Report to the Congress on Ocean Dumping Research

January through December 1975

Public Law 92-532, Title II, Section 201

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
JUNE 1976

Report to the Congress on Ocean Dumping Research

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Submitted in compliance with Section 201,
Title II of the Marine Protection, Research,
and Sanctuaries Act of 1972
(Public Law 92-532)

June 1976

UNITED STATES
DEPARTMENT OF COMMERCE
Elliot L. Richardson, Secretary

National Oceanic and
Atmospheric Administration
Robert M. White, Administrator

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

President of the Senate
Speaker of the House of Representatives

August 25, 1976

Sirs:

Title II of the Marine Protection, Research, and Sanctuaries Act of 1972 assigned to the Department of Commerce a responsibility to initiate a program of ocean dumping monitoring and research. Section 201 of the Act specifies that an annual report be made to Congress on the progress of such research.

I am pleased to submit to the Congress this third annual report on Federally sponsored research on ocean dumping. This report covers activities of calendar year 1975, and focuses on the three main categories of ocean dumped materials; dredged material, municipal sewage sludge, and industrial wastes.

Substantial progress is being made in developing an understanding of the fate and effects of ocean dumping through both site-specific field studies and laboratory research. Additionally, a significant amount of research is being directed toward developing economically and environmentally sound alternatives to ocean dumping.

Sincerely,

Elliot L. Richardson

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CHAPTER I

INTRODUCTION

BACKGROUND

The Marine Protection, Research, and Sanctuaries Act (MPRSA) was passed in 1972--largely in response to environmental concerns expressed by the Council on Environmental Quality (CEQ) in its 1970 report to the President on ocean dumping. The CEQ report recommended a comprehensive National policy on ocean dumping of wastes to end unregulated ocean dumping and prohibit ocean disposal of any materials harmful to the marine environment. Recommendations regarding specific types of wastes were:

- Dredged material: "Ocean dumping of polluted dredge spoils should be phased out as soon as alternatives can be employed. In the interim, dumping should minimize ecological damage. The current policy of the Corps of Engineers on dredging highly polluted areas only when absolutely necessary should be continued, and even then, navigational benefits should be weighed carefully against damages."

- Sewage sludge: "Ocean dumping of undigested sewage sludge should be stopped as soon as possible and no new sources allowed. Ocean dumping of digested or other stabilized sludge should be phased out and no new sources allowed. In cases in which substantial facilities and/or significant commitments exist, continued ocean dumping may be necessary until alternatives can be developed and implemented. But continued dumping should be considered an interim measure."

- Industrial waste: "Ocean dumping of industrial wastes should be stopped as soon as possible. Ocean dumping of toxic wastes should be terminated immediately, except in those cases in which no alternative offers less harm to man or the environment."

Passage of the Marine Protection, Research, and Sanctuaries Act of 1972 committed the United States on a National basis for the first time to:

> "...regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare or amenities, or marine environment, ecological systems, or economic potentialities."

AGENCY ROLES AND RESPONSIBILITIES

The Marine Protection, Research, and Sanctuaries Act of 1972 is organized into three major titles. Title I deals with regulatory aspects of ocean dumping. The Act assigns regulatory authority and involvement to the

Environmental Protection Agency (EPA), and the Corps of Engineers (COE), and the Coast Guard (USCG). Title II of the Act deals principally with research aspects of ocean dumping that are needed to support the intent of the Act to limit ocean dumping of harmful materials. The research responsibilities described in Title II are to be coordinated by the Department of Commerce (NOAA) in consultation and coordination with other Federal agencies. Title III of the Act provides for the designation of marine sanctuaries. This Title is administered through the Department of Commerce in consultation with other Federal Departments and agencies.

Section 201 of Title II assigns the responsibility for a comprehensive and continuing program of monitoring and research regarding the effects of dumping material into ocean waters, coastal waters, and the Great Lakes to the Department of Commerce, in coordination with the Coast Guard and EPA. The Department of Commerce is responsible for reporting annually to the Congress on these research activities. This section is the authority for preparing this report to the Congress on ocean dumping research. This report has been prepared in collaboration with the Environmental Protection Agency, the United States Army Corps of Engineers, and the United States Coast Guard.

SCOPE OF THE 1975 OCEAN DUMPING RESEARCH REPORT

This is the third annual report to the Congress on the status of Federally sponsored ocean dumping research as required by the Marine Protection, Research, and Sanctuaries Act of 1972, Title II, Section 201. The report describes progress made by Federal agencies in ocean dumping research in 1975, elements of interagency coordination, and future program direction. It is intended to provide a framework for assessing strengths and weaknesses in the Federal effort. Although not specifically required by the legislation, this report also includes a summary of 1975 activities directed to fulfilling the requirements of Title II, Section 203, research into disposal alternatives to ocean dumping.

