, dispersion, and settling. Plume-tracking exercises included deployment of surface drogues directly into sludge plumes; marking of the surface expression of the plume with dyes; use of *in situ* transmissometry, acoustics, and/or ultraviolet/fluorescence; measurement of physical, chemical, and biological tracers; and monitoring the plume with visual observations from the survey vessel and an aircraft. These methods are described in Battelle (1987c, 1988e).

Because all sludge plumes cannot be directly monitored for all ocean disposal activities at the 106-Mile Site, the information gathered during the seasonal exercises has been used in conjunction with continuous measurements of surface currents and temperature at the site to estimate behavior and fate of sludge plumes. A mooring with current meters located at 25 and 100 m was deployed at the site in January 1989. Data from the surface current meter is transmitted via the ARGOS satellite data-collection system to the National Environmental Satellite, Data, and Information Service (NESDIS). Information from this mooring describes the speed and direction of surface currents within the site (Figure 2-2). The mooring will be deployed for at least 2 years, and may be used in Tier 3 as well as in Tier 2 studies (see Section 2.4).

Information on the structure of the water column has been obtained by deploying expendable bathythermograph (XBT) probes to determine the depth of the thermocline. The vertical structure of current shear at the site has also been evaluated using expendable current profilers (XCP). Together, results from the mooring, the XBTs, and the XCPs have provided information to estimate sludge plume movement throughout the year.

Results of Nearfield Fate Monitoring

Results from nearfield fate monitoring demonstrated that under the conditions originally set for sludge disposal [i.e., the original court-ordered dumping rate of 15,500 gal/min (≈58,660 L/min)] $H_0 3$ and $H_0 4$ were false. Concentrations of sludge constituents frequently did not meet the regulatory requirements for concentrations of sludge constituents within the site after 4 h and outside the site at all times. WQC for copper and lead have been exceeded both within the site 4 h after disposal and outside the site. Sludge

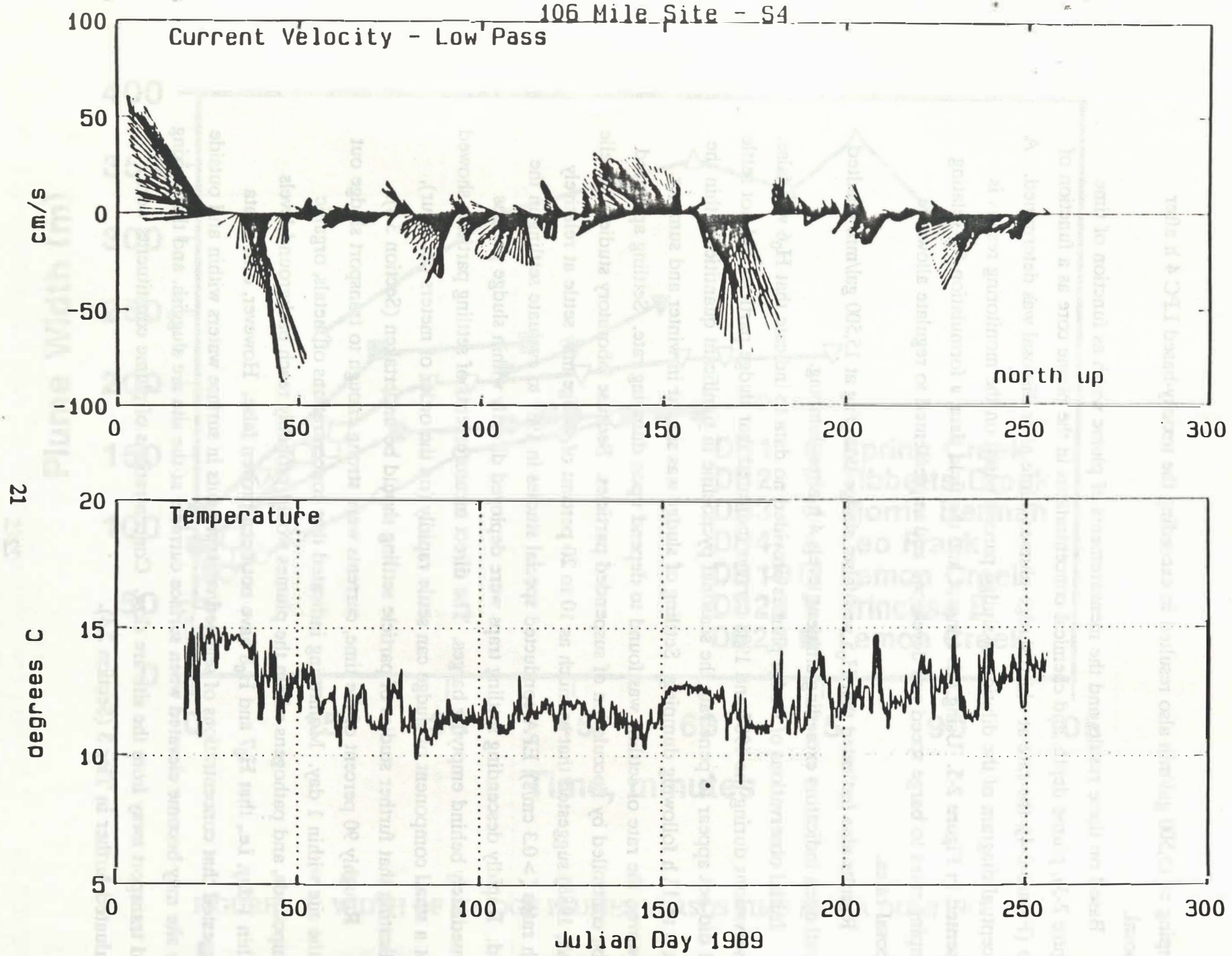


FIGURE 2-2 CURRENT METER RESULTS BETWEEN JANUARY 1989 AND SEPTEMBER 1989 FROM EPA REAL-TIME CURRENT METER MOORING AT THE 106-MILE SITE

dumping at 15,500 gal/min also resulted in exceeding the toxicity-based LPC 4 h after disposal.

Based on these results and the measurements of plume width as function of time (Figure 2-3), plume depth, and chemical concentrations in the plume core as a function of time (Figure 2-4), the rate at which sludge plumes dilute after disposal was determined. A conceptual diagram of the dilution of sludge parcels based on the monitoring results is presented in Figure 2-5. Using this concept and the field data, a formulation for relating dumping rates to barge speed was developed and implemented to regulate allowable disposal rates.

Results also indicated that $H_0 5$ was false: sludge dumping at 15,500 gal/min resulted in pathogen indicators exceeding ambient levels 4 h after dumping.

Initial observations of sludge plumes provided no data to indicate that $H_0 6$ was false. Observations during the 1987 and 1988 surveys indicated that sludge particles did not settle and did not appear to penetrate the seasonal pycnocline in significant quantities within the first 8 to 12 h following dumping. Settling of sludge was similar in winter and summer. However, the rate of settling was found to depend upon dumping rate. Settling appeared to be controlled by flocculation of suspended particles. Because laboratory studies (Lavelle et al., 1988) suggested that as much as 10 to 20 percent of sludge may settle at relatively high rates (>0.3 cm/s), EPA conducted special studies in 1989 to evaluate settling in the field. Rapidly descending settling traps were deployed directly within sludge plumes immediately behind emptying barges. The direct measurements of settling particles showed that a small component of sludge can settle rapidly (on the order of meters per hour), indicating that further studies of particle settling should be undertaken (Section 3.4).

Roughly 90 percent of the time, currents were strong enough to transport sludge out of the site within 1 day. Monitoring indicated that concentrations of metals, organic compounds, and pathogens within the plumes would probably reach background levels within 1 day, i.e., that $H_0 7$ and $H_0 8$ have not been proven false. However, other data suggested that concentrations of selected contaminants in surface waters within and outside the site may become elevated when surface currents at the site are sluggish, and that mixing and transport away from the site are slow. Concentrations of plume constituents were evaluated further in Tier 3 (Section 2.4).

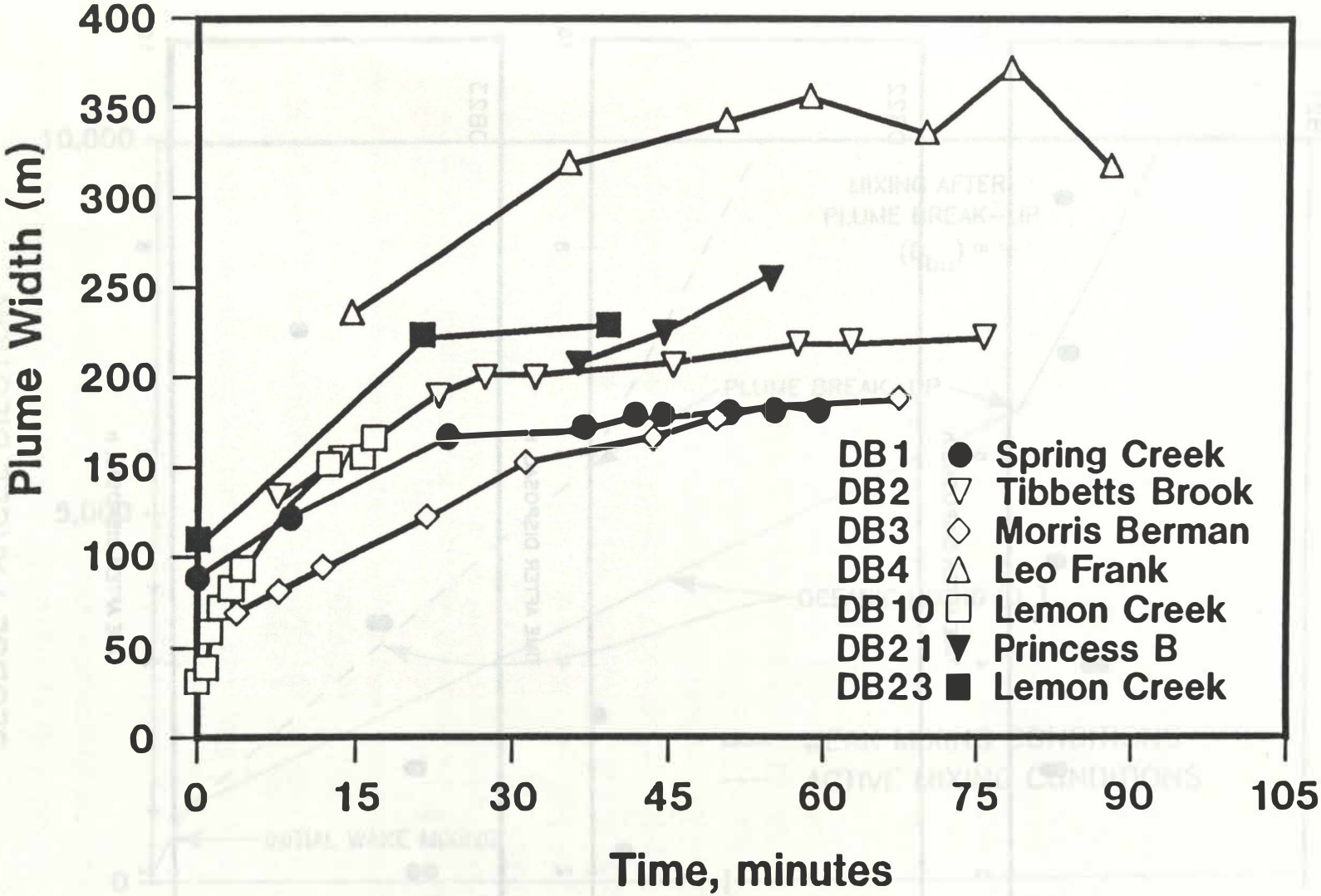


FIGURE 2-3. WIDTH OF SLUDGE PLUMES VERSUS TIME AFTER DUMPING

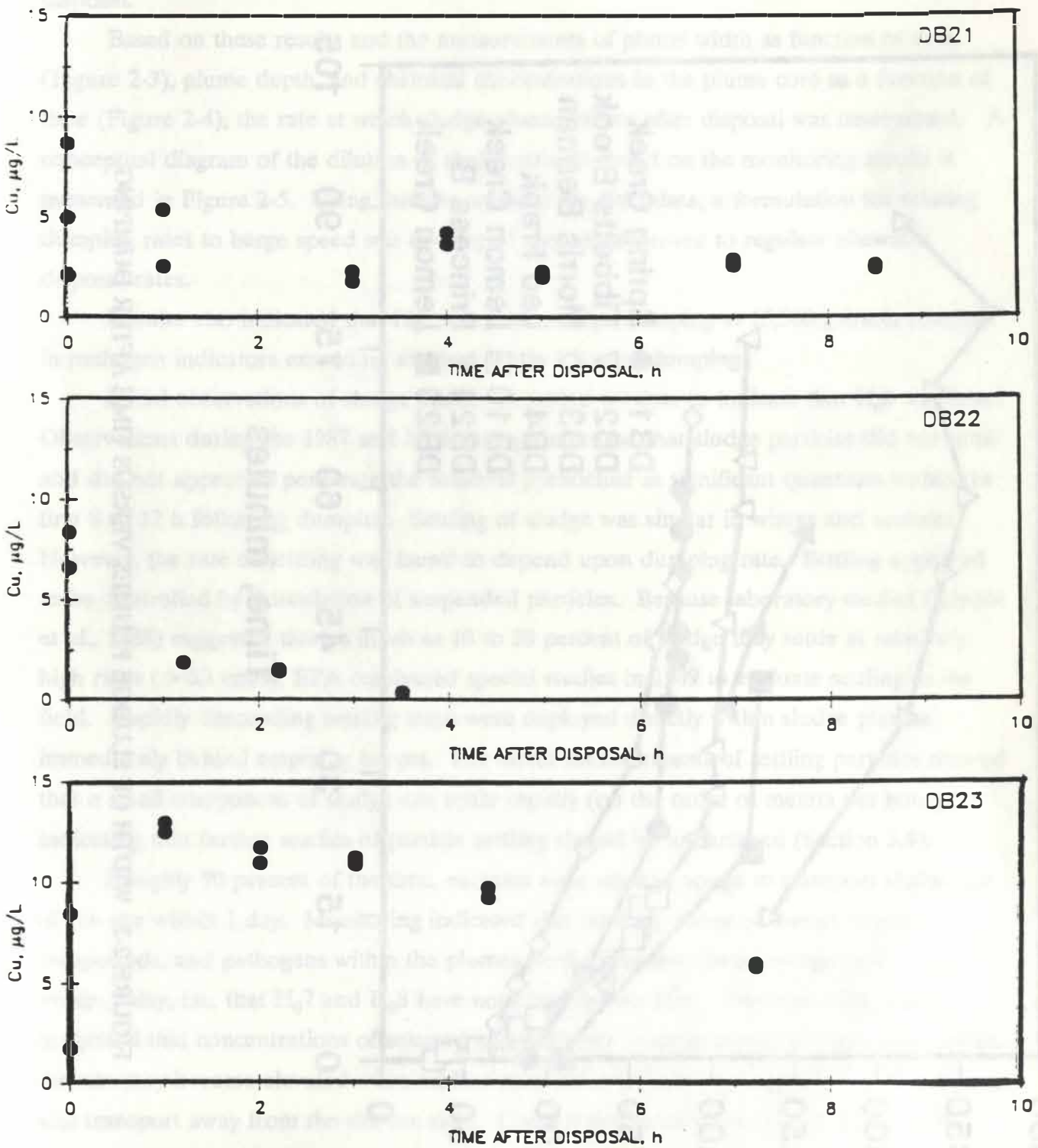


FIGURE 2-4. COPPER CONCENTRATIONS IN SLUDGE PLUMES VERSUS TIME FOR PLUMES SAMPLED IN OCTOBER 1988

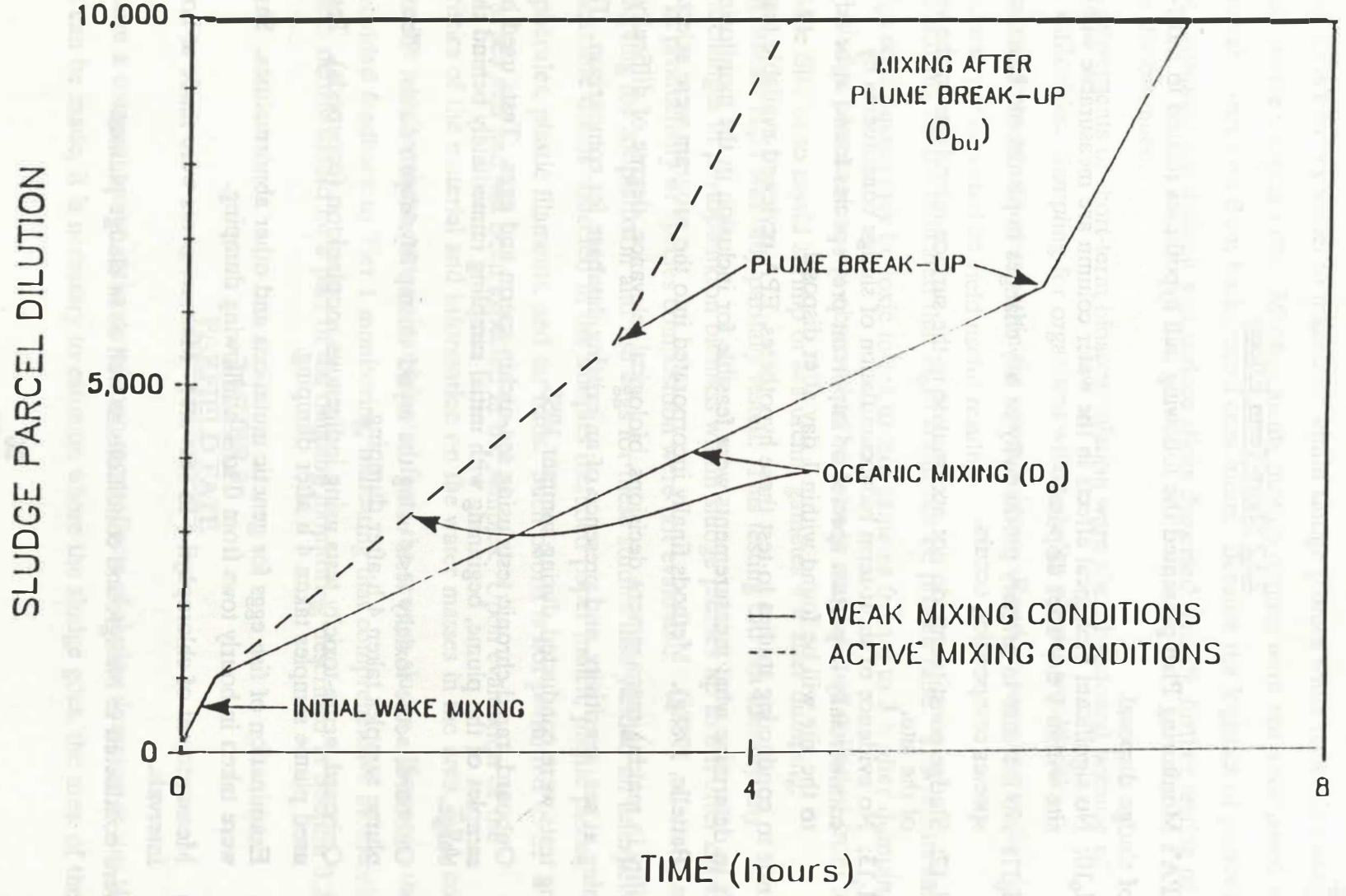


FIGURE 2-5. CONCEPTUAL DIAGRAM OF DILUTION OF SLUDGE PARCELS UNDER TWO MIXING CONDITIONS

No data indicated that $H_0$9 could be proven false. Dissolved oxygen depression was not found to be biologically significant, nor did significant changes in pH occur from sludge dumping.

2.3.2 Short-Term Effects

EPA's Monitoring Plan presented the following null hypotheses related to short-term effects of sludge disposal.

$H_0$10: No significant biological effects in the water column are measurable within the site within 1 day after disposal.

$H_0$11: No increase in primary productivity or any changes in planktonic biomass or species composition occurs.

$H_0$12: Sludge constituents do not accumulate in the surface microlayer in the vicinity of the site.

$H_0$13: No evidence of short-term bioaccumulation of sludge constituents by commercially important species or important prey species found at or adjacent to the site will be found within 1 day after disposal.

Prior to conducting studies to test these hypotheses, EPA reviewed available test methods to determine what measurements were feasible for inclusion in the monitoring program (Battelle, 1988g). Methods finally incorporated into the program were selected for their utility in making management decisions, biological relevance, degree of difficulty for performing at sea, sensitivity, and presence of an existing database for comparison. The following tests were conducted during summer 1988.

- Onboard, rapid-chronic tests using sea-urchin sperm and eggs. Tests used hourly samples of the plume, beginning with initial sampling immediately behind the barge.
- Onboard, acute-toxicity tests using the mysid shrimp *Mysidopsis bahia*. Tests used plume samples taken 4 h after dumping.
- Onboard, acute-toxicity tests using indigenous zooplankton (copepods). Tests used plume samples taken 4 h after dumping.
- Examination of fish eggs for genetic mutations and other abnormalities. Samples were taken in hourly tows from 0 to 4 h following dumping.
- Measurement of chlorophyll *a* in seawater. Measurements were made at hourly intervals.

Tests were conducted in background conditions as well as in sludge plumes.

Examination of the sea-surface microlayer within sludge plumes was also planned. However, attempts to collect microlayer samples in sludge plumes severely hampered abilities of EPA's survey vessel to maneuver within sludge plumes while collecting samples to evaluate plume dilution rates. Measurements outside plumes were not anticipated to yield detectable variation from background conditions. Because the logistics of performing microlayer sampling are difficult and surface slicks dispersed quickly, further testing of $H_0$12 was discontinued.

Measurements of short-term bioaccumulation were also abandoned because of logistical difficulties. Sampling for organisms within sludge plumes would risk contamination from constituents within the water column. Random sampling in the vicinity of the site was not expected to yield useful results.

Monitoring results indicated that $H_0$10 could not be proven false. The results showed that sludge constituents may be toxic to sea urchin gametes from 0 to 3 h after dumping. However, sludge plumes were not observed to be toxic to zooplankton collected from near the 106-Mile Site or to mysid shrimp or sea urchin gametes 4 h after dumping.

Hypothesis $H_0$11 was only partially tested. This testing did not identify any significant changes in phytoplankton biomass within sludge plumes up to 8 h after disposal. Changes in productivity or species composition were not evaluated.

Sampling for zooplankton and fish eggs for these studies also yielded an unexpected result: floatable debris collected in the samples included paper mulch, plastic pieces, pellets, spherules, plastic filaments, and tar balls. Such debris is not permitted to be dumped at sea and had not been expected in the samples. Upon evaluation of the characteristics of the material and information on the water masses in the area, EPA could not determine whether these materials originated from the sewage sludge. However, these results provided feedback to Tier 1 monitoring, indicating that comprehensive monitoring for floatable debris should be a part of the ongoing monitoring described in Section 3.2.

2.4 TIER 3: FARFIELD FATE

Before a comprehensive estimate of long-term effects of sludge dumping at the 106-Mile Site can be made, it is necessary to estimate where the sludge goes, the area of the

seafloor that may be influenced by sludge particles, and the cumulative concentrations that may be expected in the water column and sediments after many years of dumping. Therefore, Tier 3 of the monitoring program was designed to estimate the transport and fate of the sludge dumped at the 106-Mile Site in the long term and the farfield.

Farfield fate of sludge dumped at the 106-Mile Site depends upon dispersion of sludge plumes in several space and time scales. The principal components of estimating fate of sludges are (1) advection, (2) mixing, and (3) sinking and coagulation. Advection is the transport of sludge particles by the movement of water, that is, in a current field. All but the largest sludge particles are expected to spend weeks to months in the water column. They are likely to encounter many current fields and travel long distances (100 - 1000 km) before deposition on the bottom. Mixing is the dilution of sludge particles in a parcel of water by small-scale turbulent processes that depend on the density and velocity of the water. Turbulent energy due to wind waves, internal waves, vertical current shear, and modified by stratification in the water column determines mixing. Sinking is dependent on particle size and density. Coagulation, the sticking together of sludge particles, may alter the distribution of particle sizes in a sludge plume and affect sinking.

Estimation of dispersion in the region of the 106-Mile Site involves evaluation of the complex transport and mixing processes on the sludge. These processes vary and can be influenced by stochastic events. Therefore, estimates can be made only in terms of statistical probabilities, and interpretation of results must be aided by use of models.

Also, a wide range of time and space scales is involved in estimation of farfield fate of the sludge, from just over 1 day after dumping to many weeks and months, and from the immediate vicinity of the 106-Mile Site to many kilometers from it. Consequently, several measurement techniques are required to evaluate the various processes involved in dispersion of sludge.

Null hypotheses concerning farfield fate addressed issues that pertained to potential movement toward and subsequent impact to shorelines, marine sanctuaries, and fisheries areas, and toward the continental shelf and slope. The hypotheses related to this category were concerned with the fate of sludges over the long term. Hypotheses were

$H_0$14: Sludge constituents do not settle beneath the pycnocline outside the disposal site.

$H_0$15: Ocean currents do not transport sludge to any adjacent shoreline, beach, marine sanctuary, fishery, or shellfishery.

$H_0$16: Sludge recirculation through the site is not significant.

$H_0$17: Sludge particles do not settle to the sea floor in the vicinity of the site or in the region predicted as a plausible settling region.

These hypotheses required direct estimates of probabilities of specific fates of sludge particles. Assessing the fate of the particles would require monitoring of currents, temperature, salinity, and deposition rates for particles. Unfortunately, there is no direct technique for following the fate of a typical sludge particle as it sinks through the water column and is acted upon by currents and turbulence. Thus, several types of measurements are required to estimate the possible results of all the physical processes acting on the particles.

The farfield monitoring activities described in EPA's Monitoring Plan included

- Studying water-mass movement from the 106-Mile Site
- Studying surface currents and water structure in the areas expected to be impacted by dumping
- Using remote-sensing information to evaluate large-scale water movements and structure
- Measuring settling of sludge particles in the field
- Using appropriate models to estimate fate of sludge constituents and to identify possible depositional areas

Only some of these activities were completed before the new monitoring, research, and surveillance plan presented in Section 3 was prepared. Study of water-mass movements was initiated through the release of satellite-tracked surface drifters during October 1988 (4 drifters), October 1989 (4 drifters), December 1989 (2 drifters), January 1990 (2 drifters), and February 1990 (2 drifters). Trajectories of these releases, illustrated in Figure 2-6, indicated that recirculation through the site could occur. None of the surface drifters has crossed onto the continental shelf. These results along with other studies are being used to evaluate water mass movement at the 106-Mile Site.

Also during 1988 and 1989, EPA monitored water-mass structure and particle concentrations at distances up to 40 nmi from the site (Battelle 1989e, 1990). These measurements were not associated with specific plumes, so they effectively bridged nearfield and farfield monitoring. Vertical profiles were made to determine the depth of the particle maximum, and water samples were collected and analyzed for sludge tracers: trace metals, selected organic compounds, *Clostridium perfringens* spores, *Salmonella* spp., other

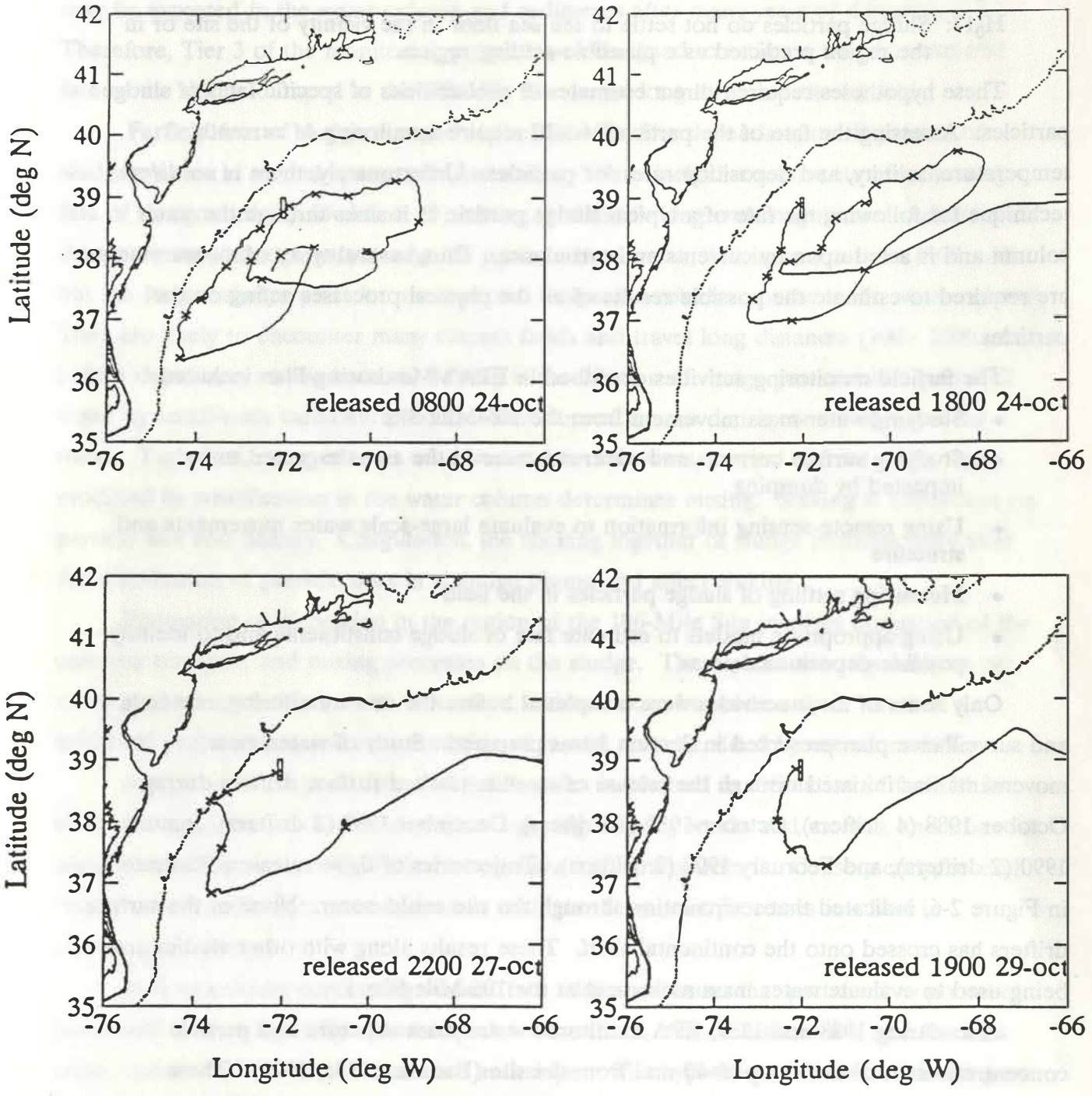


FIGURE 2-6. TRAJECTORIES OF DRIFTERS RELEASED AT THE SITE

pathogens, chlorophyll *a*, and xylem tracheids. Preliminary results suggested that sludge tracers could be identified at many stations downcurrent from the site and that further farfield studies were warranted.

Results of these farfield fate studies suggest that

- The seasonal pycnocline, where particles concentrate naturally, is a region of the water column where sludge particles also concentrate.
- Warm-core eddies are a viable but poorly understood mechanism for potential northward transport of sludge constituents to the edge of the continental shelf.
- On average, sludge particles are likely to remain in the water column, become entrained in the Gulf Stream, and be subject to great dispersion, which would not result in identifiable impacts to the environment.
- Under some oceanographic conditions, diluted sludge components may be recirculated through the site.

In a later survey, EPA deployed sediment traps designed to collect any particles that settle rapidly following disposal (Battelle, 1989f). Preliminary results indicate that a component of the sludge resembling grit (sand, other inorganic materials) may settle rapidly after disposal. Thus, a small, as yet unquantified, fraction of the sludge may settle rapidly beneath the plumes. Further studies of the sludge settling rates are being initiated to better define this material and quantify associated settling rates.

Further study of water mass movements and currents, coupled with remote sensing techniques to evaluate large-scale water movements and structure are currently being implemented by EPA and NOAA. These activities are presented in Section 3.4.

2.5 TIER 4: LONG-TERM EFFECTS

The objective of Tier 4 studies was to assess whether there are long-term impacts from sludge disposal at the 106-Mile Site. Tier 4 included plans for studies of impacts on fish species, biological communities that are prey for fish species, and other marine resources.

Long-term effects must be assessed within or outside the site. Long-term effects in the site might occur if, for example, there is a progressive decline in water quality—although such a decline is not predicted—or if significant quantities of sludge particles settle to the seafloor within the site. Effects outside the site, such as

bioaccumulation of sludge constituents, may occur if sludge particles are regularly transported in the direction of marine resource areas.

Because the 106-Mile Site was specifically located in an area that would minimize the likelihood of effects on the marine environment, long-term effects were not predicted when EPA's Monitoring Plan was developed. Although results from earlier tiers have not indicated that predictions were incorrect, concern for human health, resources, and the marine environment dictated that studies of long-term effects be conducted.

EPA's Monitoring Plan listed the following null hypotheses for assessing long-term effects of sludge disposal at the site.

$H_0$18: Sludge constituents have no significant long-term effect on the distribution of endangered species in the vicinity of the site.

$H_0$19: Sludge constituents do not accumulate in the tissues of commercially important species resident in the shelf and slope areas adjacent to the site.

$H_0$20: Benthic community structure does not change significantly due to sludge disposal.

$H_0$21: Sludge disposal has no effect on sensitive eggs and larval stages of indigenous animals.

$H_0$22: Sludge disposal has no measurable long-term impact on offshore plankton communities.

$H_0$23: Pathogen levels do not increase in the water column or biota as a result of sludge disposal.

The plan stated that other and more specific hypotheses could be developed. Testing the hypotheses listed in the plan would require a diverse set of measurement activities:

- Conducting endangered species studies
- Conducting bioaccumulation studies
- Conducting benthic studies
- Conducting studies of sensitive life stages
- Conducting plankton community studies

Few long-term effects studies had been initiated when the joint EPA/NOAA/USCG plan superseded EPA's plan. Studies that have been conducted are discussed below. Studies to be conducted are described in Section 3.5.

From the onset of monitoring, EPA included trained observers of marine mammals, reptiles, and birds on all surveys related to the 106-Mile Site. The observers recorded the presence, number, and behavior of all species of mammals, reptiles, and birds in 15-min

intervals along the survey track (Payne et al., 1984). Each observation period represented a transect, and several transects are performed each day during the survey. Data from each survey conducted while dumping took place could be compared to data from predumping surveys. Such observations are expected to continue throughout the use of the site. Results to date have not indicated that endangered species have been affected. However, results are not yet sufficient to test $H_0$18 completely.

NOAA and EPA have also conducted a preliminary evaluation of the use of midwater fishes inside and outside the 106-Mile Site for bioaccumulation studies. Results have indicated that body burdens of PCB and pesticides were detectable but low in fishes from stations within the site, to the northeast of the site, to the southwest of the site, and in the Sargasso Sea (Battelle, 1989g). Concentrations of metals suggested that one species of myctophid collected within the 106-Mile Site accumulated several metals that are found in sludge (Zdanowicz et al., 1990). This study showed that sampling and analysis of midwater fishes is feasible and that further monitoring is warranted. Bioaccumulation studies to be conducted as part of the EPA/NOAA/USCG monitoring, research, and surveillance plan are described in Section 3.5.

3.0 CONTINUING MONITORING, RESEARCH, AND SURVEILLANCE OF THE 106-MILE SITE

This section presents the monitoring, research, and surveillance activities that will result from EPA, NOAA, and USCG development of a joint strategy for meeting ODBA requirements. This new plan builds on EPA's monitoring program, which was presented in Section 2. It also uses the findings and recommendations of the workshop that the agencies held in 1989 to evaluate past research, monitoring, and surveillance and recommend future studies (EPA, NOAA, and USCG, 1989).

3.1 BACKGROUND INFORMATION AND BASELINE STUDIES

The monitoring, research, and surveillance program will use the same set of baseline data used and developed by EPA's monitoring program. No new baseline studies can be conducted. However, EPA is currently preparing an updated summary of information that is known about the site. This summary will draw upon research and monitoring conducted since 1982 by NOAA, EPA, other Federal agencies, private firms, and academic institutions.

3.2 TIER 1: WASTE CHARACTERISTICS AND DISPOSAL OPERATIONS

3.2.1 Waste Characteristics

Ongoing monitoring of sludge characteristics was originally specified in 1984. New requirements were established in 1989 after EPA evaluations indicated some shortcomings of the original requirements. For this joint Monitoring Plan, the working hypothesis is changed to

$H_0 1$: The physical and chemical characteristics of sludge are consistent with waste characterization information available at the time permits for the 106-Mile Site were issued.

Permits issued in August 1989 for the 106-Mile Site have specified the physical, chemical, biological, and toxicological parameters to be measured and requirements for sampling and analysis of these parameters. To ensure that the data quality, sample

collection and analysis are being conducted under quality assurance plans developed by the permittees and approved by EPA.

For all characterization studies, representative sludge samples are taken during vessel loading. Samples are collected from a point on the discharge side of the pump delivering sludge from a digester or holding tank to the vessel being loaded. A flow-weighted composite sample, collected during the entire loading procedure, is required.

Permittees using an individual vessel to dispose of sludge from more than one treatment plant are required to characterize a composite sample from samples drawn from each compartment of the barge. If the permittee chooses to request EPA approval to calculate allowable disposal rates based on the weighted average of sludges entering the vessel, analysis of individual compartments is required to demonstrate the homogeneity of the sludge in the vessel.

Required parameters are listed in Table 3-1. Specific organic compounds for which analyses are required are listed in Battelle (1989h). Samples are collected and analyzed at the following frequencies.

- **Monthly for parameters required to evaluate and, if necessary, revise dumping rates.** These include (1) conventional parameters; (2) copper, lead, cadmium, and mercury in the suspended and liquid phases; and (3) 96-h acute toxicity tests (these tests may be performed quarterly). Chemical analysis of settleable solids and solid-phase toxicity tests may be required if settleable solids are present. Toxicity tests are used to revise dumping rates quarterly.
- **Quarterly for parameters required to evaluate loading at the 106-Mile Site.** These include (1) organic compounds for which there are marine water quality criteria; (2) conventional and nonconventional pollutants; and (3) floatable materials (which are not permitted to be in the sludge). Both the suspended-particulate and liquid phases must be analyzed. Volume of sludge generated and transported to the site must also be reported.
- **Semiannually for organic priority pollutants and compounds excluded from dumping by the London Dumping Convention.** Measurements include determination of radioactivity and a full organic priority-pollutant scan. These tests need be conducted only on the suspended-particulate phase unless settleable solids are present. Analysis of settleable solids may also be required if they are present.

All toxicity testing, physical characterization, and chemical analysis must be performed on the same sample. All tests must be completed within the limits of EPA-approved holding times. Toxicity tests, which are conducted monthly, use the test organisms *Menidia menidia* and *Mysidopsis bahia* and/or a substitute organism designated by

TABLE 3-1. ANALYTICAL PARAMETERS INCLUDED IN ONGOING TIER 1 MONITORING

Parameter		Frequency
Conventional Parameters		Monthly
Biological oxygen demand		
Chemical oxygen demand		
Total residue		
Total filterable residue		
Total nonfilterable residue		
Total organic carbon		
Specific gravity		
Settleable solids		
pH		
Total Cd, Pb, Hg, Cu		
Acute 96-h Toxicity Testing		Monthly[a]
Conventional and Nonconventional Pollutants		Quarterly
Total coliform bacteria	Arsenic	
Fecal coliform bacteria	Cadmium	
Clostridium perfringens spores	Chromium	
Fecal streptococcus	Copper	
Total phosphate	Lead	
Total Kjeldahl nitrogen	Mercury	
Ammonia	Nickel	
Nitrate	Selenium	
Oil and grease	Vanadium	
Total PAHs	Zinc	
Cyanide		
Phenols		
Full Organic Priority Pollutant Scan		Semiannually
Radioactivity		Semiannually
Gross alpha		
Gross beta		
Radium 226		
Radium 228		
Floatable Debris		Quarterly

[a]May be conducted quarterly.

EPA as more appropriate. Tests are conducted under the guidance and procedures established by APHA (1985), EPA (1985, 1987), and other documents specified by EPA. LC_{50} and 95 percent confidence intervals are calculated by using the binomial, trimmed Spearman-Karber, moving-average, or probit method, and justification of the method must be provided. The LC_{50} is reported in milligrams per liter (mg/L) of sludge and as a percentage of the whole sludge.