The principal research efforts of involved Federal agencies during calendar year 1975 are organized by category of ocean-dumped material rather than agencies. This organization emphasizes the total research effort being applied to each major type of material now being dumped in the ocean. The three categories of ocean-dumped materials discussed in this report are dredged material, municipal wastes, and industrial wastes.

STATUS OF OCEAN DUMPING

The practice of ocean dumping of waste materials has continued since the passage of the Marine Protection, Research, and Sanctuaries Act of 1972. Comparative levels of ocean dumping activity provided by COE and EPA for 1973, 1974, and 1975 are:

	1973	1974	1975
Dredged material (yd^3)	not available	98,665,520	87,826,362
Municipal waste (tons)	4,898,900	5,010,000	5,039,600
Industrial waste (tons)	5,050,800	4,592,000	3,446,000

The amount of dredged material decreased slightly from 1974 to 1975. However, this should not necessarily be taken as a trend, as the need to dredge is dictated in part by natural events, such as floods and siltation. Nevertheless, it is important to note that the amount of contaminated material that is disposed of in the ocean has markedly decreased. In data supplied to the Council on Environmental Quality, the Corps of Engineers estimated that approximately 34 percent of the dredged material dumped in the ocean in 1968 was contaminated. The amount of contaminated dredged material now being disposed of in the ocean is substantially reduced. This reduction in contaminated dredged material is due in part to regulatory controls on municipal and industrial contaminated wastes discharged into receiving waters, and increased use of alternative disposal methods.

The amount of sewage sludge being dumped in the ocean off the Atlantic coast has increased slightly. This is primarily due to the increase in population in the region and the required tertiary treatment of sewage, which yields greater amounts of sludge. The amount of sludge being dumped in the ocean is expected to increase until ocean dumping is terminated through development and installation of environmentally acceptable alternative methods of disposal.

A significant reduction has been achieved in the amount of industrial waste that is dumped in the ocean. This decrease is the result of newly developed and implemented alternative methods of disposal.

A significant reduction in ocean dumping can not be achieved until environmentally suitable alternative methods of disposal are developed and adopted. These methods include, but are not limited to, incineration, pyrolysis, land disposal, waste recycling, and industrial process changes. In the case of dredged material, some of the options being considered are: habitat development research into artificial marsh and island creation, improved disposal operations such as confined dredged material disposal facilities, and various productive uses of dredged material.

The principal scientific and technical expertise for developing these alternatives exists within EPA and COE. Both agencies have active programs underway in this area. These agencies also have the capability to promote the adoption of appropriate alternatives as they become available through regulatory activities, and through such programs as EPA grants for municipal wastewater treatment plants.