Analysis of conventional parameters and conventional pollutants is conducted according to procedures recommended by Battelle (1989h) or by substitute methods selected by the permittee and approved by EPA. Method detection limits are as specified by APHA (1985) and EPA (1979, 1986). Specific detection limits are summarized by Battelle (1989h). Reporting units for all physical and chemical parameters are in milligrams per liter (mg/L). Replicate analyses are required for the quarterly analyses and for at least two of the 12 monthly analyses. All methods and data quality requirements are documented in quality assurance plans for sludge characterization submitted by the permittees for EPA approval. Approved quality assurance plans are required for all analyses to be conducted.

The sludge characteristics data will be entered into a sludge characteristics data management system in place at EPA Region II. Selected statistical analysis will be performed by EPA, using the data management system. This analysis will be used to identify significant deviations in sludge characteristics from the information supplied in the permit applications, identify significant changes in the sludge characteristics for each sewerage authority, and allow quarterly revisions to be made in the sludge dumping rates as defined in the permits issued for the 106-Mile Site. In addition, the data can be used to estimate the total loading of contaminants into the 106-Mile Site environs, an essential component of the farfield fate evaluation conducted under Tier 3 of the joint Monitoring Plan.

In the event that the permittee-generated sludge characterization data are found to be insufficient for evaluating the transport and fate of sludge disposed at the 106-Mile Site, EPA will consider conducting additional analyses. These analyses would be conducted for the following reasons: (1) to lower detection limits, (2) to identify unique tracers of sludge or (3) to expand the available database on contaminants identified from the farfield fates studies being conducted by EPA.

3.2.2 Disposal Operations

Ongoing surveillance of disposal operations has also been specified in permits to dump sludge at the site. The permits provide allowable dumping rates and designated tracklines along which dumping must take place. The working hypothesis for disposal operations remains unchanged from the EPA program.

$H_0 2$: Disposal rates and operations are consistent with the requirements of the ocean dumping permits.

Under the joint Monitoring Plan, EPA will continue the use of shipriders to monitor sludge transfers and disposal operations as defined in Condition 27 of the permits for the 106-Mile Site. Under Condition 27, the permittees are required to have one or more inspectors present before any sludge is loaded onto a transfer (feeder) vessel or ocean-going barge. These shipriders observe and record all operations involving transfer of sludge onto or between vessels designated to carry sludge. In addition, all feeder vessels designated to carry sludge must have all discharge valves permanently sealed with EPA-approved seals. Valves used for transfer operations are sealed by the shipriders immediately upon completion of transfers (unloading or loading). Ocean-going vessels must have all discharge valves sealed prior to departure for the 106-Mile Site. All transfers are recorded on Waste Manifest Forms each time a transfer is completed. Forms must be submitted to EPA and the USCG within three business days after completion of loading. Shipriders are required on all vessels unless EPA waives that requirement. Shipriders report to EPA on disposal operations within 72 h of return to shore.

In addition to the shiprider requirement, the waste transporter must provide to the USCG, at the onset of a trip to the 106-Mile Site, information about the estimated time of arrival at and departure from the site. For each voyage, waste transporters prepare and submit Ocean Dumping Notification Forms (ODNF) that describe the location and rate of dumping. Monthly reports from waste transporters are also submitted to EPA. These reports include

- Name of each vessel that departed port for the site
- Date of departure for each vessel
- Reference number for each vessel mission
- Quantity of waste from each permittee dumped by each vessel

- Type of waste dumped by each vessel
- Date upon which each vessel began dumping operations
- Date upon which each ODNF was mailed

Remote surveillance of dumping operations will continue to be conducted with the Ocean Dumping Surveillance System (ODSS). The ODSS comprises three main components: (1) the electronics package or "black box" that is installed on vessels authorized to dump at the site; (2) the transducers, or pressure sensors, that measure changes in the vessel's draft, allowing calculation of dumping rate; and (3) the base and relay stations, located onshore. Each permittee must allow the USCG to install on each vessel to be used for dumping a black box and the transducers required by the ODSS. The ODSS provides independent measurements of vessel location during dumping and dumping rate.

3.3 TIER 2: NEARFIELD FATE AND SHORT-TERM EFFECTS

Continued monitoring under Tier 2 is being conducted by EPA and the permittees. Monitoring will provide additional measurements related to the hypotheses concerning nearfield fate that were presented in the EPA Monitoring Plan. Some hypotheses have been revised from those included in the EPA Monitoring Plan to provide a clearer statement of the hypotheses. The joint Monitoring Plan includes the following hypotheses.

$H_0$3: Concentrations of sludge and sludge constituents are below the permitted LPC and WQC outside the site at all times.

$H_0$4: Concentrations of sludge and sludge constituents are below the permitted LPC and WQC within the site 4 h after disposal.

$H_0$5: Pathogens or biological tracers of sewage sludge do not exceed ambient levels 4 h after disposal.

$H_0$6: Sludge particles do not settle in significant quantities beneath the seasonal pycnocline (50 m) or to the 50-m depth at any time, within the site boundaries or in an area adjacent to the site.

$H_0$7: The concentration of sludge constituents within the site does not exceed the LPC or WQC 4 h after disposal and is not detectable in the site 1 day after disposal.

$H_0$8: The concentration of sludge constituents at the site boundary or in the area adjacent to the site does not exceed the LPC or WQC at any time and is not detectable 1 day after disposal.

Although EPA monitoring has already provided information relevant to all of these hypotheses, additional measurements will provide information to evaluate variability and trends.

Testing of $H_0$9 through $H_0$13 of the EPA Monitoring Plan (Sections 2.3.1 and 2.3.2) either did not show evidence of an adverse impact ($H_0$9 - $H_0$11) or are now believed to be untestable ($H_0$13). Hypothesis $H_0$12 was found to be logistically difficult to test due to the transient nature of the surface slick observed in the wake of the barge and the difficulty in sampling the slick properly. In addition, the management decision to reduce the sludge disposal rates to ensure that water quality criteria are met at all times further reduces the risk of any short-term or nearfield effects resulting from the disposal of sludge at the site. Furthermore, the observed consistent, rapid transport of sludge from the disposal site and public concern for potential effects on marine resources in the vicinity of the site caused the monitoring program focus to shift to Tiers 3 and 4 activities. Therefore, no additional testing of $H_0$9 through $H_0$13 listed in the previous EPA Monitoring Plan is planned. If information developed under this joint Monitoring Plan indicates that additional testing should be undertaken, the joint plan will be appropriately modified to conduct these actions. Permittees may be required to perform additional Tier 2 studies if EPA decides that the measurements are necessary.

One monitoring activity that is continued from Tier 2 of the EPA Monitoring Plan is the acquisition of continuous measurements of surface currents using the EPA-sponsored current meter mooring (Section 2.3). This mooring will continue to gather data on currents in surface waters at the site. In addition, the permittees are required to conduct the following activities:

- Purchase and deploy satellite-tracked surface drifters
- Purchase and deploy expendable current profilers (XCP)

The data from these devices will be used by the agencies to

- Determine water column movement in the vicinity of 106-Mile Site
- Determine current shear and water temperature to a depth of ≈1,500 m at the 106-Mile Site

3.4 TIER 3: FARFIELD FATE

Farfield fate studies will address following the hypotheses:

$H_0$14: Significant amounts of sludge do not settle below the surface mixed layer outside the disposal site.

$H_0$15a: Ocean currents do not transport sludge to any adjacent shoreline, beach, marine sanctuary, fishery, or shellfishery.

$H_0$15b: Ocean currents do not transport sludge onto the continental shelf.

$H_0$16a: Recirculation of slope water through the 106-Mile Site is not significant.

$H_0$16b: Concentrations of sludge constituents dumped at the 106-Mile Site that are associated with any recirculating slope water do not exceed EPA chronic Marine Water Quality Standards.

$H_0$17a: Significant amounts of sludge particles do not settle to the sea floor in the vicinity of the site or in the region predicted as a plausible settling region.

$H_0$17b: Organic, inorganic, and bacterial contaminants that are present in sewage sludge discharged at the 106-Mile Site do not measurably increase concentrations of contaminants in the sediment within the expected dispersion area or reference areas.

The wording of some of these hypotheses has changed from the EPA Monitoring Plan and others have been added to ensure greater clarity and testability of the hypotheses. Testing these hypotheses is being accomplished through the following activities (responsible agencies are shown in parentheses):

- **Studying water temperature of oceanographic sections through the 106-Mile Site.** The temperature structure of the water masses in the vicinity of the site from the continental shelf to the north wall of the Gulf Stream will be determined with expendable bathythermographs (XBT). (NOAA and EPA)
- **Studying water-mass movement from the 106-Mile Site.** Study of movements of surface water masses (i.e., Lagrangian measurements) involves deploying satellite-tracked drifters at the site. (Permittees, EPA and NOAA)
- **Studying currents and water structure throughout the water column in the areas expected to be impacted by dumping.** These Eulerian, moored measurements include temperature and current measurements in surface, middepth, and near-bottom waters. (EPA)
- **Using remote sensing information to evaluate large-scale water movements and structure.** These measurements include use of advanced very high resolution radiometer (AVHRR) on polar-orbiting satellites for mapping surface temperature throughout the study area. These measurements will be used in tandem with the drifter studies. (EPA and NOAA)

- Studying settling of sludge particles in the field. These studies include deployment of moored sediment traps at several locations and depths in conjunction with current measurements. (EPA)
- Performing laboratory settling studies. These studies will be conducted under conditions that simulate those in the field. They will measure the rapidly settling component of sludges. (EPA)
- Evaluating appropriate models to determine fate of sludge constituents and to identify possible depositional areas. This effort requires identifying models for prediction of the three-dimensional movement of sludge particles released from the site (NOAA) and application of simple transport models to assist in the interpretation results from the sediment trap program (EPA).
- Determining the concentration and distribution of sludge constituents and indicators of sewage sludge in sediment. These studies will include collection of sediments from the outer continental shelf, submarine canyons in the vicinity of the 106-Mile Site, and continental shelf areas in and near the 106-Mile Site. (NOAA)

The studies that will be conducted are described in Sections 3.4.1, 3.4.2, and 3.4.3. The outcome of each study will be integrated through the exchange of data and results, combining data sets as appropriate, and producing a syntheses report for the farfield fate studies. The data exchange and expected reports from this monitoring tier are discussed in Section 4.

3.4.1 Water-Mass Studies

In addition to the monitoring objectives presented in the EPA Monitoring Plan, the water mass studies will provide information to assess

- Large-scale southwest drift over the Mid-Atlantic Bight continental shelf and slope and the hypothesized recirculation of the slope-sea gyre
- Existence and role of convergence at the shelf break
- Entrainment of sludge constituents into the Gulf Stream at Cape Hatteras versus possible transport to the South Atlantic Bight

Continued collection of information on specific water mass movements will also provide the evidence of sludge movement towards shorelines.

EPA requires the permittees to deploy an average of one expendable, satellite-tracked drifter per week at the site. Starting March 1990, the drifters will be deployed from sludge barges, near the center of the site. The drifters will be tethered and ballasted so

that the drogue centers remain at a depth of 10 m for the life of deployment. The drifters will be tracked three to four times daily for 4 months by ARGOS satellite. Analysis of drifter tracks will be supported by an AVHRR imaging program and the XBT program. Service ARGOS, an agency specializing in satellite data collection, will be contracted to provide all aspects of satellite telemetry and data acquisition over the duration of the measurement program. From the drifters and via direct access of the computer data center maintained by Service ARGOS, EPA will receive information on drifter positions and surface-water temperature in near real-time.

EPA will be responsible for evaluating these data. The drifter studies will also aid in estimating the effects of features such as wind events, warm-core eddies, and Gulf Stream meanders. Launching one drifter per week for approximately 18 to 24 months should be adequate to characterize water-mass movements. In addition to the permittee deployed drifters, EPA Region II plans a near-synoptic deployment of several undrogued surface drifters to evaluate the movement of any material that may remain at the air/sea interface and whose transport will be affected more by wind than by surface currents in the area. These drifter data will be coupled with an analysis of wind data from the National Weather Service (NWS) buoy located near the 106-Mile Site to define the frequency and directions of potential floatable debris transport at the 106-Mile Site.

Satellite imagery will be used to identify surface water masses, interpret drifter tracks, and follow significant physical features. Satellite imagery may also be used as input to a modeling effort. Data from an AVHRR satellite-imagery program can be used to depict the surface-temperature structure of the entire region that could be impacted by the 106-Mile Site. EPA will acquire daily AVHRR data from the NOAA TIROS polar-orbiting satellites (NOAA-10 or NOAA-11). The data will be corrected for water vapor in the atmosphere, remapped to a mercator projection, and displayed as color-enhanced images. Meteorological data may be scanned for cloud cover over the region, so that only clear passes will be used for sea-surface temperature (SST) mapping. At least one clear image per week will be selected for overlay of the satellite-tracked drifter data.

An oceanographic section of temperature versus depth from the shelf break to the north wall of the Gulf stream will be acquired by the NOAA/Atlantic Regional Group. These data will be available as part of the ship-of-opportunity program routinely conducted between New York City and Bermuda. The data will be routinely supplied to EPA for use

in the interpretation of water mass and drifter movement. The data will also be used in association with the moored current (Eulerian) studies discussed below.

NOAA will contribute to the water mass studies through seasonal deployments of expendable, satellite-tracked drifters, an AVHRR satellite-imagery program, and conducting hydrographic surveys. Approximately seven satellite-tracked near-surface drifters (the same type of drifter as deployed by the permittees for EPA) will be deployed twice (summer 1990 and winter 1991) across the site from the outer shelf to the outer slope. These seasonal studies are meant to examine the behavior of drifters deployed quasisimultaneously across the site in different water masses and to supplement the EPA studies by providing statistics on dispersion of multiple drifters deployed simultaneously at the same place and in the same water mass.

The summer 1990 drifter deployment will be done during the NOAA midwater fish/hydrographic survey. Hydrography will consist of conductivity/temperature/depth (CTD) measurements with a transmissometer sensor to examine particle concentrations in the water column. CTD stations will be taken in support of bioaccumulation studies (see Section 3.5.1) at each midwater fish station [see Figure 3-5 for the proposed midwater fish (myctophid) survey map], and a more closely spaced grid of CTD stations will be taken near the dumpsite. A nominal near-site sampling and drifter deployment plan is illustrated in Figure 3-1. The actual location of CTD stations and deployment locations will depend upon the relationship of surface-water masses across the site (determined from satellite-derived sea-surface temperature data) and the three-dimensional distribution of particle concentrations and water masses determined at the time of the cruise.

The winter 1991 drifter deployment is currently planned for February 1991. There will be additional hydrographic surveys in support of bioaccumulation studies and midwater fish surveys (Section 3.5).

NOAA will access daily advanced very high resolution radiometer (AVHRR) data from NOAA's TIROS polar-orbiting satellites (NOAA-10 and/or NOAA-11) using NESDIS in-house software for image processing. Using NOAA's Ocean Products Center as a conduit for data, sea-surface temperature (SST) fields for the western North Atlantic will be produced, focusing attention on the Mid-Atlantic Bight, the dumpsite, and the region occupied by the drifters. The SST field will be monitored by using the NOAA SST display

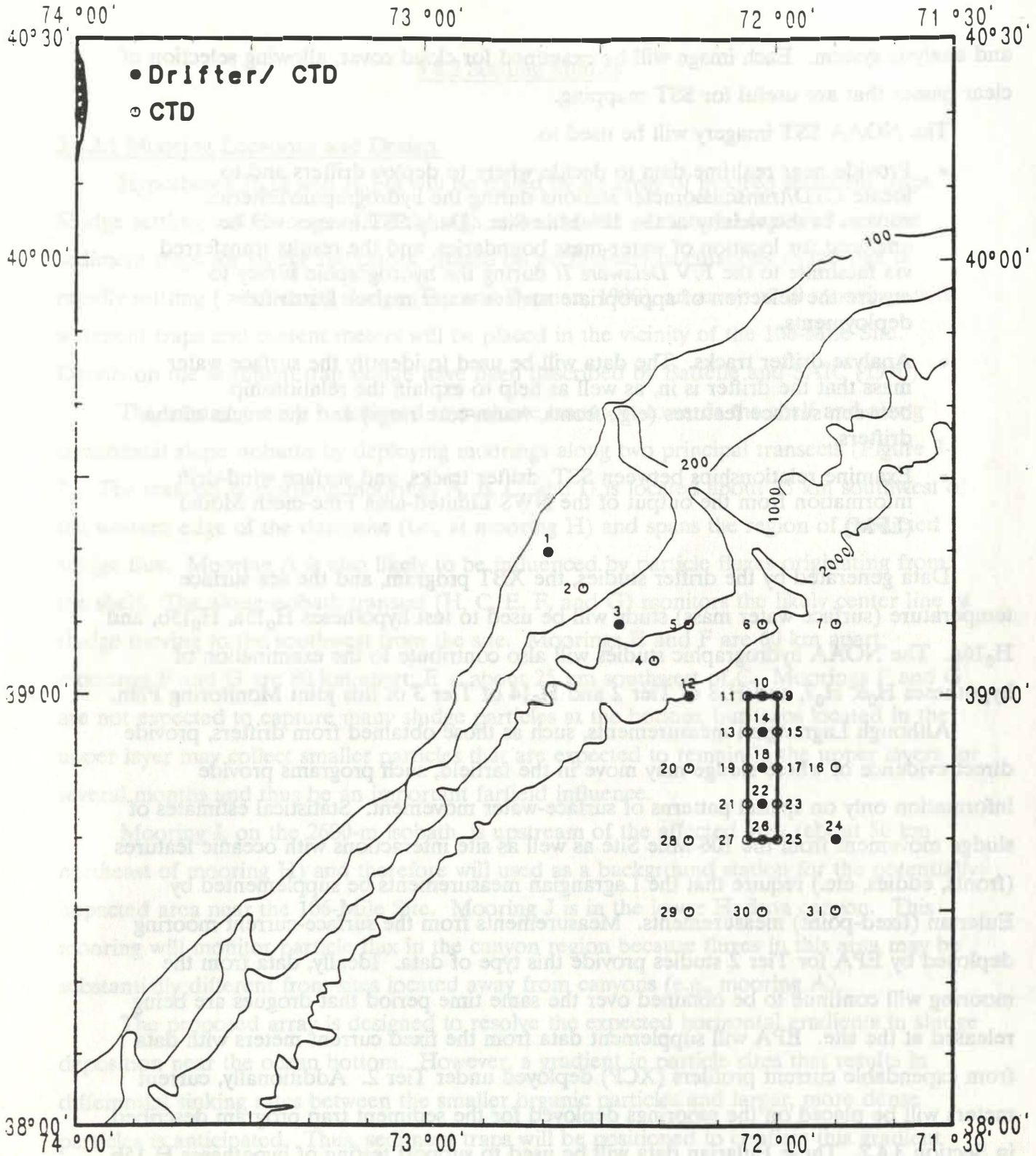


FIGURE 3-1. POSSIBLE STATION LOCATIONS FOR CTD AND DRIFTER DEPLOYMENTS

and analysis system. Each image will be examined for cloud cover, allowing selection of clear passes that are useful for SST mapping.

The NOAA SST imagery will be used to

- Provide near realtime data to decide where to deploy drifters and to locate CTD/transmissometer stations during the hydrographic/fisheries surveys in the vicinity of the 106-Mile Site. Daily SST images will be analyzed for location of water-mass boundaries, and the results transferred via facsimile to the F/V *Delaware II* during the hydrographic survey to ensure the selection of appropriate surface water masses for drifter deployments.
- Analyze drifter tracks. The data will be used to identify the surface water mass that the drifter is in, as well as help to explain the relationship between surface features (e.g., fronts, warm-core rings) and the tracks of the drifters.
- Examine relationships between SST, drifter tracks, and surface wind-drift information from the output of the NWS Limited-area Fine-mesh Model (LFM).

Data generated by the drifter studies, the XBT program, and the sea surface temperature (surface water mass) study will be used to test hypotheses $H_0$15a, $H_0$15b, and $H_0$16a. The NOAA hydrographic studies will also contribute to the examination of hypotheses $H_0$6, $H_0$7, and $H_0$8 of Tier 2 and $H_0$14 of Tier 3 of this joint Monitoring Plan.