CHAPTER II

DREDGED MATERIAL RESEARCH

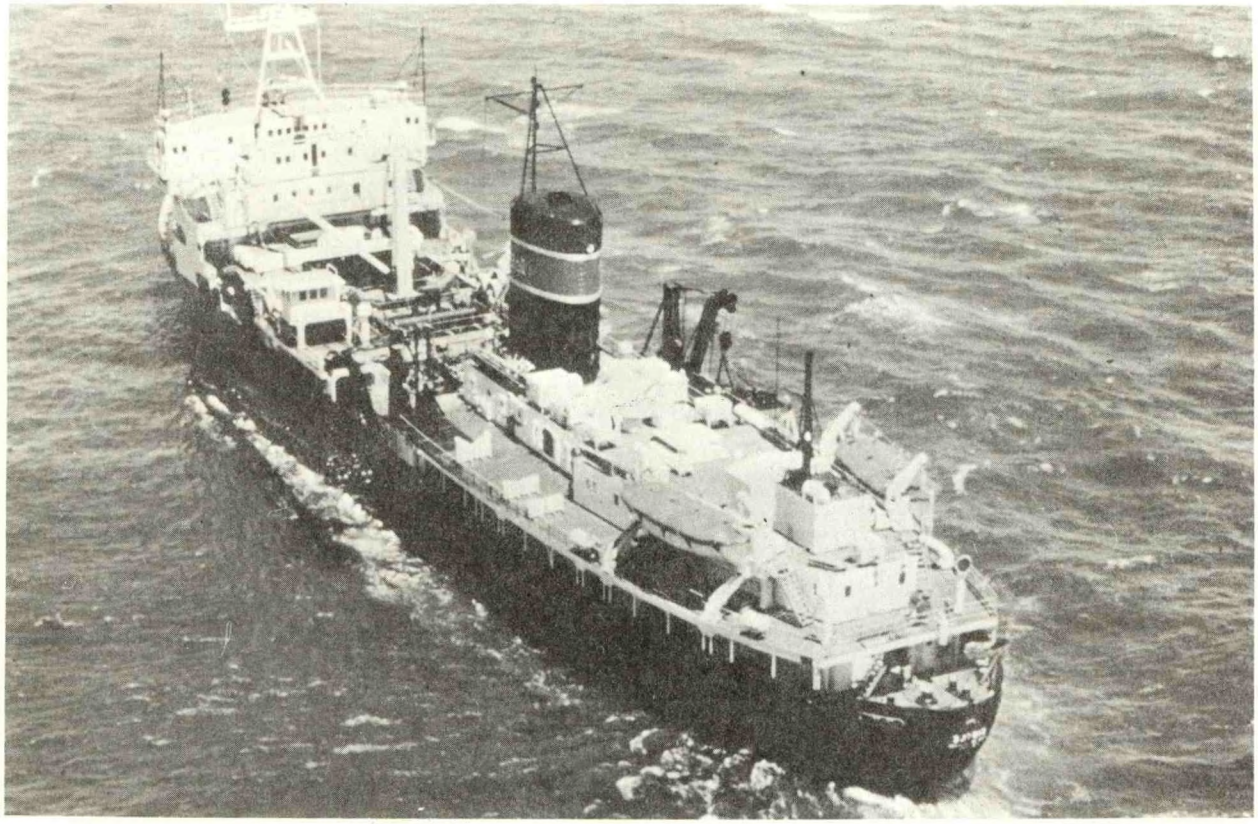
Research into fate and effects of dredged material and alternatives to ocean dumping is undertaken by several Federal agencies. The Federal Government's primary thrust in dredged material research is the Dredged Material Research Program (DMRP) of the U.S. Army Corps of Engineers. Less comprehensive research efforts on dredged material were supported by EPA and NOAA during 1975.

DREDGED MATERIAL RESEARCH PROGRAM

The U.S. Army Corps of Engineers Dredged Material Research Program (DMRP) began in March 1973. One objective of this 5-year $30 million program was to provide definitive information on the environmental impact of dredging and disposal of dredged material (fig. 1). A second objective of the research was to develop technically satisfactory, environmentally compatible, and economically feasible alternatives for dredging and disposal. The program is being conducted by the Corps' Waterways Experiment Station (WES) at Vicksburg, Mississippi. The scope of DMRP includes both freshwater and marine environs. Over 30 percent of the effort deals directly with ocean-related dredged material research.

DMRP comprises four projects--each directed by a full-time project manager and each with its own support staff. The four projects are: 1) Environmental Impacts and Criteria Development Project, 2) Habitat Development Project, 3) Disposal Operations Project, and 4) Productive Uses Project. The research effort in the Environmental Impacts and Criteria Development Project is devoted to studying the environmental impacts of both contained land and open-water disposal. In addition, this research is developing valuable regulatory criteria. This project also addresses processes involved in an methodologies for predicting the fate and effects of ocean dumping of dredged material. The other three projects in part explore alternatives to ocean disposal of dredged material.

In August 1975 the former Aquatic Disposal Research Project was renamed the Environmental Impacts and Criteria Development Project. This redesignation reflects the generally increased emphasis on multiple aspects of the development of criteria and guidelines for regulating disposal operations in terms of both water quality and biological effects. Promulgation of regulatory criteria for dredged and fill material, as required by the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, has been the impetus for the development of detailed evaluative procedures and interpretive guidelines for Section 404B of the Act. Revision and promulgation of state-of-the-art criteria have emphasized the need for the expanded criteria research incorporated into the project. Laboratory investigations of the acute and chronic water quality impacts of open-water disposal are completed and have clearly delineated the problem areas from the nonproblem areas. Biological research in the laboratory is nearing completion and will contribute significant information to enable the environmental manager to minimize or negate any biological impact associated with aquatic disposal.



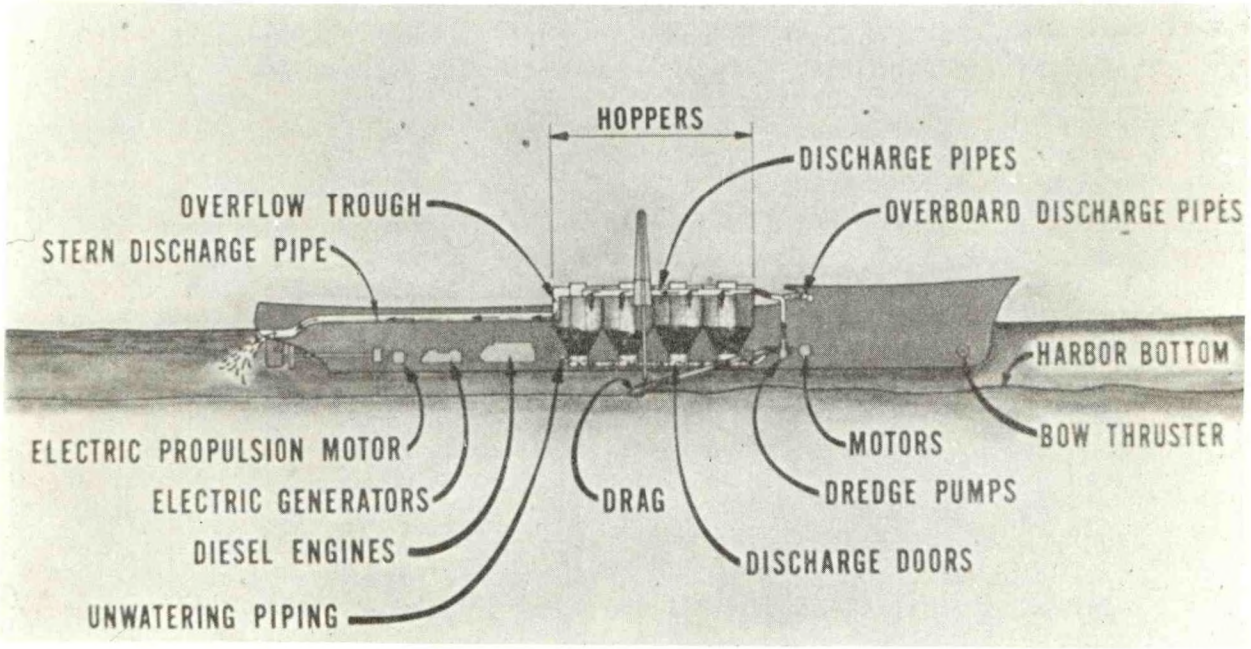


Figure 1.--U.S. Army Corps of Engineers hopper dredge *Markham*. Disposal from a hopper dredge is the most common method of ocean disposal of dredged material. (Source: Corps of Engineers)

Characterization of the pollution potential of upland containment areas has been initiated with completion of 6 of 10 selected sites. This project is now the focal point for research on the effects of both land and open-water disposal of dredged material.

There are four locations for major field investigations into the physical, biological, and chemical impacts of open-water disposal. They are in the Pacific Ocean just off the mouth of the Columbia River; the Gulf of Mexico off Galveston, Texas; Lake Erie off Ashtabula, Ohio; and the newly initiated estuarine site in Elliott Bay (Puget Sound) for disposal of material from the Duwamish Waterway near Seattle, Washington. The Duwamish Waterway site was selected to replace the cancelled investigation at Eatons Neck, New York, where field activities were terminated because of local opposition.

To date, the baseline research and controlled disposal investigations are completed and postdisposal monitoring is currently underway at the first three sites.

- Columbia River Site. At the ocean disposal site off the Columbia River, baseline and postdisposal physical and chemical field work is completed. Physical characteristics of sediments are being used to define the spatial distribution and volume of dredged material placed at the site. Hydrodynamic, turbidity, and meteorological data will be integrated with the sediment data to describe movements and temporal changes of the deposited dredged material. Baseline, disposal operations, and postdisposal chemical and biological data are being interpreted to ascertain overall impacts. Benthic studies have concentrated on the rate and extent of recolonization of the dredged material deposit; physical and chemical data on sediments will be used to explain recolonization patterns. Impacts on plankton and fisheries are also being evaluated.

- Galveston Site. Disposal at offshore sites of noncontaminated silty sand and silty clay dredged material from the Galveston entrance channel and contaminated dredged material from the Texas City Ship Channel has been completed, and postdisposal research is underway. Tentative results indicate that manganese and ammonia were the only two constituents released in measurable concentrations to the water column during disposal. Heavy metals and nutrients were found to show no significant increase or decrease in concentration during disposal. Chlorinated hydrocarbon studies are inconclusive at this point; however, initial field results suggest little release from the contaminated sediments. Initial postdisposal data indicate no apparent chronic impact on water quality at any of the three experimental disposal sites. Biological studies of the acute impact of dredged material disposal on planktonic, benthic, and demersal assemblages are complete. Longer term studies of the rates and patterns of benthic recolonization of the dredged material deposits are continuing.