Although Lagrangian measurements, such as those obtained from drifters, provide direct evidence of where sludge may move in the farfield, such programs provide information only on spatial patterns of surface-water movement. Statistical estimates of sludge movement from the 106-Mile Site as well as site interactions with oceanic features (fronts, eddies, etc.) require that the Lagrangian measurements be supplemented by Eulerian (fixed-point) measurements. Measurements from the surface-current mooring deployed by EPA for Tier 2 studies provide this type of data. Ideally, data from the mooring will continue to be obtained over the same time period that drogues are being released at the site. EPA will supplement data from the fixed current meters with data from expendable current profilers (XCP) deployed under Tier 2. Additionally, current meters will be placed on the moorings deployed for the sediment trap program described in Section 3.4.2. These Eularian data will be used to support testing of hypotheses $H_0$15b, $H_0$16a, and $H_0$17a.

3.4.2 Settling Studies

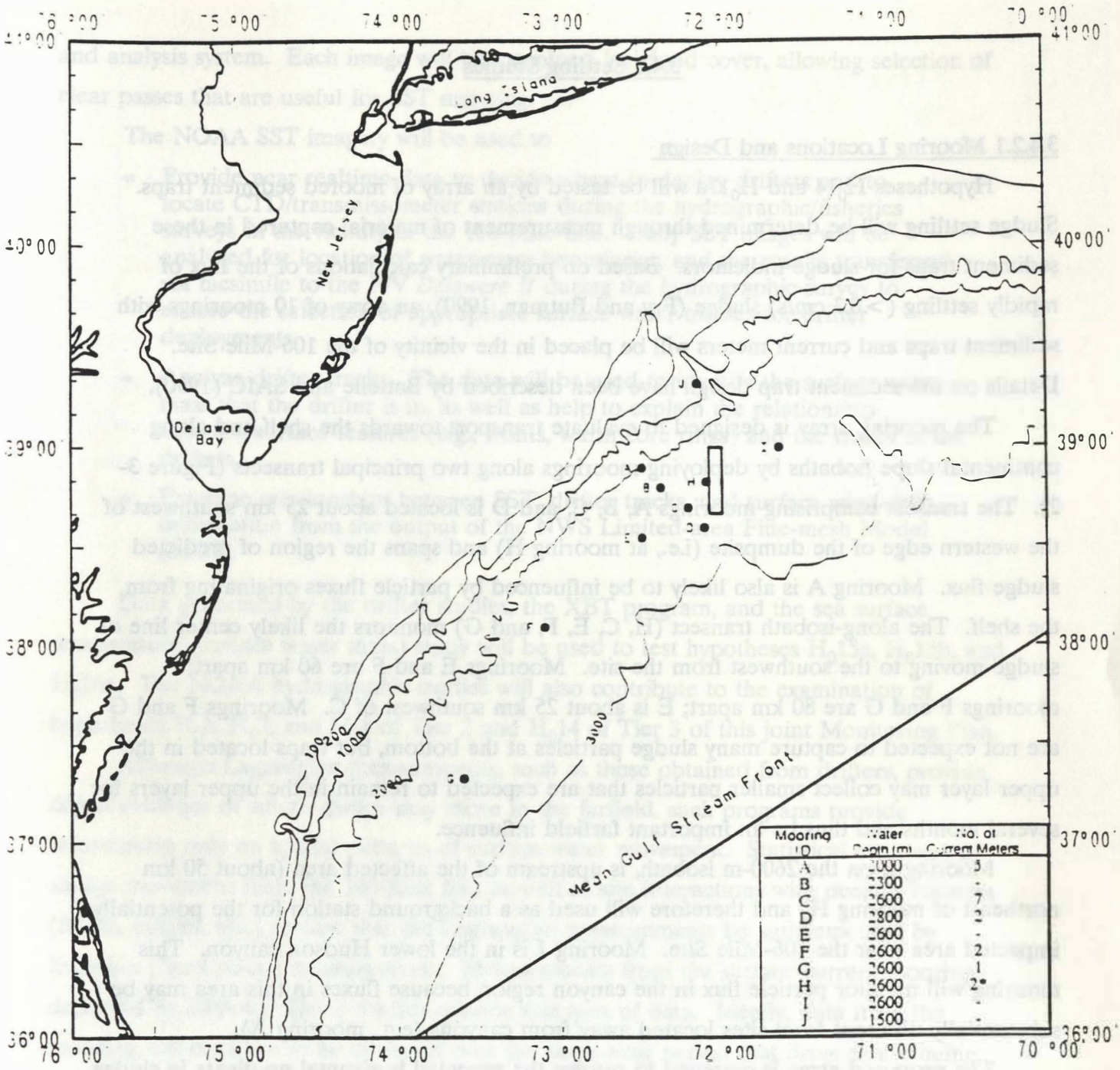
3.4.2.1 Mooring Locations and Design

Hypotheses $H_0$14 and $H_0$17a will be tested by an array of moored sediment traps. Sludge settling will be determined through measurement of material captured in these sediment traps for sludge indicators. Based on preliminary calculations of the flux of rapidly settling (>0.3 cm/s) sludge (Fry and Butman, 1990), an array of 10 moorings with sediment traps and current meters will be placed in the vicinity of the 106-Mile Site. Details on the sediment trap design have been described by Battelle and SAIC (1990).

The mooring array is designed to evaluate transport towards the shelf and along continental slope isobaths by deploying moorings along two principal transects (Figure 3-2). The transect comprising moorings A, B, C, and D is located about 25 km southwest of the western edge of the dumpsite (i.e., at mooring H) and spans the region of predicted sludge flux. Mooring A is also likely to be influenced by particle fluxes originating from the shelf. The along-isobath transect (H, C, E, F, and G) monitors the likely center line of sludge moving to the southwest from the site. Moorings E and F are 60 km apart; moorings F and G are 80 km apart; E is about 25 km southwest of C. Moorings F and G are not expected to capture many sludge particles at the bottom, but traps located in the upper layer may collect smaller particles that are expected to remain in the upper layers for several months and thus be an important farfield influence.

Mooring I, on the 2600-m isobath, is upstream of the affected area (about 50 km northeast of mooring H) and therefore will used as a background station for the potentially impacted area near the 106-Mile Site. Mooring J is in the lower Hudson canyon. This mooring will monitor particle flux in the canyon region because fluxes in this area may be substantially different from sites located away from canyons (e.g., mooring A).

The proposed array is designed to resolve the expected horizontal gradients in sludge deposition near the ocean bottom. However, a gradient in particle sizes that results in differential sinking rates between the smaller organic particles and larger, more dense particles is anticipated. Thus, sediment traps will be positioned to confirm this gradient and capture slower sinking particles in the water column before dispersion results in concentrations too dilute to detect.



Mooring ID	Water Depth (m)	No. of Current Meters
A	2000	5
B	2300	-
C	2600	7
D	2800	2
E	2600	-
F	2600	2
G	2600	1
H	2600	2*
I	2600	-
J	1500	-

FIGURE 3-2. 106-MILE SITE SEDIMENT TRAP MOORING LOCATIONS

Sediment traps will be placed at three depths on each mooring: the top of each mooring (at about 100 m depth), at 1000 m depth, and at a position 250 m above the bottom. Placing the bottom traps 250 m above the bottom should locate them well above the influence of bottom-sediment resuspension events, minimizing the influence from resuspended bottom sediment on any sludge signals. The 1000-m level is approximately midway between the upper and lower traps and is in the region of transition from the upper-layer Slope Sea Gyre and Gulf Stream eddy currents to the deeper current regions that are usually considered to be part of the Deep Western Boundary Current System.

The recommended depths for the traps and current meters for each mooring are given in Table 3-2. The placement of the current meters is based on the requirement that the currents be measured throughout the water column so that interpretation of particle fluxes at the sediment trap levels can be based upon well-resolved current information. Current meter placement on the moorings is chosen to enable evaluation of variability over the region of maximum particle flux and also to enable evaluation of effects from Gulf Stream eddies passing over the 106-Mile Site. The placement of instrumentation on mooring transect A through D is diagrammed in Figure 3-3. To resolve the current shear on this transect adequately, the moorings have been more heavily instrumented. Mooring C has the most instruments. This will help to resolve the vertical current shears along the isobath extending from mooring H. In general, current meters have been placed roughly 5 m below the sediment traps so that the flow field near the trap is monitored. Because the upper layers (100 to 500 m) are likely to have the largest current shear, particularly during the passage of warm-core eddies, current meters have been concentrated in this region of the water column.

Sediment-trap samples will represent a 3- to 9-month integration of particulate input to the ocean in the vicinity of the 106-Mile Site. The trap design does not facilitate the collection of time-series data that may be useful for interpreting the influence of specific events that may affect sludge transport (phytoplankton blooms, shelf intrusions, warm-core rings, etc.). Sediment traps modified to collect discrete samples representing shorter periods of time may be added to the mooring array if it is determined that they are necessary to meet the program objectives.

The initial deployment of the moorings will be from early summer to the fall of 1990. All moorings will be recovered and redeployed in the fall of 1990. The moorings will be

TABLE 3-2. DEPTHS OF INSTRUMENTATION ON MOORED ARRAYS

Mooring	Water Depth (m)	Trap Depths (m)	Current Meters Depths (m)
A	2000	100 1000, 1750	100, 200, 500 1000, 1750
B	2300	100, 1000 2550	
C	2600	100 1000 2350	100, 150, 200, 500 1000, 1750 2350
D	2800	100, 1000 2500	100, 1000
E	2600	100, 1000 2350	
F	2600	100, 1000 2350	100, 1000
G	2600	100, 1000	100
H	2600	100, 1000 2350	25,[a] 100[a]
I	2600	100, 1000 2350	
J	1500	100, 1000	

[a]These current meters are installed on EPA's realtime mooring that is adjacent to the proposed Mooring H.

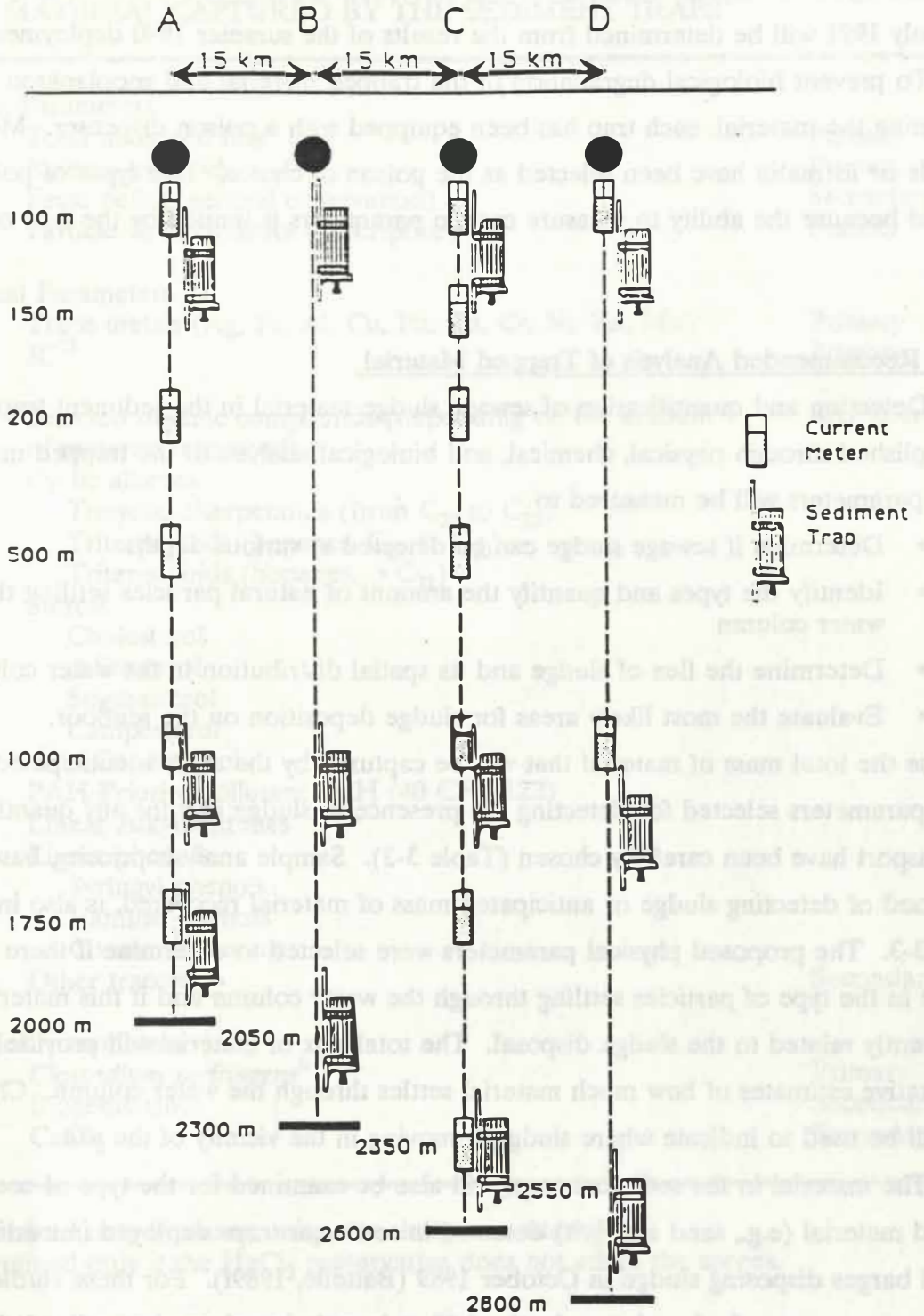


FIGURE 3-3. MOORING DESIGN: CURRENT METERS AND SEDIMENT-TRAP LOCATIONS

recovered again in July of 1991 after a deployment period of 7 to 9 months. Deployment after July 1991 will be determined from the results of the summer 1990 deployment.

To prevent biological degradation of the trapped material and zooplankton from consuming the material, each trap has been equipped with a poison dispenser. Mercuric chloride or formalin have been selected as the poison of choice. Two types of poison were selected because the ability to measure certain parameters is limited by the type of poison used.

3.4.2.2 Recommended Analysis of Trapped Material

Detection and quantification of sewage sludge material in the sediment traps will be accomplished through physical, chemical, and biological analysis of the trapped material. These parameters will be measured to

- Determine if sewage sludge can be detected at various depths
- Identify the types and quantify the amount of natural particles settling through the water column
- Determine the flux of sludge and its spatial distribution in the water column
- Evaluate the most likely areas for sludge deposition on the seafloor.

Because the total mass of material that will be captured by the traps is anticipated to be small, parameters selected for detecting the presence of sludge and for any quantification of its transport have been carefully chosen (Table 3-3). Sample analysis priority, based on the likelihood of detecting sludge or anticipated mass of material recovered, is also indicated in Table 3-3. The proposed physical parameters were selected to determine if there is a change in the type of particles settling through the water column and if this material can be consistently related to the sludge disposal. The total flux of material will provide quantitative estimates of how much material settles through the water column. Changes in flux will be used to indicate where sludge is moving in the vicinity of the site.

The material in the sediment traps will also be examined for the type of coarse-grained material (e.g., sand and grit) detected in sediment traps deployed immediately behind barges disposing sludge in October 1989 (Battelle, 1989f). For these studies, sediment traps were deployed at a depth of 40 m in a sludge plume immediately behind a barge dumping sludge. The traps were recovered after 1 h and the material captured examined for any evidence of settling sludge. The material observed in these traps

TABLE 3-3. SUGGESTED PARAMETERS FOR LABORATORY ANALYSIS OF THE MATERIAL CAPTURED BY THE SEDIMENT TRAPS

Physical Parameters	
Total mass and flux	Primary
Xyleme tracheids	Primary
Fecal pellet (general observation)	Secondary
Particle characteristics (descriptive)	Priority
Chemical Parameters	
Trace metals (Ag, Fe, Al, Cu, Pb, Cd, Cr, Ni, Zn, Mn)	Primary
δC^{13}	Primary
Selected organic compounds (depending on the amount of material recovered)	Secondary
Cyclic alkenes	
Tricyclic diterpenoids (from C_{20} to C_{25})	
Triterpenoids (hopanes, C_{27} to C_{30})	
Triterpenoids (hopanes, $>C_{31}$)	
Sterols	
Cholesterol	
β-Sitrsterol	
Stigmasterol	
Campesterol	
β-Coprostanol	
PAH-Priority pollutant PAH (40 CFR 122)	
Linear Alkylbenzenes	
Lignin phenols	
Syringyl phenols	
Vanillze phenols	
Conmanicphenols	
Other tracers[a]	Secondary
Biological parameters	
Clostridium perfringens[b]	Primary
Biogenic silica	Secondary
$CaC0_3$	Secondary

[a]Will be determined only if tracers unique to sludge are identified.
[b]Will be determined only if the $HgCl_2$ preservative does not effect the spores.

included sand particles, a coarse granular black material, and flocculent organic. The maximum settling rate of this material is estimated to be 40 m/h (1.1 cm/s).

Capture of fecal pellets from marine zooplankton by the traps is expected. The general abundance and size of the pellets will be noted. However, specific measurements or enumeration of fecal pellets are not planned. Other parameters listed in Table 3-3 may be determined if it becomes evident that the information is necessary for interpreting the primary data. Additional rationale for selecting these parameters will be discussed in a Quality Assurance Project Plan developed specifically for the analysis of the sediment-trap samples.

3.4.3 Sediment Studies

Several studies are planned to determine if sludge is reaching the sediments of the outer continental shelf, submarine canyons, or the continental slope near the 106-Mile Site. These studies will be conducted by the National Marine Fisheries Service (NMFS) and the National Undersea Research Program (NURP). NURP is planning to conduct two studies. One program will be conducted in the continental slope and rise environment in the vicinity of the 106-Mile Site; the other program will focus on the outer continental shelf and submarine canyons near the site. Each program has components that relate to the Tier 3 monitoring, but the primary focus of the studies will be on long-term effects (Tier 4). The planned activities are summarized in the following sections and Section 3.5.

3.4.3.1 Studies by the NOAA National Undersea Research Program

The continental slope and rise study will be conducted by Rutgers University through the NOAA NURP office. The outer shelf/canyon study will be conducted by the University of Connecticut NURP office. These activities are not being supported by the ODBA funds, but the data from both programs will be made available to the joint Monitoring Program.

The continental slope and rise study will conduct research to measure contaminants from sludge that may reach the sediments in the vicinity of the 106-Mile Site and to determine possible areas on the seafloor where sludge may accumulate. This study will also determine the fate of material settling to the seafloor ($H_0$17a), especially the pattern of accumulation of particles and particle mixing with respect to sediment resuspension,

microtopography, and the activities of deepsea animal populations. Features that will be studied include depressions and burrows that act as natural sediment traps.

Under the continental slope and rise study, the following tasks will be conducted (the relevant Tier 3 hypothesis for each task is indicated in parentheses):

- Recover current meters and sediment-trap moorings deployed just west of the 106-Mile Site in September 1989 and deploy two similar moorings designed to complement the EPA sediment-trap program ($H_0$17a)
- Analyze and interpret current-meter and sediment-trap data from the September 1989 deployment ($H_0$17a)
- Conduct chemical analyses in short sediment cores collected with a spade box corer for tracers of sewage sludge and the precise ARGO-JASON navigation system ($H_0$17b) (planned for FY91)
- Survey the seafloor, using the ARGO-JASON system and a deep-towed, side-scan sonar unit (planned for FY91)
- Analyze sediments from inside and outside the 106-Mile Site and sediment-trap samples for selected human pathogens ($H_0$17b)

The continental slope and rise study will also examine potential effects of sludge disposal on benthic populations and ichthyoplankton. Those studies are discussed in Section 3.5.

The shelf/canyon study is designed as a long-term research program (3 to 5 years) to be conducted on the outer continental shelf adjacent to the 106-Mile Site and to a depth of ≈700 m in the major submarine canyons in this area. The major objective of this program is

- To determine if gradients in sludge associated contaminants exist in sediments and edible tissue and organs of commercial benthic species on the outer continental shelf and upper slope outside the potential area of impact defined by Bisagni (1983).

Because this study is a long-term research effort, several other objectives relating to station selection, variability in the concentrations of contaminants within stations, and visual documentation (video and still camera) procedures for evaluating species abundance and megabenthic community status are also being addressed by the program.