- Ashtabula Site. Disposal of contaminated and noncontaminated sediments from Ashtabula Harbor at two locations within the Lake Erie disposal site was completed by August 1975. A spring 1976 disposal at this site is planned to investigate seasonal variations. Data are being analyzed to quantify the rate and extent of recolonization of the disposal site by macroinvertebrates and fishes; acute impacts on plankton populations also are being assessed. Data on sediments and water circulation will be used in the interpretation of chemical and biological data. Preliminary results indicate that impacts on the water column were minimal from both types of dredged material. Ammonia and reactive silica were the only chemicals showing release patterns. Surface turbidity was less than 5 ppm and would be of aesthetic importance only. Evaluations of longer term impact on benthos are currently underway. A spring 1976 disposal is planned at this site to supplement the 1975 investigation by evaluating impacts under a different set of seasonal lake conditions.

- Elliot Bay Site. The newest addition to the aquatic disposal field investigations is the estuarine disposal site in Puget Sound. The material selected for disposal at this site is dredged during channel maintenance in the Duwamish Waterway. The pilot survey, selection of the disposal site, and selection of a sampling station for organisms, sediments, and water have been completed. This study will focus on the release and possible uptake of polychlorinated biphenyls and selected heavy metals contained in the dredged sediment. Results will be compared with those at a confined upland disposal site where the most polluted material from the Duwamish is being disposed. EPA is participating in this work through an interagency agreement.

Reports are in various stages of preparation for each study site. These will evolve as DMRP technical reports. All data are put into the Waterways Experiment Station computer-based storage facilities for subsequent retrieval, interpretation, and evaluation. Of particular importance will be the comparisons of data obtained within specific disposal sites and among all the open-water disposal sites.

Two new work units dealing with the movement of dredged material were begun in late 1975. The first is a field investigation of the "Effects of Winter Storms on the Stability and Fate of Dredged Material in Subaqueous Disposal Areas." This work unit was initiated in response to recommendations of a prior work unit titled Assessment of Factors Controlling the Long Term Fate of Subaqueous Banks of Dredged Material. The research will investigate the effects of major winter storms on the hydraulic regime and the stability and fate of deposits of dredged material at actual and potential open-water sites in central Long Island Sound.

The second work unit is an "Investigation of the Physical Characteristics of Dredged Material and the Effects of Dispersion Behavior During Open-Water Disposal Operations." This work unit is designed to field verify an estuarine dispersion model developed under a prior work unit. The

objectives are to quantitatively define the physical processes that control the dispersion and deposition of dredged material that is released from a barge, hopper dredge, or pipeline at selected sites and to compare these results with the theoretical (simulated) results of the model. This work unit will have direct application to ocean dumping operations.

The laboratory evaluation of dredged material disposal is another recently completed task. Results of these investigations showed that acute chemical effects on the water column at a disposal site are insignificant or completely nonexistent. Only ammonium, iron, and manganese were shown to be released to the water in quantities significantly greater than background. These constituents are not considered highly toxic, and are required nutrients for organisms. Mobilization of toxic metals from the redeposited dredged material over long time intervals was insignificant, or was in the direction from the water to the sediment. Nutrients, however, were released in significant quantities. Almost all of the sediments studied were found to contain at least trace quantities of PCBs, DDT, and isomers of DDT. Certain other chlorinated hydrocarbons were found depending on sediment location. Very little or no chlorinated hydrocarbons were found to be released to the water column during simulated disposal. They remained with the solid-phase sediment material. These findings are being verified by field investigations and will be tested at other DMRP field test sites.

Another preliminary conclusion generated as a result of these laboratory investigations is that oxidation-reduction conditions, which are generally found in open-water disposal areas, actually appear to inhibit the release of most sediment contaminants rather than to enhance their release. Anaerobic sediments disposed of in oxygenated water are found to be efficient scavengers of dissolved contaminants already present in the water column. Sediment interstitial water concentrations at the dredged site were found to be similar to that found in natural undisturbed sediments. In summary, Corps laboratory findings have shown that the intermediate release of toxic constituents due to aquatic disposal was negligible.

Another area of concern to Corps scientists is how dredging and disposal, including ocean disposal, affect aquatic organisms. A specific work task was designed to examine the response of representative organisms to the previously mentioned physicochemical conditions. Laboratory investigations were made in 1975 on the effects of resuspended dredged material (turbidity) on representative marine, estuarine, and freshwater organisms at concentrations up to 20 grams per liter (g/l) over a 21-day exposure time. This resulted in the mortality of only a small number of the organisms being assayed from freshwater and estuarine noncontaminated and moderately contaminated sediments. Sediments from the highly contaminated Oakland Inner Harbor area had critical exposure-mortality effects on marine organisms at 5-day 20 g/l and 7-day 4 g/l exposure-concentration levels. Shrimp, clams, shiner, perch, and rainbow trout were some of the organisms studied. It should be noted that the turbidity concentrations and duration (2-20 g/l for 21 days) are much higher than found in dredged material disposal operations. The normal range is 5-200 mg/l for a few hours.

Vertical migration investigations, completed by the University of Delaware in 1975 for the Corps, showed that representative bottom-dwelling organisms have a significant ability to migrate upward through coverings of various depths of dredged material. Those organisms most severely impacted were sand-dwelling organisms that had a clayey sediment deposited on them and mud-dwelling organisms covered with a sandy dredged material. Effects of the physicochemical nature of sediments on organism response will continue to be evaluated. However, these initial tests indicate the desirability of choosing a disposal site characterized by a substrate similar to the material to be disposed.

In other investigations, the uptake of pesticides by benthic organisms was shown to be related to the concentrations of pesticides in interstitial waters. Organisms also take up pesticides from the solid-phase material, but to a much lesser degree. Consequently, to predict total acute effects, the leaching characteristics of dredged material must be evaluated before disposal. Studies of heavy metals and their availability to benthic organisms from the solid-phase portion of dredged material were started in 1975. Sediments from the Houston Ship Channel were chosen as the contaminated dredged material. Shrimp, clams, and polychaete worms were used as test organisms. Preliminary results indicated general toxicity of the sediments, but little or no uptake of a wide selection of heavy metals.

During 1975 the Corps also studied the contamination status of specific dredged materials. To define the contamination status of dredged material required the development of chemical and biological procedures for determining the contamination properties of various types of dredged material on a regional basis. Research has shown dredged material to be a complex combination of naturally occurring silicate-soil material, bound and unbound water, an organic phase, and a range of contaminant and noncontaminant elements distributed within the complex. Elemental partitioning, a procedure used to characterize a sediment, showed that the release of chemical constituents from sediments does not depend on the total constituents present in the sediment. Consequently, it was concluded that a total or bulk sediment analysis, which measures the sum of the native and contaminant forms of a constituent, does not measure the potential effect of dredged material on water quality. These same studies also showed that chemical contaminants in sediments are unequally distributed among a number of chemically defined phases. Release of contaminants from dredged material varied from site to site and was a complex function of the chemically defined phases; however, there was a statistically significant relationship between the elutriate test and those sediment phases shown to be mobile or active.

In 1975 a second study, Development of Dredged Material Disposal Criteria, was undertaken to evaluate the factors that will influence the performance of the elutriate test. Results suggest that the elutriate test response depends on the oxygen concentration during the mixing procedure and is insensitive to most other experimental factors. The only constituents that were generally observed to be released in potentially significant quantities during the elutriate test evaluation were ammonia and manganese. Several constituents were found to decrease. During 1975, these results were verified in the field at actual dredging operations. The

elutriate test evaluation study indicated that the observed response would vary with the source of the dredged material, which suggests that the elutriate test would be sensitive to regional variations. Additional work, to be done in 1976, will study the rate of dilution and bioassays to predict the extent of biological effects at a disposal site.

The EPA procedures for solution-phase bioassay were modified for use with the elutriate test in 1975. Biological assessment of the elutriate demonstrated that elutriates prepared from several types of dredged material would elicit a variety of responses from cultures of protozoa, bacteria, and algae. These results also suggest that the elutriate test can be used with a wide variety of sediments. To interpret results of elutriate tests or bioassays in terms of potential environmental impacts in the water column at a disposal site, additional information is being gathered on the degree of dilution and dispersion that will occur at a disposal site.

DREDGED MATERIAL DISPOSAL CRITERIA RESEARCH

The EPA has a responsibility under Section 404 of the Federal Water Pollution Control Act as amended and the ocean dumping act to provide scientific criteria for the disposal of dredged materials. To develop sufficient data on which to base the required criteria, it is essential that EPA maintain its own research. In 1975, EPA's research program on dredge material fate and effects included the following studies:

- A grant to Columbia University is in progress to study concentration and bioaccumulation of trace metals attributable to disposal of dredged material and sewage sludge in sediments and overlying waters. Scientists are sampling the Hudson estuary and adjacent coastal waters. Natural radioactive tracers and heavy metals are being used. The sediment/water interchange of these materials is being studied by chemical analysis to determine the rate and nature of pollutants released from dredged materials into estuarine and coastal waters and biota. The study is also investigating the role of bacterial communities and organic polymers in heavy metal mobilization.