Under the shelf/canyon study specific regions where there are commercial fisheries will be studied. The planned activities are relevant to both the farfield fate (Tier 3) and long-term effects (Tier 4) studies to be conducted under this joint Monitoring Plan. The study will focus primarily on commercial species such as tilefish *(Lopholatilus chamaeleonticeps),* red crab *(Chaceon quinquedens),* ocean quahog *(Arctica islandica),* and

four-spot flounder *(Paralichthys oblongus),* and the sediments within the habitat of each of these species. The following tasks will be conducted:

- Red crab study: Red crabs from ≈650 m depth at 11 stations located in and adjacent to submarine canyons are being assessed for shell disease, bacterial and faunal species associated with the shell disease, and trace-metal and organic compound concentrations in edible tissue and hepatopancreas.
- Ocean quahog study: Samples of ocean quahogs and sediments are being collected from 27 middle and outer continental shelf locations in association with the NMFS shellfish surveys. Tissues and sediments will be analyzed for trace-metal and organic compounds plus heart tumors and other pathological conditions.
- Four-spot flounder study: Samples collected during NMFS groundfish surveys will be analyzed for (1) trace-metal and organic compounds, (2) disease status, and (3) bacterial flora from fins and the intestinal tract of the organisms.
- Manned submersible studies: Submersible dives will be conducted at stations located in ≈200 and ≈650 m of water within the eight major submarine canyons located between Veatch and Baltimore Canyons. These dives will (1) use laser scaled video to examine the megabenthic communities and (2) collect sediment samples from topographic highs and lows at each site and from within red crab and tilefish borrows for analysis of chemical contaminants and bacterial indicators of sewage sludge.

The sediment samples collected during these studies will contribute to the information necessary to test $H_0$17b. The other studies will contribute to the testing of several Tier 4 hypotheses that are discussed in Section 3.5.

3.4.3.2 NMFS Sediment Studies

NMFS will also collect and analyze sediments from the vicinity of the 106-Mile Site for chemical and bacterial indicators of sludge. Parameters included in the NOAA National Status and Trends Program will be measured (Table 3-4). These samples will be collected as part of the long-term effects studies discussed in Section 3.5. Metals, pesticides, PAHs, PCBs, coprostanol, and bacterial indicators (*Clostridium perfringens* spores) will be analyzed in sediments from Sites 1 through 31 (see Section 3.5.1 for station locations). These sediment samples will be collected with a box core. Replicated box cores

TABLE 3-4. PARAMETERS THAT WILL BE DETERMINED BY NOAA IN SEDIMENT ORGANISMS COLLECTED AT THE 106-MILE SITE. These parameters are the same as those determined in the NOAA National Status and Trends Program.

Polynuclear Aromatic Hydrocarbons
Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene
Biphenyl
2,6-Dimethylnaphthalene
Acenaphthylene
Acenaphthene
2,3,5-Trimethylnaphthalene
Fluorene
Phenanthrene
Anthracene
1-Methylphenanthrene
Fluoranthene
Pyrene
Benz(*a*)anthracene
Chyrsene
Benzo(*b*)fluoranthene
Benzo(*k*)Fluoranthene
Benzo(*e*)pyrene
Benzo(*a*)pyrene
Perylene
Indeno(1,2,3-*c,d*)pyrene
Dibenz(*a,h*)anthracene
Benzo(*g,h,i*)perylene

Pesticides
Hexachlorobenzene
Lindane
Heptachlor
Aldrin
Heptachlorepoxide
alpha-Chlordane
trans-Nonachlor
Dieldrin
Mirex
o,p'-DDD
p,p'-DDD
o,p'-DDE
o,p'-DDE
o,p'-DDT
p,p'-DDT

Butyltins
Tributyltin
Dibutyltin
Monobutyltin
Tetrabutyltin

Polychlorinated Biphenyls
2,4,-Cl2(8)
2,2'5-Cl3(18)
2,4,4'-Cl3(28)
2,2'3,5'-Cl4(44)
2,2',5,5'-Cl4(52)
2,3',4,4'-Cl4(66)
2,2'4,5,5'-Cl5(101)
2,3,3'4,4'-Cl5(105)
2,3'4,4',5-Cl5(118)
2,2'3,3',4,4'-Cl6(128)
2,2'3,4,4',5'-Cl6(138)
2,2',4,4'5,5'-Cl6(153)
2,2',3,3',4,4',5-Cl7(170)
2,2',3,4,4',5,5'-Cl7(180)
2,2',3,4,5,5',6-Cl7(187)
2,2',3,3',4,4',5,6-Cl8(195)
2,2',3,3'4,4',5,5',6-Cl9(206)
Decachlorobiphenyl-Cl10(209)

Trace Metals
Aluminum (Al)
Silver (Ag)
Arsenic (As)
Cadmium (Cd)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Mercury (Hg)
Nickel (Ni)
Lead (Pb)
Selenium (Se)
Tin (Sn)
Zinc (Zn)

Auxiliary Parameters
Total organic carbon/total carbonate (TOC/TIC) (sediment)
Clostridium perfringens (sediment)
Sediment grain size (sediment

will be collected at only 12 stations. These stations will be selected to coincide with the stations sampled previously during baseline surveys or previous studies in the area. Single box cores will be collected at the remaining 19 stations. Multiple undisturbed subsamples will be taken from each sample. Cores for contaminant analysis will be frozen; those for bacterial analysis will be refrigerated at 2° to 4°C. Cores will be subsectioned in horizontal strata at shore-based laboratories for analysis.

The results of the analyses will be used in interpreting any observed effects in organisms collect at the same time under these programs. In addition, the results will used to identify possible linkages with sludge disposal at the 106-Mile Site.

3.4.4 Modeling

NOAA will continue to evaluate possible models that can be used to determine the fate of sludge and to identify possible deposition areas. An appropriate sludge transport model should include three components: a water-circulation component, an advection-diffusion component, and a particle-deposition component. Potential circulation models include a Dynalysis, Inc., model of the Middle Atlantic Bight (Mellor and Ezer, 1990) and Harvard Gulf Stream model (Robinson and Walstad, 1987).

During FY90, NOAA will assess the suitability of historical data sets that could be used to initialize a circulation model or to compare with results from a model of the farfield fate of sludge constituents. Viable historical data include measurements of temperature and salinity (CTD and XBT data) and data from moored current meters taken during the Shelf Edge Exchange Processes (SEEP I and II) programs and the Middle Atlantic Slope and Rise (MASAR) experiment.

During FY91, NOAA will evaluate the utility of using output from available circulation models as input to the circulation component of a transport model for the environs of the 106-Mile Dumpsite. NOAA will also assess existing advection-diffusion and particle transport models for suitability of application. Potential advection-diffusion models include those of O'Connor et al. (1983) and Walker et al. (1987). Potential deposition models include those of Partch (1985) and Nocito-Gobel et al. (1989).

EPA modeling studies will be used primarily to help to interpret the sediment-trap data. Models will form the primary link between the Lagrangian and Eulerian field

observations and data results from the sediment traps. Specific model requirements will be refined during the planning phase for the data syntheses designed to evaluate the farfield fate of the sludge (Section 4.2.1).

3.5 TIER 4: LONG-TERM EFFECTS

The continuing monitoring, research, and surveillance plan will test some of the same hypotheses that were included in Tier 4 of EPA's Monitoring Plan. Other hypotheses listed in the EPA Monitoring Plan have been modified; still other hypotheses are added to this tier of the joint Monitoring Plan. Hypotheses that are carried over from the EPA Monitoring Plan include

$H_0$18: Sludge constituents have no significant long-term effect on the distribution of endangered species in the vicinity of the site.

$H_0$19 Sludge constituents do not accumulate in the tissues of commercially important species resident in the shelf and slope areas adjacent to the site.

$H_0$21: Sludge disposal has no effect on eggs and larval stages of indigenous animals.

$H_0$23: Pathogens or biological tracers of sewage sludge do not increase in the water column or biota as a result of sludge disposal.

Hypothesis $H_0$18 is intended to ensure that endangered species are considered in the plan. The emphasis for testing $H_0$18 will be shipboard observations to identify and enumerate marine mammals (to include endangered species) occurrence and distribution near the 106-Mile Site. Testing of contaminant levels in endangered species is not planned. $H_0$22 of the EPA Monitoring Plan is not included because lack of baseline data makes a definitive test difficult. This new plan modifies $H_0$20 of the EPA Monitoring Plan to test effects on benthic organisms and populations as well as communities. The revised hypothesis is

$H_0$20: Benthic metabolism, populations, and/or communities do not change significantly because of sludge disposal.

The new plan also includes the following new hypotheses.

$H_0$24: There are no detectable differences in the body burdens of sludge contaminants in midwater fishes in the immediate vicinity of the 106-Mile Site compared to a broad area surrounding the dumpsite.

$H_0$25: The prevalence of shell disease exhibited by commercially important crustaceans is not significantly different in collections of commercially valuable American lobsters and red crabs, off New Jersey, adjacent to and downstream from the 106-Mile Site, from those in collections off Georges Bank and southern New England.

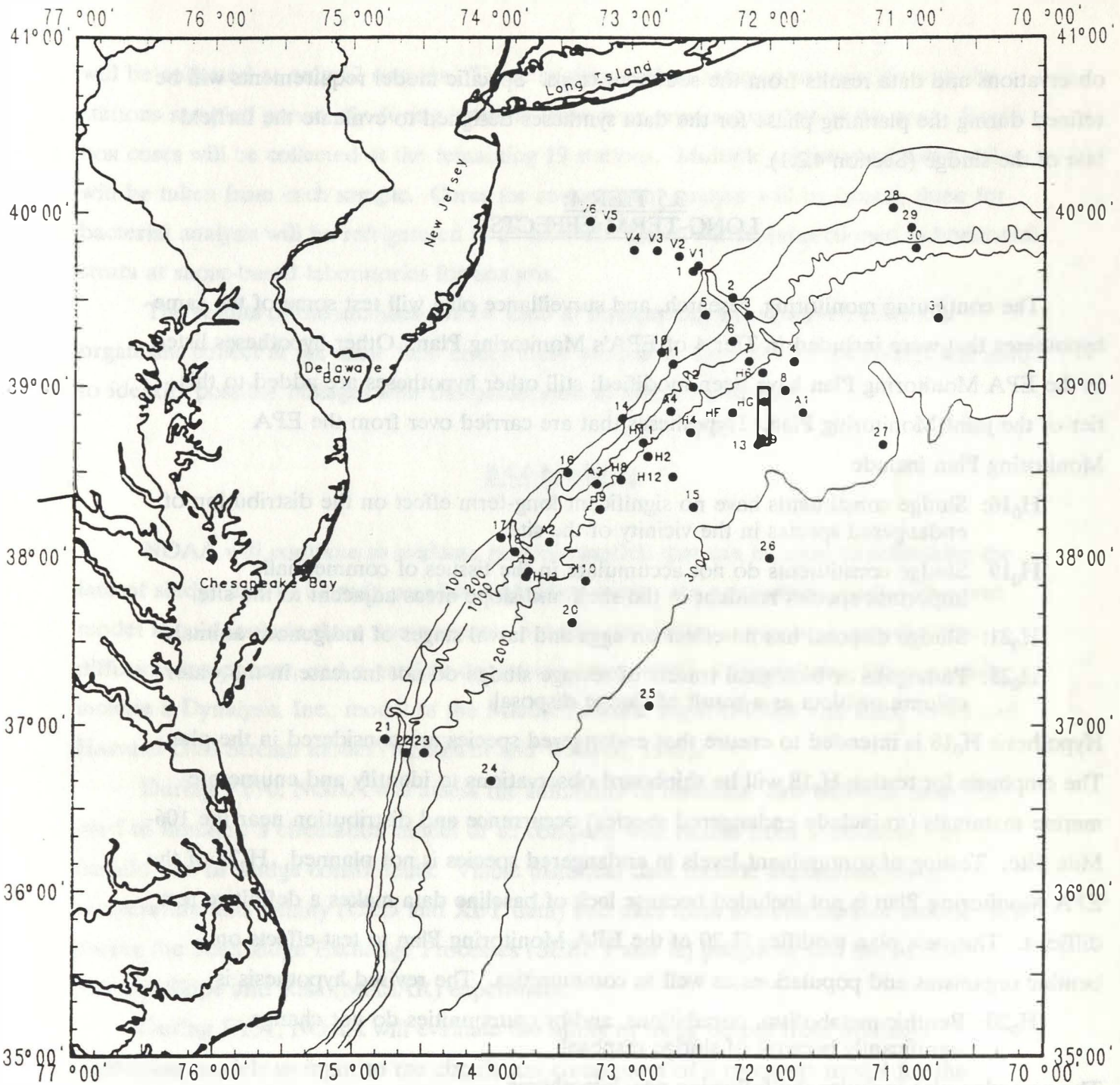


FIGURE 3-4. PROPOSED LOCATIONS FOR NOAA SEDIMENT AND TRAWL STATIONS.

Bioaccumulation by macrobenthic organisms ($H_0$19and $H_0$28). A wide variety of benthic fish and shellfish occurs on the continental shelf and on the slope to depths of 500 m (NOAA, 1983; Maciolek et al., 1987). Lobsters, red crabs, and tilefish are the most abundant resource species, although their ranges do not extend much deeper than 500 m. They are not found within the 106-Mile Site. Below 1000 m, brittle stars, sea urchins, and rattails are the predominant species. Densities of organisms are very low at those depths, generally less than 0.1 to 1 animal per square meter.

An Isaacs-Kidd trawl will be used to collect benthic fishes and crustaceans at depths between 200 and 3500 m. Because tilefish, American lobsters, and red crabs cannot always be collected with this gear or at the stations specified for the benthic samplings, separate collections will be made through the commercial fishery. These collections will be undertaken at several continental slope areas which may include Lydonia, Atlantis, Hudson-Toms, Baltimore, and Norfolk Canyons, depending on the fishery. Traps will be set for lobsters; long lines or hand lines will be used for tilefish.

Whenever the otter trawl catch permits, as many as 30, but no fewer than 12, individuals of as many as five benthic species will be collected, identified, and sorted for chemical analysis. For the lobsters, at least 20 adult individuals, half with and half without evidence of substantial shell disease, will be collected at each station. At least 10 tile fish will be sampled at each site. One to as many as five species from each site will be analyzed for metals, pesticides, PAHs, and PCBs. Resource species will be preferred.

The shelf/canyon study will also measure bioaccumulation of metals and organic compounds in several commercial species (see Section 3.4.3.1 for details). The results of these studies can be applied to hypotheses $H_0$19, $H_0$23, $H_0$26, and $H_0$28.

Measurement of chemical contamination in American lobsters and red crab ($H_0$19, $H_0$27, and $H_0$28). Given the uncertainty that sludge-derived contaminants might reach the continental slope of New Jersey and the Delmarva peninsula, specimens of American lobsters and red crabs will be obtained to determine the prevalence of shell disease (Section 3.4.3.1 and 3.5.2). The chemical contaminants in organisms recovered during the shellfish disease study will be determined. Approximately 20 adult American lobsters, half with and half without substantial evidence of shell disease, will be collected the five previously indicted continental slope area stations for chemical analysis. Both the muscle

and the hepatopancreas will be analyzed for the same metal and organic compounds measured in benthic organisms and midwater fish collected under this Monitoring Plan.

Contaminants will also be measured in the red crabs sampled under the shelf/canyon study (Section 3.4.3.1). These results will help in the evaluation of hypotheses $H_0$25 and $H_0$27.

Bioaccumulation by midwater fishes ($H_0$24). The lantern fishes (Myctophidae) and hatchet fishes (Sternopychidae) are relatively abundant throughout the slope water of the Middle Atlantic. Trawls in the vicinity of the 106-Mile Site indicate that they are the most abundant of the midwater fishes, comprising 95 percent of the nighttime catch in the upper 200 m and 90 percent of the daytime catch in the upper 800 m. Lantern and hatchet fishes migrate vertically, moving to the surface to feed (on zooplankton and micronekton) at night and returning to depths of 200-700 m before daylight. They are weak swimmers, and except for their vertical migrations are essentially planktonic.

These midwater fishes have been selected as the primary organisms for detecting and studying the presence of sludge associated contaminants surface waters in the vicinity of the 106-Mile Site. Samples will be collected from the vicinity of the 106-Mile Site and in a pattern over a broad area around the site (Figure 3-5). A stepwise double-oblique towing profile focused on the expected capture depth for the time of day of sampling and water mass present will be used to recover the organisms. An Isaacs-Kidd or other midwater trawl will be used for sampling.

Captured fishes will be sorted, identified, measured, counted, and frozen for transport to the analytical laboratories. Twenty individual specimens of each of the seven most abundant species will be collected from each trawl. Samples of zooplankton and micronekton will also be recovered for contaminant analysis. The strategy will be to oversample, so that similarity of species among sites can be maximized. At the end of each sampling survey, the three species at each station that give the best area coverage will be selected for analysis. Organisms will be analyzed for the same metals and organic compounds determined in the benthic organisms. Where possible, 10 samples (individuals or composites of two organisms) of each species selected will be analyzed.

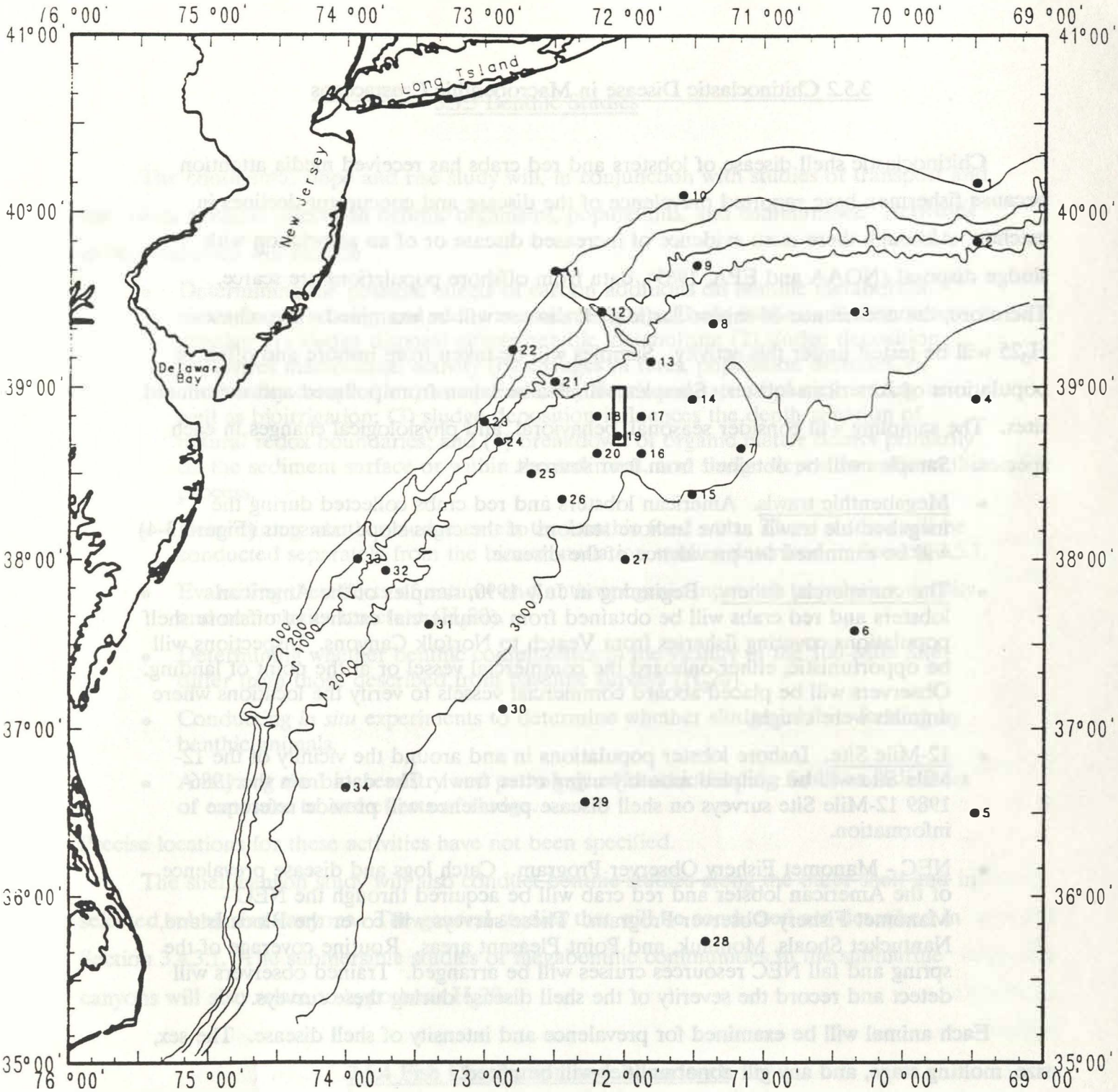


FIGURE 3-5. PROPOSED LOCATIONS FOR NOAA MYCTOPHID SURVEYS

3.5.2 Chitinoclastic Disease in Macrobenthic Crustaceans

Chitinoclastic shell disease of lobsters and red crabs has received media attention because fishermen have reported prevalence of the disease and concurrent declines in catches. Although there is no evidence of increased disease or of an association with sludge disposal (NOAA and EPA, 1989), data from offshore populations are scarce. Therefore, the occurrence of chitinoclastic shell disease will be examined. Hypotheses $H_0$25 will be tested under this activity. Samples will be taken from inshore and offshore populations of American lobster. Samples will also be taken from polluted and unpolluted sites. The sampling will consider seasonal, behavioral, and physiological changes in each species. Samples will be obtained from four sources.

- Megabenthic trawls. American lobsters and red crabs collected during the megabenthic trawls at the inshore stations of the cross-slope transects (Figure 3-4) will be examined for prevalence of the disease.
- The commercial fishery. Beginning in July 1990, samples of the American lobsters and red crabs will be obtained from commercial catches of offshore shelf populations covering fisheries from Veatch to Norfolk Canyons. Inspections will be opportunistic, either onboard the commercial vessel or at the point of landing. Observers will be placed aboard commercial vessels to verify the locations where animals were caught.
- 12-Mile Site. Inshore lobster populations in and around the vicinity of the 12-Mile Site will be sampled monthly using otter trawl. The data from the 1986-1989 12-Mile Site surveys on shell disease prevalence will provide reference information.
- NEC - Manomet Fishery Observer Program. Catch logs and disease prevalence of the American lobster and red crab will be acquired through the NEC - Manomet Fishery Observer Program. These surveys will cover the Block Island, Nantucket Shoals, Montauk, and Point Pleasant areas. Routine coverage of the spring and fall NEC resources cruises will be arranged. Trained observers will detect and record the severity of the shell disease during these surveys.

Each animal will be examined for prevalence and intensity of shell disease. The sex, size, molting stage, and any gill abnormalities will be noted.

The shelf/canyon study also plans to examine red crabs for shell disease as described in Section 3.4.3.1. These results may also be applied to evaluating hypothesis $H_0$25.

3.5.3 Benthic Studies

The continental slope and rise study will, in conjunction with studies of transport and fate, study possible effects on benthic organisms, populations, and communities. Activities to be conducted will include

- Determining the possible effects of carbon additions on benthic metabolism, macrofaunal activity, and redox zonation ($H_0$20). These studies will determine whether (1) sludge disposal affects benthic metabolism; (2) sludge deposition influences macrofaunal activity (by changes in rates, population densities, or community composition) as evidenced by depth and rate of particle mixing as well as bioirrigation; (3) sludge deposition influences the depth zonation of natural redox boundaries; and (4) breakdown of organic matter occurs primarily on the sediment surface or within the sediment, and sludge deposition affects this process.
- Determining whether sludge enters the benthic food web. These studies will be conducted separately from the bioaccumulation studies described in Section 3.5.1.
- Evaluating the effects of natural and anthropogenic inputs on population density and community structure ($H_0$20).
- Determining whether benthic communities in the vicinity of the 106-Mile Site differ from those described from baseline surveys ($H_0$20).
- Conducting *in situ* experiments to determine whether sludge inhibits feeding by benthic animals.
- Analyzing the biochemistry and pathology of benthic-feeding fishes as indicators of exposure to and effects of sludge.

Precise locations for these activities have not been specified.

The shelf/canyon study will also conduct benthic studies along the outer shelf and in selected submarine canyons. The general studies that will be conducted are described in Section 3.4.3.1. The submersible studies of megabenthic communities in the submarine canyons will also relate to hypothesis $H_0$20.

3.5.4 Fish Distribution and Abundance

Studies to test the null hypothesis $H_0$29 will be supported under NMFS funded programs rather than fees collected under ODBA. These studies will assess the possible influence of dumping on the temporal and spatial differences in fish distribution and abundance as determined through analysis of catch per unit effort (CPUE) data.

3.5.5 Sensitive Life Stage Studies

Under the continental shelf and rise program, ichthyoplankton samples will be collected using surface-deployed nets. The results from these samples will be compared with previous studies in the region (hypothesis $H_0$21). Methods used in the studies will follow those used in the NOAA MARMAP program. Double-oblique tows using a frame fitted with a 0.05-mm-mesh net will be performed. The net will be lowered to a maximum depth of 200 m at 50 m/min and retrieved at 20 m/min. Ship speed will be maintained at 1 to 2 kn. Information on distribution of fish eggs and larvae will be compared with similar information from reference stations. These activities are not expected to provide definitive evidence of effects on sensitive life stages of fishes. However, they will provide ongoing measurements that can be assessed in conjunction with additional studies, should Tier 3 results indicate that degradation of water quality in the vicinity of the site may occur.

3.5.6 Pathogen and Biological Tracers of Sewage Sludge

Enumeration of *Clostridium perfringens* spores will be made on samples from the EPA sediment-trap study and on samples collected in conjunction with the various sediment studies planned by NOAA. The results will be used to test hypothesis $H_0$17b in Tier 3.

The NURP studies will also look for selected human pathogens and biological tracers of sewage sludge in sediment samples from the vicinity of the site, various submarine canyons, and outer continental shelf areas. The pathogen *Acanthamoeba* will be determined in sediment collected as part of the shelf/canyon study. As part of the continental shelf and rise program, sediment samples will be tested for total microbial nucleic acids to detect enteropathogenic bacteria using pathogen-specific hybridization probes and microbial community structure using DNA-DNA reassociation kinetics. One organism that the sediments will be tested for is *Salmonella*. Other tests may be used as they are developed. The DNA-DNA reassociation studies will be used to examine the complexity of the microbial population in sediments in and near the 106-Mile Site and will compare the results against control stations.

3.5.7 Endangered Species Studies

EPA and NOAA will continue to include trained observers of marine mammals, reptiles, and birds on all surveys related to the 106-Mile Site with available space. The data will be used to evaluate $H_0$18. The observers will record the presence, number, and behavior of all species of mammals, reptiles, and birds in 15-min intervals along the survey track (Payne et al., 1984). Each observation period represents a transect, and several transects are to be performed each day during the survey. Data from each survey conducted while dumping is taking place will be compared to data from predumping surveys. Such observations are expected to continue throughout the use of the site.

4.0 SCHEDULE, COMMUNICATIONS, AND DATA USE FOR THE 106-MILE SITE MONITORING PLAN

This section integrates the findings of EPA's past monitoring efforts with the plans for continued monitoring, research, and surveillance by EPA, NOAA, and the USCG. It presents an overall schedule for the program; describes the plans for communications among the agencies, with members of the scientific community, and with the public; and shows how results of the program have been and will continue to be used.

4.1 MASTER SCHEDULE FOR THE PROGRAM

Responsibilities for activities conducted as part of the monitoring, research, and surveillance plan are summarized in Table 4-1. Responsibilities are divided among EPA, NOAA, and the USCG. The schedule of activities already completed by the EPA monitoring program and for implementing those new activities planned by EPA, NOAA, and the USCG is presented in Figure 4-1.

Monitoring at the 106-Mile Site began in 1984 with surveys for collection of baseline information in support of the site designation process. Additional baseline data were collected during 1985 and 1986. Dumping at the site had already begun when 1986 data were collected. However, stations were selected to avoid contamination from sludge plumes.

Initial evaluations of variability for Tier 1 monitoring of sludge characteristics and disposal operations were completed during 1988. Permits for continued use of the site, which were issued in 1989, have specified continued monitoring and surveillance. Tier 2 monitoring was initiated with preliminary observations of sludge plumes in the summer of 1986 and with collection of water samples in the plume in conjunction with plume-tracking exercises in the summer of 1987. Winter and summer measurements were made in 1988, and winter measurements were repeated in 1989. Also, during 1989 a surface-current mooring was deployed. Short-term biological assessments were made during the summer 1988 survey.

TABLE 4-1. RESPONSIBILITIES FOR MONITORING, RESEARCH, AND SURVEILLANCE DURING 1990-1992. (T: Tables. E: Electronic Format. R: Reports. G: Graphics.)

Activity	Data Collection	Data Archive[a]	Data Availability and Frequency of Distribution	Data Format
Sludge Characteristics				
Ongoing Monitoring	Permittees	EPA	Monthly	E,T
Disposal Operations				
Ongoing Surveillance	Permittees	USCG/EPA	Monthly	E,T
Nearfield Fate				
Current Meter	EPA	EPA	Monthly; 2 months for internally recording units	E,G,R
XCP Deployment	Permittees	EPA	Monthly	E,G,R

TABLE 4-1. RESPONSIBILITIES FOR MONITORING, RESEARCH, AND SURVEILLANCE DURING 1990-1992. (T: Tables. E: Electronic Format. R: Reports. G: Graphics.) (CONTINUED)

Activity	Data Collection	Data Archive[a]	Data Availability and Frequency of Distrubution	Data Format
Farfield Fate				
Drifters	EPA	EPA	Monthly	E,G,R
Seasonal Drifter Study	NOAA	NOAA	Monthly	E,R
SST Imagery	NOAA	EPA/NOAA NOS	Monthly	E,G,R
XBT Deployment	NOAA	EPA/NOAA NOS	Monthly	E,G,R
MWDAS[b] Station	EPA	EPA	Monthly	E,G,R
Sediment Traps	EPA	EPA	Within 4 months of recovery	E,R
	NOAA (NURP)[c]	NOAA	Within 6 months of recovery	E,R
Current Meters	EPA	EPA	Within 4 months of recovery	E,R
	NOAA (NURP)[c]	NOAA	Within 6 months of recovery	E,R
Hydrographic Studies	NOAA	NOAA	Within 6 months of survey	E,R
Sediment Studies	NOAA	NOAA	Within 6 to 12 months of survey	E,R
	NOAA (NURP)	NOAA	Within 6 to 12 months of survey	E,R

TABLE 4-1. RESPONSIBILITIES FOR MONITORING, RESEARCH, AND SURVEILLANCE DURING 1990-1992. (T: Tables. E: Electronic Format. R: Reports. G: Graphics.) (CONTINUED)

Activity	Data Collection	Data Archive[a]	Data Availability and Frequency of Distribution	Data Format
Long-Term Effects				
Endangered Species Observations	EPA and NOAA	EPA	Within 4 months of survey	E,R
Bioaccumulation Studies	NOAA	NOAA	Within 10 to 12 months of survey	E,G,R
Chitinoclasia Studies	NOAA	NOAA	Within 10 to 12 months of survey	E,R
Benthic Studies	NOAA (NURP)[c]	NOAA	Within 10 to 12 months of survey	E,R
Sensitive Life-Stage Studies	NOAA (NURP)[c]	NOAA	Within 10 to 12 months of survey	E,R
Selected Pathogen Studies	NOAA/ NOAA (NURP)[c]	NOAA	Within 6 to 12 months of survey	E,R

[a]Indexing system.

[b]Meteorological/Wave Data Acquisition System.

[c]NURP is participating in this program under separate source of research funds.

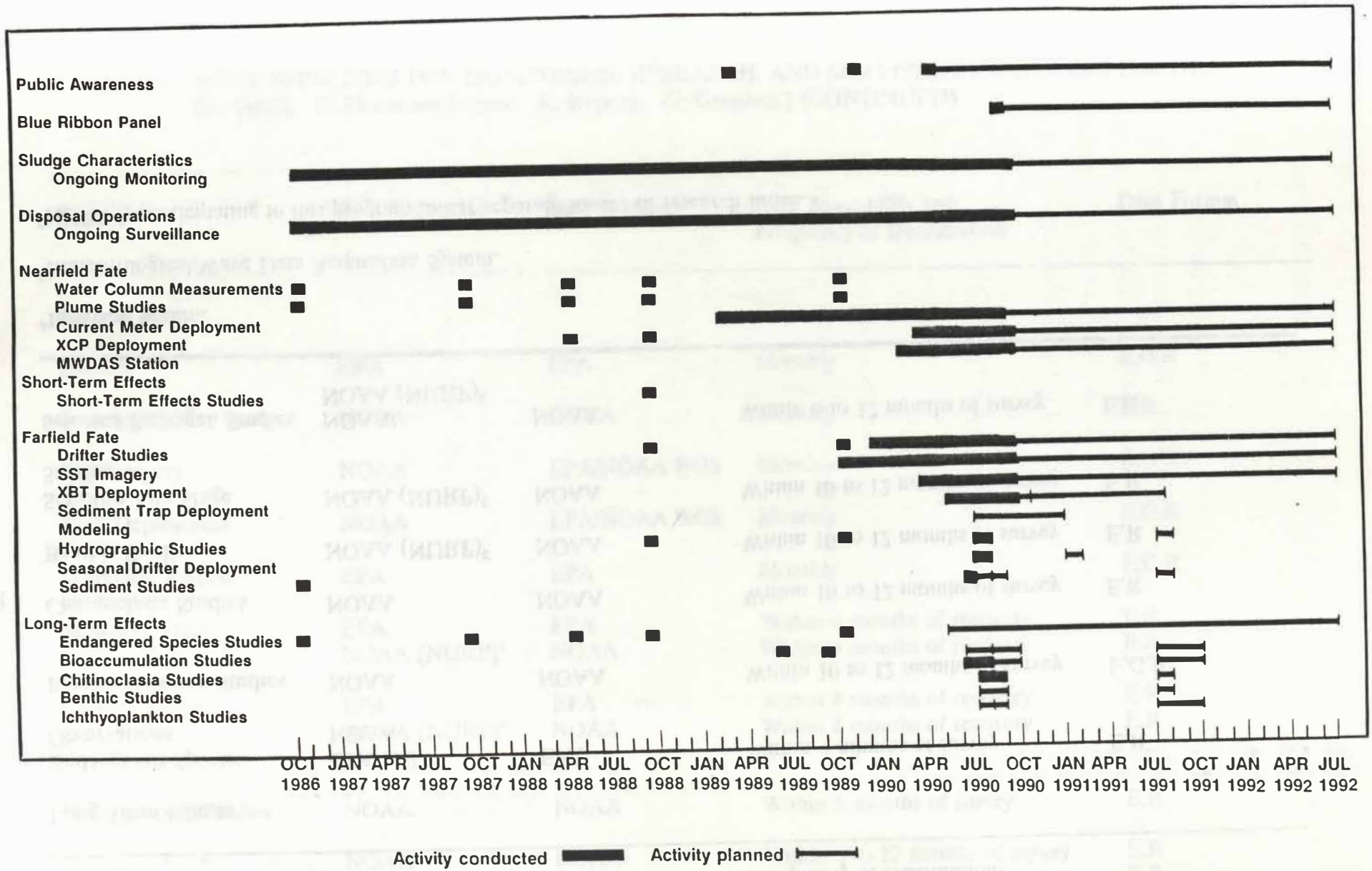


FIGURE 4-1. MASTER SCHEDULE AND ACTIVITIES CONDUCTED AS OF OCTOBER 1990 FOR THE MONITORING, RESEARCH, AND SURVEILLANCE PROGRAM

Many Tier 2 studies were completed in 1989; others will extend through 1991. In March 1990, weekly XCP deployments from sludge barges began and will extend through 1991. Data from these will be used to determine the vertical shear in horizontal currents and water temperature.

Tier 3 monitoring was initiated in 1988. Use of drifters and remote sensing to estimate farfield fate of sludge disposed at the site was initiated in 1988. Weekly drifter deployments will begin in March 1990. Also, the surface-current mooring deployed for Tier 2 is being used for Tier 3 studies. Further Tier 3 studies, including sediment studies, will be conducted during 1990 and 1991.

Long-term effects, Tier 4, studies were initiated in 1989 and will continue for the duration of the program. Effects on endangered species have been assessed since dumping began and will continue throughout the life of the program. During 1989, NOAA and EPA conducted preliminary studies of contaminants in lantern and hatchet fishes. Other bioaccumulation studies, studies of chitinoclasia, benthic studies, assessment of ichthyoplankton, and measurements of pathogens in sediments will proceed during 1990 and 1991.

Monitoring and research activities to be conducted in 1992 will be determined based on results from the 1990 and 1991 monitoring. These may include continuing the program discussed previously or modifying certain aspects based on the results of the monitoring and research program and ongoing sludge disposal activities.

4.2 COMMUNICATIONS AND DATA EXCHANGE

Communications and data exchange are integral parts of the monitoring, research, and surveillance program. This section describes (1) data quality and data exchange; (2) expert reviews of plans and results; and (3) public awareness.

4.2.1 Quality Assurance Requirements

All activities under the joint Monitoring Plan will be conducted under well defined Quality Assurance programs. Specific quality assurance activities conducted under the joint Monitoring Plan will be the responsibility of each agency conducting the activity. All

activities will be conducted under project-specific plans (e.g., survey, laboratory, or other work plan) that specify at a minimum the project goals, the relationship of the specific project to the overall joint Monitoring Plan, the hypotheses from the joint Monitoring Plan that are being tested, schedules of activities, data quality requirements, sample or data collection procedures, analytical methods and quality control measures, and data documentation and validation procedures. Analytical laboratories performing chemical analysis must participate in the quality assurance program used in the National Status and Trends (NS&T) program. This will ensure accuracy, precision, and comparability of sediment and tissues results being generated by the various laboratories. The NOAA NS&T quality assurance program includes the National Institute of Standards and Technology (NIST)/NOAA NS&T program for organic contaminants and the National Research Council (NRC) of Canada/NOAA NS&T program for metals.

Data interpretation and synthesis will be the responsibility of all three agencies issuing the joint Monitoring Plan. Because of the complex interactions required to evaluate the sludge fate, an organization chart showing the interrelationships of research activities in Tiers 2 and 3 are shown in Figure 4-2. Synthesis of data will take place as reports are being written. EPA has established a specific project to synthesize the data obtained under the EPA Tier 3 Farfield Fate studies. The overall synthesis of the physical oceanographic data will include application of simple transport models designed to bridge the sediment-trap observations and the physical oceanographic data. The model will form a framework for evaluating sludge transport and fate information derived from the sediment-trap program. The interrelationship of the long-term effects studies has been similarly organized (Figure 4-3).

4.2.2 Reports and Information Exchange

Several reports have been and will continue to be prepared by EPA and NOAA to document the plans and results of the program. Descriptions of those reports that will be developed under the program are presented in Table 4-2.