- Preliminary dredged material studies off Narragansett Bay have indicated the possible distribution of fine grain sediments beyond the limits of the dumpsite. It should be noted that clayey harbor sediments were deposited on a sand substrate; consequently, the fine grain sediments contain higher natural abundances of a wide range of heavy metal than the sand. Nonetheless, these findings prompted an indepth comprehensive field study in October 1975. This study focused on: sediment characteristics, metals, and the benthic biota, including foraminifera and edible shellfish. The objective is to carefully delineate the area of influence around this dumpsite.

- The University of Michigan had a grant to study the effects of dredging on water quality in large lake systems. The major objective was to determine the rate and mechanisms of exchange

of chemical species between sediments and water during disposal of dredged material in open lake waters. The study has been completed, and a report is being prepared.

SEA GRANT DREDGED MATERIAL RESEARCH

The National Sea Grant program sponsors a number of research efforts on dredged material. Grants include studies of:

- Marsh regeneration on dredged material--by investigators in the Departments of Biology and Soil Sciences at the University of North Carolina. Seeding and transplanting have established Spartina on dredged material. Continuous monitoring has proved that transplantation can be used to restore disturbed areas. Breakwater protection devices have been found to assist in stabilization of dredge material shorelines.

- Effects of dredged material disposal on benthic animals--by investigators at the Graduate School of Oceanography at the University of Rhode Island. Major objectives are to determine the status of recolonization of dredged material by benthic invertebrates, identify sources of colonizing species, and predict future development of the benthos in disturbed areas.

- The effects of wave processes on the erosion of dredged material islands--a new Sea Grant project at Texas A&M. Field and model studies are being made to provide a predictory capability necessary for site selection.

The Sea Grant Program in New York is assisting in publication of the MESA New York Bight monograph series. Other Sea Grant publications on dredging and ocean dumping include: Proceedings of the Seventh Dredging Seminar, November 8, 1974, New Orleans, Louisiana, published under Sea Grant support in 1975; Prevention of Marine Pollution by Dumping of Wastes and Other Matter, prepared by researchers at Woods Hole Oceanographic Institution; and History of Ocean Dumping in the Gulf of Mexico, published by the Sea Grant Program at Texas A&M.

CHAPTER III

MUNICIPAL WASTE RESEARCH

Both EPA and NOAA have major research efforts on municipal wastes. The scope of EPA research includes both fate and effects of pollutants and alternatives to ocean disposal of municipal waste. There are only two active sites for ocean dumping of municipal sewage sludge. One site is in the apex of the New York Bight and is used for the disposal of about 4.8 million cubic yards of sewage sludge annually from sewage treatment plants in the New York-New Jersey metropolitan area. The other site is about 50 nmi southeast of the mouth of the Delaware Bay and is used by the Philadelphia metropolitan area, which dumps about 0.5 million cubic yards of sewage sludge each year. Field studies are being conducted at both the New York and Philadelphia sites.

NEW YORK BIGHT SITE INVESTIGATION

Waters of the New York Bight are contaminated by waterborne and airborne wastes from the Nation's largest metropolitan complex. The quality of the waters, particularly in the Bight Apex, has declined over the years. The Apex has designated sites for the disposal of dredged material, cellar dirt, acid wastes, wrecks, and sewage sludge (fig. 2).

The need for information on the effects of pollution on the New York Bight ecosystem led to the initiation of a major NOAA investigation in 1973 -- the Marine Ecosystems Analysis (MESA) New York Bight Project. The 8-year $30 million project is designed primarily to determine the fate of pollutants in the New York Bight and their effect on the ecosystem of the Bight with particular emphasis on ocean dumping. A second broader objective of the project is to understand the major ecological and physical processes in the Bight.

In 1975, the NOAA ship *Kelez* made 15 surveys in the New York Bight in support of the MESA project's research efforts. These efforts focused on investigating sewage sludge dispersion, pollutant sources, effects of sewage sludge, and selection of alternative sewage sludge disposal sites.

Sewage Sludge Dispersion

Little is known about the physical behavior of dumped material in the water column or the particulate fractions that settle to the bottom. Some study results indicate that the bulk density of sewage sludge from the New York-New Jersey metropolitan area is between 1.0054 and 1.0210 g/cm^3. The mean density of about 1.014 g/cm^3 is somewhat less than seawater. The tendency, therefore, is for the sewage sludge to be slightly buoyant in seawater, and to be dispersed by surface waters with attendant shear and turbulence. However, the heterogeneous sewage sludge also contains particles as large as sand with densities of about 2.65 g/cm^3. These larger and denser particles can be deposited relatively near the dumpsite. The smaller, less dense particles, if dispersed, can be carried for varying distances. Some are dispersed widely over the Bight. Even light particles can be deposited