Records of work to be performed, including details about sampling locations and methods for sampling and analysis are currently documented in work plans or work/quality

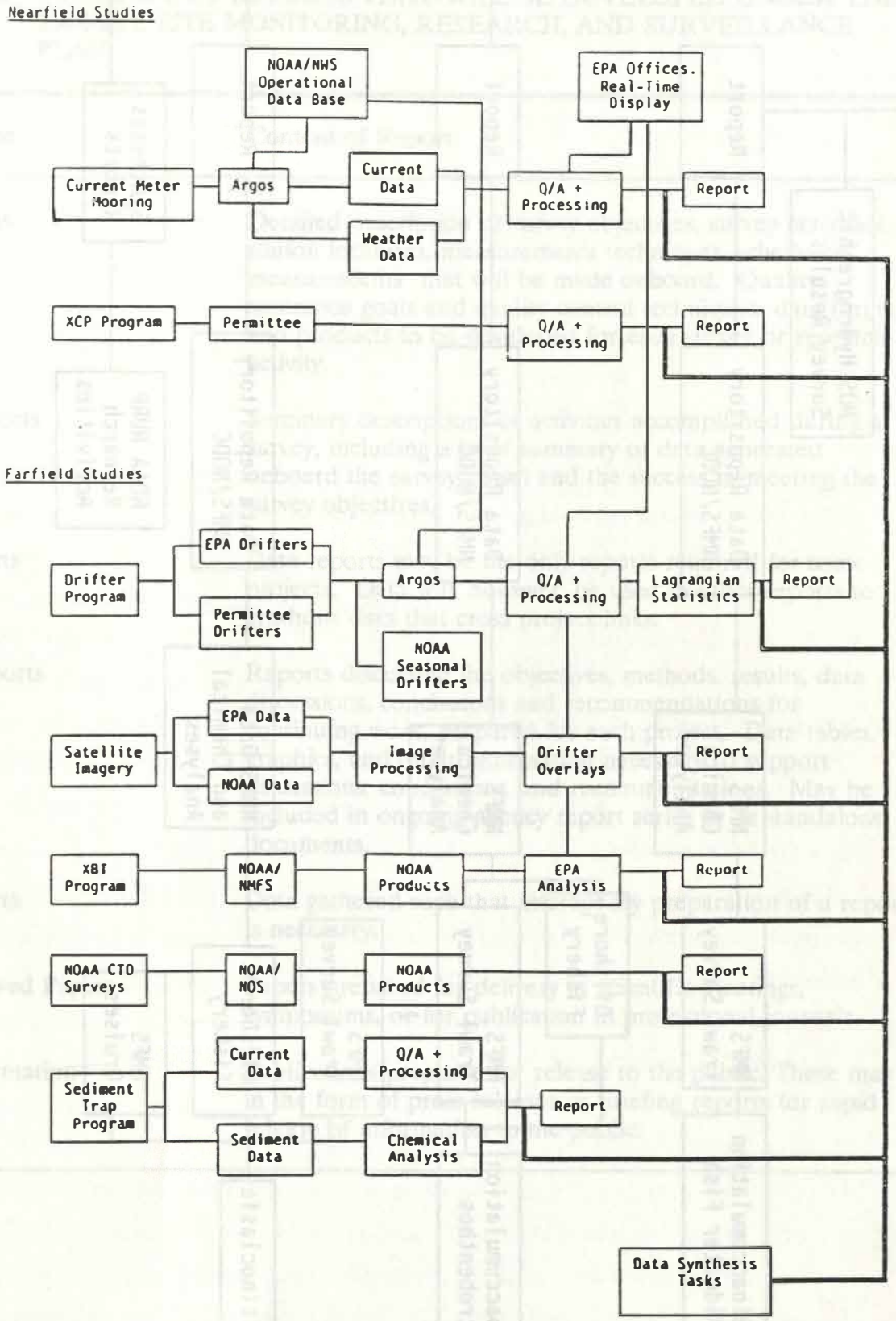


FIGURE 4-2. TIER 2 AND TIER 3 MONITORING AND RESEARCH ACTIVITIES, DATA SOURCES, DATA PROCESSING REPORTS, AND SYNTHESIS

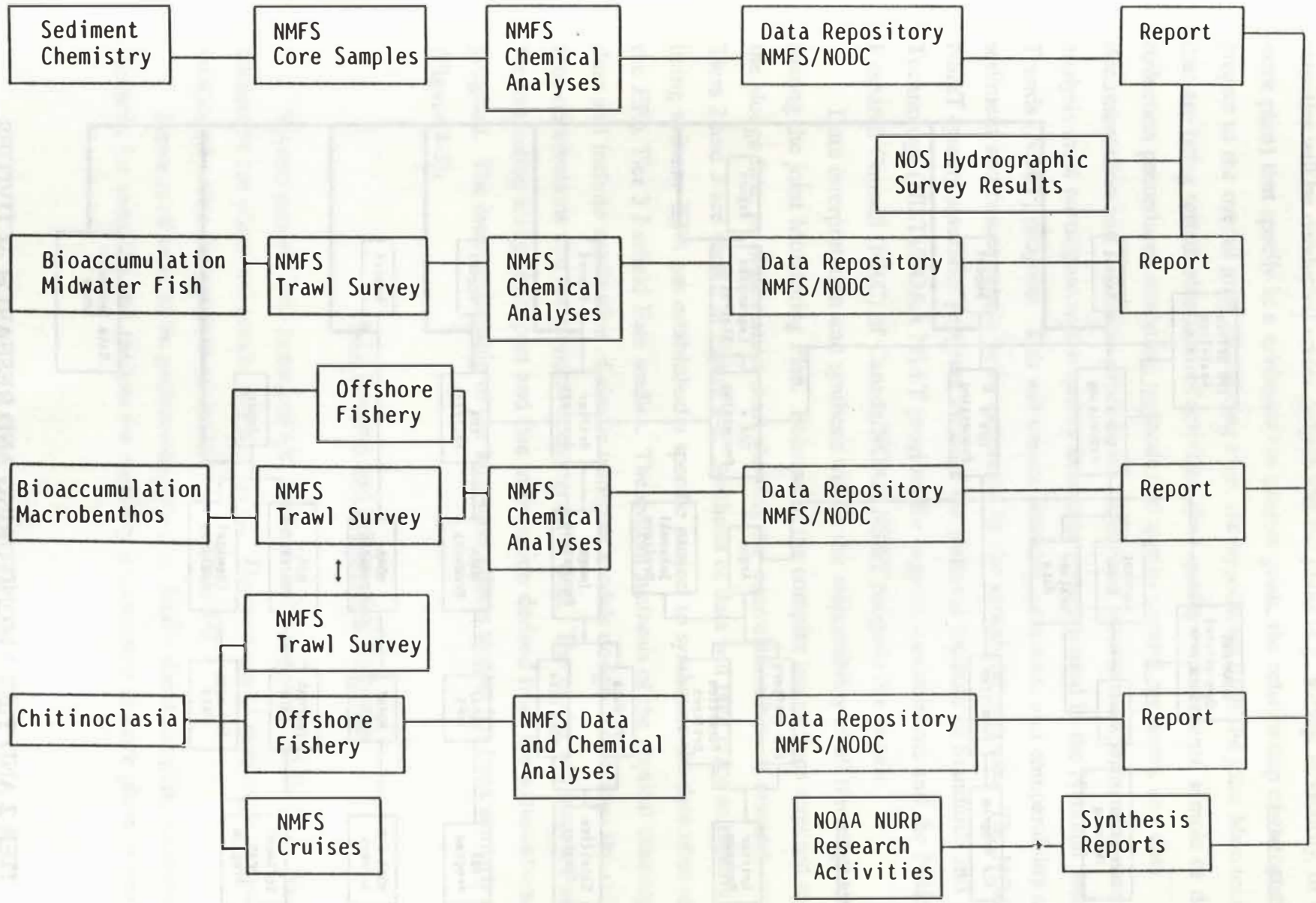


FIGURE 4-3. NOAA NMFS ODBA-FUNDED RESEARCH AND MONITORING ACTIVITIES, DATA SOURCES, REPORTS, AND DATA SYNTHESIS. RESEARCH ACTIVITIES PLANNED BY THE NURP PROGRAMS ARE DISCUSSED IN THE TEXT OF THE JOINT MONITORING PLAN

TABLE 4-2. SUMMARY OF REPORTS THAT WILL BE DEVELOPED UNDER THE 106-MILE SITE MONITORING, RESEARCH, AND SURVEILLANCE PLAN

Report Type	Content of Report
Survey Plans	Detailed description of survey objectives, survey activities, station locations, measurements techniques, schedules, measurements that will be made onboard. Quality-assurance goals and quality-control techniques, data formats, and products to be developed for each survey or research activity.
Survey Reports	Summary descriptions of activities accomplished during a survey, including a brief summary of data generated onboard the survey vessel and the success in meeting the survey objectives.
Data Reports	Data reports may be the only reports required for some projects. Data will, however, be used in other reports to synthesis data that cross project lines.
Project Reports	Reports discussing the objectives, methods, results, data discussions, conclusions and recommendations for continuing work, prepared for each project. Data tables, graphics, and other information necessary to support discussions, conclusions, and recommendations. May be included in ongoing agency report series or as standalone documents.
Joint Reports	Data gathered such that interagency preparation of a report is necessary.
Peer-Reviewed Papers	Papers prepared for delivery at scientific meetings, symposiums, or for publication in professional journals.
Public Information	Publications prepared for release to the public. These may in the form of press releases or briefing reports for rapid release of information to the public.

TABLE 4-2. SUMMARY OF REPORTS THAT WILL BE DEVELOPED UNDER THE 106-MILE SITE MONITORING, RESEARCH, AND SURVEILLANCE PLAN (CONTINUED).

Report Type	Content of Report
Reports to the Congress	ODBA-required reports on the progress towards ending ocean dumping and on monitoring results.
Ocean-Dumping Symposium	During FY91 or FY92, a conference to review the status of the 106-Mile Site Monitoring activities is planned. The symposium will include international activities related to sewage sludge disposal and synthesize existing data on the 106-Mile Site, proceedings volume will be published.
Final Compendium	At the conclusions of all research, monitoring, and surveillance activities involving sewage sludge disposal at the 106-Mile Site a final compendium of results will be prepared. The compendium will summarize the findings of the research plus consider regulatory issues, management actions, scientific results. This will provide a volume upon which scientists and policy makers can draw for information on the use of the ocean for waste disposal should such options be considered in the future.

assurance project plans and survey plans. These types of documents are required for all projects and surveys. Results are documented in survey, data, and final project reports. Other reports may also be issued as necessary.

So that information will be shared between NOAA and EPA, regular meetings will be held to plan activities and discuss results. As required by the ODBA, an annual report to the Congress, prepared by EPA with NOAA and USCG review, will summarize results of the monitoring, research, and surveillance program.

4.2.3 Data Management and Archival

So that other participating scientists may use the information gathered during the joint monitoring program, a data management plan will be developed and implemented. The data management plan will allow ready access to the information generated during the various monitoring and research efforts. However, a single centralized data management system containing all data generated under the joint Monitoring Plan will not be developed. Initially, each agency or investigator participating in the joint program will be responsible for maintaining data in readily accessible formats and locations. These data will be made available to the data management system when it is implemented. When possible, data will be maintained within data management systems presently available within each agency.

For long-term data archival, Federal data systems currently available for storage of environmental or oceanographic data may be used. Such systems as the NOAA National Ocean Data Center (NODC) or the EPA STORET or Ocean Data Evaluation System (ODES) will be employed when possible. Final disposition of all data will be determined before the joint monitoring program is closed. All projects conducted under the joint monitoring program will be encouraged to provide data to the database management systems in a timely manner and will be required to submit data sets to the final data archival systems.

To facilitate information exchange, development of a centralized data management index system will be assessed and implemented as necessary to ensure accessibility of the data for other data users. This indexing system will direct current and future data users to the relevant information sources or data archival locations. The system will include information such as the type of data, the data storage format, storage location, the

appropriate agencies or offices to contact to access the data, and directions for retrieving the information. Placement of the data index on a readily available computer system and publication of a brochure containing the relevant information will be evaluated.

Data submission requirements will be defined as the program progresses, but will include at a minimum

- Final quality-assured and approved data
- Supporting quality control information
- A brief assessment of the data quality
- Supporting information such as sample depth, location, replicate number, etc.
- A brief narrative describing the sample-collection methods and analytical procedures
- Citations of reports or other publications containing the data

Processed satellite-tracked drifter and sea surface imagery data will also be archived with appropriate indications of the national archival locations for the raw data.

Information and data will be exchanged among the various studies as necessary to complete data interpretation and to prepare reports. Every effort will be made to complete data generation and data exchange in a timely manner. However, only approved independently quality-assured final data will be exchanged. Data interchange will be in formats that expedite the data transfer.

Cooperating agencies and individuals will also work together to ensure appropriate recognition of data sources. Investigators will work together to provide interpretive reports in a timely manner. Investigators may also be requested to provide preliminary information to the Blue Ribbon Panel of Federal Experts (Section 4.2.4) or to annual reports as required by the program managers.

4.2.4 Expert Review of Plans and Results

The information generated through implementation of the research, monitoring, and surveillance plan shall also be reviewed formally. A Blue Ribbon Panel of Federal Experts will aid the agencies in making decisions about site management issues and future research, monitoring, and surveillance needs. EPA, NOAA, and USCG are convening this panel. It will include a core group of representatives of Federal agencies. Representatives from outside the Federal Government will provide specific expertise as needed.

Expert review of the results of the program will also take place at a symposium to be conducted in 1991 or 1992. EPA, NOAA, and the USCG will convene the symposium. Representatives from Federal, State, and local governments, scientific institutions, fishermen's groups, and environmental groups will be invited to review results of monitoring, research, and surveillance activities.

4.2.5 Public Awareness

Participants at the joint EPA/NOAA/USCG workshop held in 1989 recommended that Federal efforts in public awareness of monitoring activities and findings should be improved.

EPA has the lead responsibility for informing the public of 106-Mile Site research, monitoring, and surveillance activities and their findings. NOAA, USCG, and EPA will collaborate to summarize up-to-date, technical information on sludge dumping and its implications. This information will address particularly the stated concerns of public-interest groups. Information will be distributed in short, newspaper-style format to (1) newspapers and news magazines, (2) radio and television stations, and (3) groups that have expressed interest in site management issues. EPA Region II will continue to publish the ODBA *Advocate,* a semiannual newsletter updating relevant ODBA activities. Aggressive efforts will be sustained to inform all groups expressing interest.

4.3 USES OF MONITORING, RESEARCH, AND SURVEILLANCE DATA

Results of monitoring at the 106-Mile Site have been and will continue to be used as a basis for initiating enforcement actions when court orders or permit conditions have been violated; setting or revising permit requirements; modifying or revising the monitoring program itself; and ultimately determining whether the site should continue to be used according to the restrictions of the site designation process and the ODBA.

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Appendix A

STRATEGY FOR MONITORING, RESEARCH, AND SURVEILLANCE OF THE 106-MILE DEEPWATER MUNICIPAL SLUDGE SITE

APPENDIX 3

Strategy for Monitoring, Research, and Surveillance of the 106-Mile Deepwater Municipal Sludge Site

STRATEGY FOR MONITORING, RESEARCH, AND SURVEILLANCE OF THE 106-MILE DEEPWATER MUNICIPAL SLUDGE SITE

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Marine and Estuarine Protection
Washington, DC

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Washington, DC

U.S. COAST GUARD
Washington, DC

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EXECUTIVE SUMMARY

This document is based on the major recommendations from participants of a workshop on research, monitoring, and surveillance of the 106-Mile Deepwater Municipal Sludge Site (106-Mile Site), held in March 1989. The document uses the recommendations of the workshop to formulate a cohesive plan that can be implemented by the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Coast Guard (USCG) to continue research, monitoring, and surveillance of sludge disposal at the site.

The workshop brought together scientists, fishermen, policy experts, and environmentalists to discuss available information on the fate and effects of sludge disposal at the 106-Mile Site and to develop a strategy for future research, monitoring, and surveillance. Discussions at the workshop focused on four questions:

1. What is the physical and chemical fate of the sewage sludge dumped at the 106-Mile Site?

2. What is the effect of sludge dumping at the 106-Mile Site on living marine resources?

3. What is the effect of sludge dumping at the 106-Mile Site on human health?

4. Are there changes in site designation, permits, or surveillance that can provide better protection of the environment, living marine resources, or human health?

NOAA, EPA, and USCG have used the recommendations and findings from the workshop to develop this strategy. The agencies have considered priorities and available resources as well as recommendations from the workshop in developing the strategy. The strategy does not include every activity that may take place. It provides a framework for developing a complete NOAA/EPA/USCG research, monitoring, and surveillance plan. A complete plan, based on this strategy document, will assign responsibilities to each agency, the activities to be conducted, and present a schedule for implementation.

Implementation of the strategy will be accomplished through close cooperation among NOAA, EPA, and USCG. A Memorandum of Understanding (MOU) is being developed to define the roles of each agency. Interagency coordination will include conduct of joint EPA/NOAA surveys as well as sharing of planning and data interpretation.

1.0 INTRODUCTION

In 1988, Congress passed the Ocean Dumping Ban Act (ODBA), legislation aimed at ending ocean dumping of municipal sludges and industrial wastes by December 31, 1991. In response to ODBA's requirement for monitoring and to consumer concerns about the safety of seafood caught in the Middle Atlantic Bight, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Coast Guard (USCG) held a workshop to solicit recommendations for increased monitoring, research, and surveillance of the 106-Mile Deepwater Municipal Sludge Site (106-Mile Site). The 106-Mile Site is the only dumpsite designated by EPA to receive municipal sewage sludges.

1.1 PREVIOUS STUDIES CONDUCTED AT THE 106-MILE SITE

1.1.1 Research and Monitoring

Since EPA designated the 106-Mile Site for disposal of municipal sewage sludges in 1984, various monitoring, research, and surveillance activities have been conducted there and in the region that could be affected by sludge disposal. The studies have been conducted by a variety of Federal agencies, contractor groups, and others. Most of the studies have been conducted by EPA and NOAA.

EPA has developed and begun implementation of a monitoring plan (most recently updated in March 1988) to determine (1) whether permit conditions are met and (2) whether sludge dumping at the site affects the environment or human health. Although permit conditions are set to protect the environment, EPA and NOAA are refining monitoring efforts not only to ensure that these permit conditions are met, but also to ensure that the conditions protect the marine environment and public health now and into the future. Results of the monitoring program are being used to modify dumping procedures and to direct the continuing monitoring activities.

EPA Region II, in consultation with NOAA, has taken primary responsibility for an interagency workgroup which reviewed published and unpublished data on shell disease (chitinoclasia) in the New York Bight. The review focused on lobsters and crabs. Fishermen had reported increased incidence of disease in catches in the Middle Atlantic Bight. Fishermen postulated that the disease resulted from dumping at the 106-Mile Site.

NOAA conducts a variety of research near the 106-Mile Site. NOAA also surveys groundfish on the continental shelf, directly inshore from the site. If sludge is transported to the continental shelf, these areas may be affected. Groundfish surveys are not conducted within the site, because those waters are beyond the edge of the continental shelf and are not fished commercially.

1.1.2 Surveillance

USCG has developed and implemented the Ocean Dumping Surveillance System (ODSS), which uses "black boxes" to track location and dumping rates of barges using the 106-Mile Site. This system allows evaluation of compliance with ocean dumping permit conditions. Currently, the systems are accurate but the reliability is less than required in the original system specifications. The ODSS system is discussed in a Report to Congress developed by EPA Region II and the USCG.

1.2 DEVELOPMENT OF THIS STRATEGY AND PLANS

In March 1989, NOAA, EPA, and USCG sponsored a 3-day workshop, which brought together scientists, fishermen, policy experts, and environmentalists to discuss available information on the fate and effects of sludge disposal at the 106-Mile Site and to develop a strategy for future research, monitoring, and surveillance. Discussions at the workshop focused on four questions:

1. What is the physical and chemical fate of the sewage sludge dumped at the 106-Mile Site?

2. What is the effect of sludge dumping at the 106-Mile Site on living marine resources?

3. What is the effect of sludge dumping at the 106-Mile Site on human health?

4. Are there changes in site designation, permits, or surveillance that can provide better protection of the environment, living marine resources, or human health?

NOAA, EPA, and USCG have used the recommendations and findings from the workshop to develop this strategy. The agencies have considered priorities and available resources as well as recommendations from the workshop in developing the strategy. The strategy does not include every activity that may take place, but provides a framework for developing a comprehensive NOAA/EPA/USCG research, monitoring, and surveillance plan. Results of monitoring will be described in annual reports to Congress.

Implementation of the strategy will be accomplished through close cooperation among NOAA, EPA, and USCG. A Memorandum of Understanding (MOU) is being developed to define the roles of each agency, and an interagency agreement will be set up to administer the MOU. Interagency coordination is expected to include joint ocean surveys. The agencies will also coordinate planning and data interpretation.

2.0 STRATEGY FOR MONITORING, RESEARCH, AND SURVEILLANCE

2.1 GENERAL CONSIDERATIONS

Information presented at the workshop showed that research, monitoring, and surveillance of ocean dumping at the 106-Mile Site has already proved useful for understanding issues needed to answer the four management questions. Participants felt, however, that Federal efforts should be continued and increased so the management questions can be answered more definitively. The workshop endorsed the existing plans for work related to the site and recommended additional studies.

Workshop participants also recommended that Federal efforts to keep the public informed should be improved. EPA will coordinate implementation of this recommendation. EPA,

NOAA, and USCG will be responsible for specific actions. Periodic reports and press releases will form the primary source of such information. Other sources may include widely distributed fact sheets and public service announcements. In addition, representatives from the public and the news media may be invited to participate in research and monitoring efforts at the site. So that scientists and others may use the information gathered through monitoring, all data will be archived under one data management system. EPA will manage the system.

Finally, workshop participants recommended that the information generated through implementation of the research, monitoring, and surveillance plan be reviewed. A "blue ribbon" panel of experts will aid the agencies, decisions regarding site management and future research, monitoring, and surveillance needs. EPA will convene the panel which will include representatives of Federal agencies. Representatives from outside the government will provide specific expertise as needed.

2.2 MANAGEMENT QUESTION 1: WHAT IS THE PHYSICAL AND CHEMICAL FATE OF SEWAGE SLUDGE DUMPED AT THE 106-MILE SITE?

To date, studies of the fate of sludge dumped at the site have focused on nearfield transport and dispersion. The workshop recommended implementation of plans to study farfield fate, including conducting studies of water mass movements and currents and using remote sensing techniques to evaluate large-scale water movements and structure. The workshop also endorsed conduct of field studies to determine the settling behavior of sludge particles. Participants recommended evaluation and use of models to assist in data interpretation. These studies, in conjunction with the model predictions, will be used to determine the likelihood of sludge constituents reaching ecologically or environmentally important areas.

2.2.1 Water Mass Movement Studies

Information on movements of specific water masses will provide the most direct information on, for example, the possible movement of sludge constituents into fisheries areas or toward shorelines. These studies will employ drifters deployed from sludge barges and may also

use other methods, such as drift cards or bottles. The depth at which drifters are deployed will be based on findings from the nearfield studies already conducted at the site. Because sludge particles eventually sink, drifters that travel in deeper waters, at or below the thermocline, may be used for some measurements. EPA, in cooperation with the municipal authorities that dump sludge at the site, will be responsible for deployment of drifters. NOAA will be responsible for other measurements of water mass movements.

2.2.2 Fixed Point Measurements

Although studies of water masses provide the most direct evidence of where sludge particles may move, such studies collect only discrete points of information. Continuous data are necessary to estimate the percent of time that sludge may move in a particular direction. Fixed point measurements of currents can provide these continuous data. These measurements will be made from a surface current meter already deployed at the site by EPA. They will be supplemented by data from expendable current profilers (XCPs). The XCPs will be deployed at intervals to assess current shear through the water column in the site and in areas through which sludge may be transported.

2.2.3 Remote Sensing

Satellite imagery will be used to depict the temperature structure of the entire region that could be affected by sludge disposal at the 106-Mile Site. Although such analysis of sea surface temperature images is not enough to determine where sludge particles go, it will provide regional coverage to aid in interpretation of the data from direct measurements. NOAA will develop and implement the remote sensing studies with support from EPA.

2.2.4 Model Evaluation and Use

Farfield fate studies will provide information for a statistical evaluation of where sludge constituents go when they leave the 106-Mile Site. Models will be necessary to conduct the statistical evaluation. Available models will be evaluated to determine their usefulness in

determining the fate of sludge dumped at the site, including the ability to predict dispersion and to define possible areas of deposition. Ability of the available models to assess transport from the continental slope to the shelf will also be evaluated. NOAA and EPA will coordinate evaluation of models.

When an appropriate model is identified, NOAA and EPA will use it to determine the type and location of studies of effects of sludge disposal on living marine resources. They will also determine appropriate locations for studies of settling of sludge particles.

2.2.5 Settling Measurements

The likelihood of sludge particles settling in significant amounts in any one region is not known. Settling studies will include field sampling, conducted by EPA, for sludge particles in the pycnocline. Sampling within the pycnocline will be guided by information from the real-time current meter already deployed at the site and from the drifter studies. Sediment trap studies will be conducted to detect settling of particles through the pycnocline and to the bottom, if such movements occur. NOAA and EPA will coordinate deployment of sediment traps along the continental shelf and in other locations identified by the modeling efforts.

2.2.6 Data Interpretation

The results of studies of fate of sludge dumped at the 106-Mile Site will be used to determine (1) the potential for sludge constituents to move into commercially important areas or onto shorelines, and (2) the geographic areas, if any, where effects on marine resources or public health may occur.

2.3 MANAGEMENT QUESTION 2: WHAT IS THE EFFECT OF SLUDGE DUMPING AT THE 106-MILE SITE ON LIVING MARINE RESOURCES?

The workshop addressed possible effects of sludge dumping on any marine organism, population, or community. Monitoring for effects on the marine environment, including

endangered species, is expected to continue. However, most discussion centered on possible bioaccumulation of sludge constituents and other effects on commercial and recreational fisheries species.

Ideally, a study of bioaccumulation of sludge constituents from the 106-Mile Site would measure sludge-related contaminants in nonmigratory, commercially important species resident within the site. No such commercial or recreational species are known to inhabit the site permanently. Therefore, a suite of studies will be conducted.

2.3.1 Studies of Nonmigratory Commercial Species Inhabiting Areas Inshore from the Site

Tilefish, which inhabit the seafloor directly inshore from the site, do not migrate and live for many years. Other species living inshore from the site are also relatively nonmigratory. Information from studies of these organisms can be used to infer effects from the 106-Mile Site. A program to study these organisms will be coordinated by EPA and NOAA. (Although lobsters migrate between inshore and offshore waters, they will be included in the studies. Data on lobsters will be more difficult to interpret than those on other species. However, concerns voiced by fishermen suggest that their inclusion in the program is warranted.)

The studies will include measurements of contaminants in animals throughout the area north, west, and southwest of the site. The studies will determine whether there is a gradient with increasing concentrations nearest to areas most likely influenced by the sludge disposal at site. Any evidence of contamination will be examined to determine whether the 106-Mile Site or another source is implicated. Such findings would indicate that further studies and actions should be implemented immediately.

The program of studies will also include an assessment of chitinoclasia, a shell disease affecting shellfish such as lobster and red crab. Animals will be collected form the mid-Atlantic shelf in an effort to determine the prevalence and severity of this disease in the area of the 106-Mile Site.

2.3.2 Studies of Midwater Species Inhabiting the Middle Atlantic Bight

Some fisheries species, such as squids, migrate through the area of the 106-Mile Site and remain within the Middle Atlantic Bight throughout their life cycles. Studies of contaminants in these species will not provide information on the effects of sludges on the species. However, if the results of such studies indicate that the organisms are not contaminated, then the 106-Mile Site probably is not affecting the organisms. Such studies will have second priority and will be conducted by NOAA if resources allow.

2.3.3 Studies of Resident, Noncommercial Species

A third priority for study will be resident species, such as lantern fish and hatchet fish, which move through the pycnocline. These small fishes have no commercial value. However, presence of sludge-related contaminants in these species can be compared to control populations from the other side of the Gulf Stream. Contaminants in fishes from the site could suggest sludge as a source. Further study would be necessary to show that contamination resulted from municipal sewage sludge. Initial studies of these small fishes will be the responsibility of NOAA. Further study will be coordinated between NOAA and EPA.

2.3.4 Analyses and Data Interpretation

Each of these studies will include analysis of tissues and samples from the water column or sediments inhabited by the organisms. The samples will be analyzed for the same suite of chemical and microbial contaminants and tracers found in sludge samples and in field studies of sludge plumes. Other indicators of effects of contaminants, e.g., presence of disease, chitinoclasia, and liver condition, will also be examined.

Results of these studies may indicate that (1) the fisheries organisms of the Middle Atlantic Bight are not contaminated, and sludge disposal at the 106-Mile Site does not affect fisheries

species; (2) the fisheries organisms of the Middle Atlantic Bight are contaminated, but sludge disposal at the site does not appear to be a cause of the problem; or (3) the fisheries organisms of the Middle Atlantic Bight are contaminated, and sludge disposal at the site may contribute to the problem. These results would guide the type and extent of future studies, as well as govern any actions to be taken. Results that either strongly implicated sludge disposal at the site or dissociated the effects from sludge disposal would be used to make decisions about continued use of the site and could prompt changes in permit conditions.

2.4 MANAGEMENT QUESTION 3: WHAT IS THE EFFECT OF SLUDGE DUMPING AT THE 106-MILE SITE ON HUMAN HEALTH?

Workshop discussions centered on possible direct and indirect effects of sludge disposal at the 106-Mile Site. Direct effects included the possibility that sludge constituents could reach the beaches of New York and New Jersey. Possible indirect effects included ingestion of fisheries organisms that come from the continental shelf region and may have bioaccumulated contaminants from the sludges. These potential effects will be addressed by the studies to be conducted in response to Management Questions 1 and 2.

2.5 MANAGEMENT QUESTION 4: ARE THERE CHANGES IN SITE DESIGNATION, PERMITS, AND SURVEILLANCE THAT CAN PROVIDE BETTER PROTECTION OF THE ENVIRONMENT, LIVING MARINE RESOURCES, OR HUMAN HEALTH?

Workshop participants recommended (1) reduction in dumping rates used at the site; (2) improvements to the USCG surveillance system, ODSS; and (3) use of research and monitoring results to reevaluate the location and configuration of the site.

2.5.1 Permit Conditions

Permits to dump sludges at the 106-Mile Site are being issued with significantly lower dumping rates than had been required. Additionally, the permits will specify a monitoring program to be carried out by the permittees.

2.5.2 Surveillance

Several plans for upgrading the ODSS to provide near real-time coverage of all or most of the operational area are currently being evaluated by EPA and the Coast Guard. EPA is encouraging the Coast Guard to implement and test one of these plans, as well as to increase efforts to improve the overall reliability of the system. In the interin, EPA-approved shipriders, supplied by the permittee, will be required on all vessels transporting sludge to the dump site. Use of a manifest system and seals on the valves of feeder barges, barges which transport sludges to the ocean-going vessels, is also being implemented to ensure that no sludge is dumped in inland waters.

2.5.3 Site Designation and Management

All research, monitoring, and surveillance results will be reviewed by NOAA, EPA, and USCG, as well as by the independent blue ribbon panel. Results will be used to determine whether (1) monitoring should be continued or modified; (2) surveillance should be increased; (3) permits should be changed; and/or (4) the site should be redesignated, dedesignated, moved, or reconfigured. (The time required to modify the site and redesignate it preclude that option at this time.)

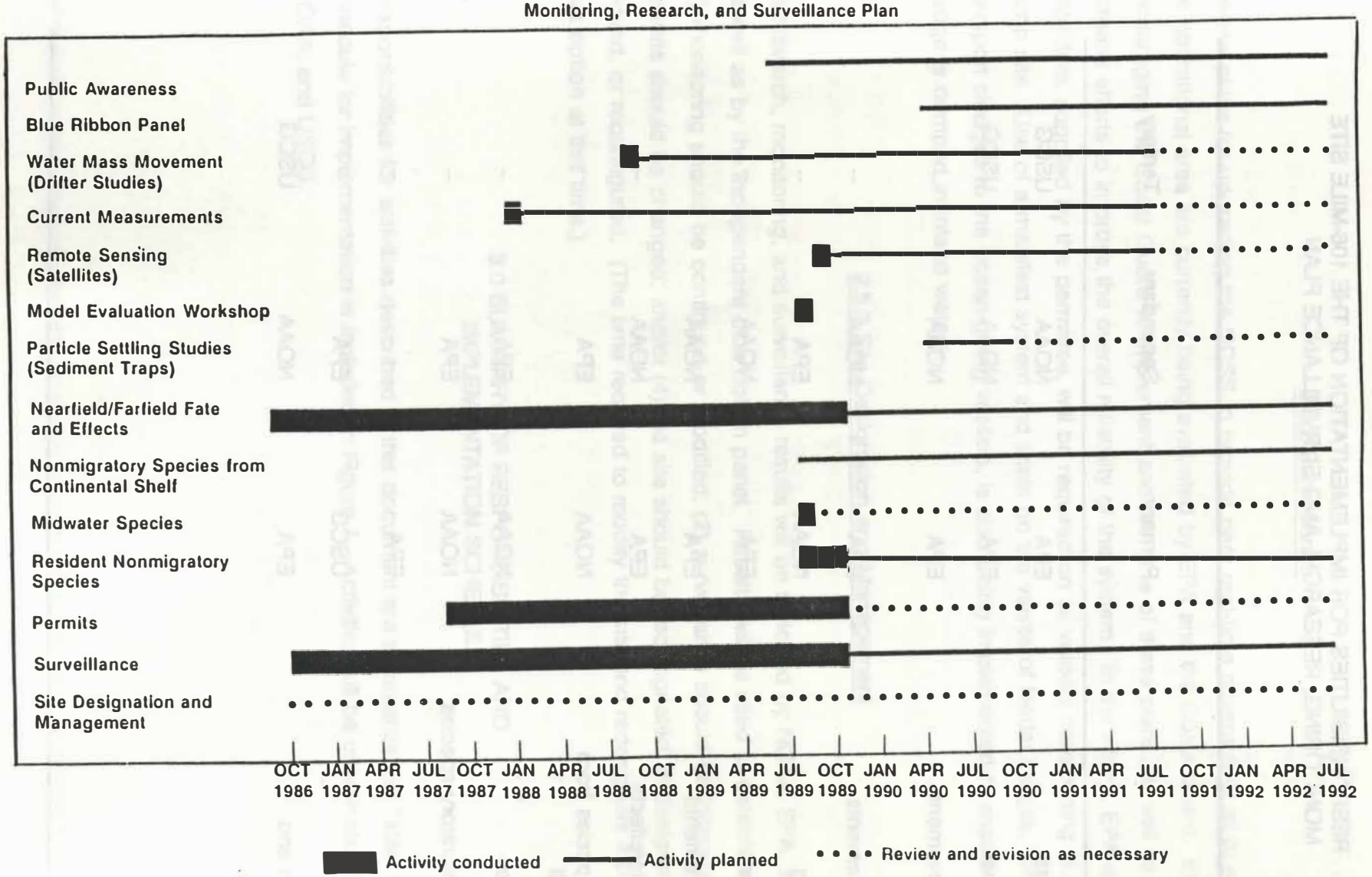
3.0 SUMMARY OF RESPONSIBILITIES AND IMPLEMENTATION SCHEDULE

Responsibilities for activities described in this document are summarized in Table 1, and the schedule for implementation is included in Figure 1. Activities will be coordinated by EPA, NOAA, and USCG.

TABLE 1. RESPONSIBILITIES FOR IMPLEMENTATION OF THE 106-MILE SITE MONITORING, RESEARCH, AND SURVEILLANCE PLAN

Activity	Primary	Secondary	Tertiary
Public awareness	EPA	NOAA	USCG
Blue ribbon panel	EPA	NOAA	USCG
Water mass movements (drifters)	EPA	NOAA	--
Current measurements	EPA	NOAA	--
Remote sensing	NOAA	EPA	--
Model evaluation	EPA	NOAA	--
Settling measurements	EPA	NOAA	--
Near-/farfield fate/effects	EPA	NOAA	--
Nonmigratory species from continental shelf	NOAA	EPA	--
Midwater species	NOAA	EPA	--
Resident, nonmigratory species	NOAA	EPA	--
Permits	EPA	--	--
Surveillance	USCG	EPA	--
Site designation and management	EPA	NOAA	USCG

Figure 1. Schedule for Implementation of the 106-Mile Site Monitoring, Research, and Surveillance Plan



Appendix B

MEMORANDUM OF UNDERSTANDING

October 11, 1989

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
AND
THE UNITED STATES COAST GUARD
AND
THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ON
THE IMPLEMENTATION OF THE OCEAN DUMPING BAN ACT

I. PURPOSE:

The United States Environmental Protection Agency (EPA), the United States Coast Guard (USCG), and the National Oceanic and Atmospheric Administration (NOAA) agree to join efforts to implement vigorously the provisions of the Ocean Dumping Ban Act of 1988 (ODBA) in a timely, complementary and environmentally sound manner. The three agencies further agree that a coordinated Federal response to ODBA will enhance the protection of human health and the marine environment and ensure consistent compliance with ODBA.

II. BACKGROUND AND SCOPE:

Nine New York and New Jersey municipalities dispose of sewage sludge at the Deepwater Municipal Sludge Dump Site (106 Mile Site), located 120 nautical miles southeast of Ambrose Light, New York and 115 nautical miles from the nearest coastline. ODBA mandates that to continue dumping after August 14, 1989, these nine municipalities must have both permits and enforceable agreements with EPA and the respective States. After December 31, 1991, it is unlawful to dump sewage sludge in the ocean.

For every dry ton of sewage sludge disposed in the ocean (currently 400,000 dry tons per year), dumpers will be assessed fees (starting August 15, 1989) that increase over time. Until the end of 1991, these fees range from $100-$200 per dry ton; should dumping continue after 1991, dumpers will be subject to penalties of $600 per dry ton; the penalties increase each year. Of these fees and penalties, $15 per dry ton is directed to EPA to be allocated evenly among EPA, USCG, and NOAA to implement the activities specified in ODBA and addressed in this MOU.

This Memorandum of Understanding (MOU) pertains to federal activities related to management and oversight of ODBA. Included in ODBA are requirements for permit compliance, monitoring and surveillance of the 106-Mile Site and environmental monitoring of the New York Bight.

Also covered under this MOU are the attached Joint Monitoring, Research, and Surveillance Strategy and its implementation. This strategy outlines further research, monitoring, and surveillance needed to answer remaining technical questions associated with management of the 106 Mile Site, and indicates responsibilities of the respective agencies. In general, the strategy calls for enhanced coordination in planning, conducting field surveys, sharing data, and analyzing and interpreting results.

III. AUTHORITIES:

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA, PL 92-532) is the primary legislative authority regulating the disposal of wastes in the ocean. It is the implementing legislation for the International Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter, commonly called the London Dumping Convention (LDC). The MPRSA prohibits dumping into ocean waters any material that would unreasonably degrade or endanger human health or the marine environment.

Under the MPRSA, EPA is responsible for issuing permits for sewage sludge disposal and for designating, managing and monitoring ocean disposal sites. Surveillance and enforcement of permit conditions is a joint responsibility of EPA and USCG. Title I of the MPRSA requires the USCG to conduct surveillance of ocean dumping activities. Title II of the MPRSA assigns to NOAA the responsibilities of monitoring the effects of dumping wastes in the ocean and conducting continuing programs of research on long-range effects of pollution to the marine environment.

ODBA amends the MPRSA and directs EPA, USCG, and NOAA to conduct specific activities that are to be covered by the ocean dumping fees and penalties.

IV. EPA'S RESPONSIBILITIES

1. Establishing and managing a permit program for transportation and dumping of sewage sludge under ODBA

2. Overseeing enforcement agreements

3. Overseeing fee collections and managing fees and penalties

4. Approving and overseeing trust accounts

5. Implementing EPA portion of the Joint Monitoring, Research, and Surveillance Strategy, which includes:

   - o Monitoring disposal operations and short-term effects of sludges within and in the vicinity of the 106 Mile Site
   - o Monitoring farfield fate and long-term effects of dumped waste

6. Overseeing ODBA Clean Ocean Fund management and procedures for accounting and reporting

7. Providing technical assistance on alternatives to ocean dumping under ODBA

8. Preparing reports, including:

   - o Reports to Congress on monitoring of the 106 Mile Site
   - o Annual Report to Congress on progress towards stopping dumping

V. USCG'S RESPONSIBILITIES

1. Implementing USCG portion of the Joint Monitoring, Research, and Surveillance Strategy, which includes conducting surveillance of transportation of wastes under the MPRSA Permit Program and reporting violations to EPA

2. Spot-checking of feeder vessels and ocean-going vessels, within New York Harbor, while they are being used for transporting sludge

VI. NOAA'S RESPONSIBILITIES

1. Implementing NOAA portion of the Joint Monitoring, Research, and Surveillance Strategy, which includes monitoring the farfield fate and long-term effects of dumped wastes on living marine resources and the marine environment

2. Continuing programs of research on long-term effects of pollution and human-induced changes to the marine environment

VII. QUALIFICATIONS AND LIMITATIONS

1. Together, EPA, NOAA, and USCG, will ensure effective implementation of ODBA by the headquarters and regional offices. The three Agencies will establish a standing committee to develop plans for implementing provisions of this MOU, report progress, identify and resolve problems, and share information.

2. Period of Agreement:

   This agreement shall continue in effect until modified or amended by the assent of all parties.

AUTHENTICATION

This agreement will become effective upon signature by all three parties.

William K. Reilly
Administrator,
Environmental Protection Agency

March 9, 1990
Date

P. A. YOST
Commandant,
United States Coast Guard

3/23/90
Date

John A. Knauss
Administrator,
National Oceanic and Atmospheric
Administration

April 26, 1990
Date