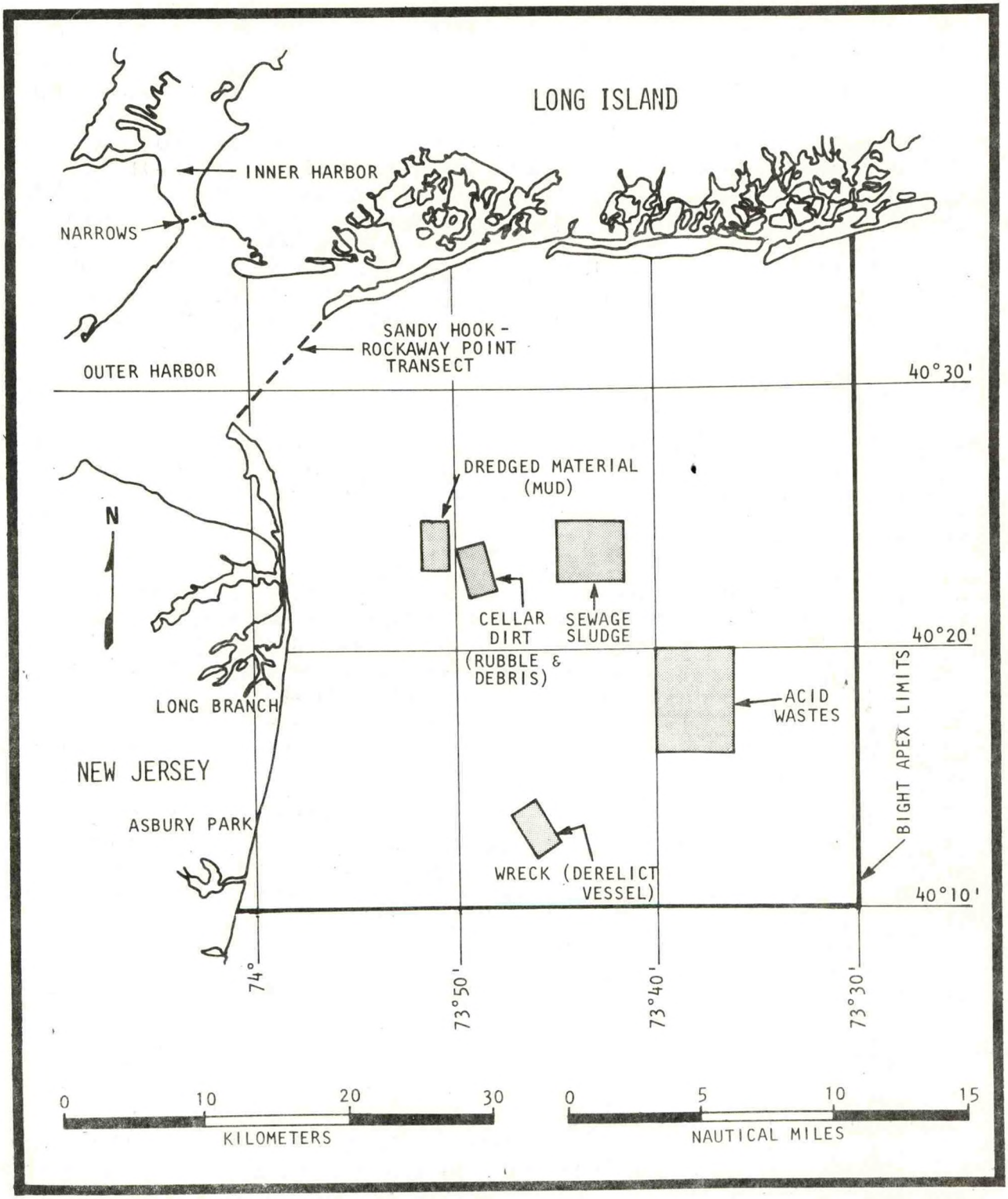


Figure 2.--Existing dumpsites in the New York Bight Apex. (Source: Environmental Protection Agency, 1974)

near the dumpsite, at least initially, because of clumping and other physical factors, which may be controllable in barge dumping operations. Both light and heavy particles, however, are subject to subsequent transport caused by storms and other oceanic current influences.

Field studies were made in 1975 to record the sinking and dispersion of dumped sludge and to map temporal changes in distribution of dumped sludge particles. In winter, without a thermocline, sludge particles were dispersed rapidly throughout the water column, while the liquid phase was diluted and transported laterally in the surface waters. A method of tracking or observing the dispersion of sewage sludge particles for several hours was demonstrated in 1975, using commercially available equipment that measures sound reflected from particles in water. Results of this work are not yet fully analyzed.

The empirically based conclusion is that very little of the sewage sludge would be expected to accumulate at the dumpsite. Indeed, MESA investigators found no detectable accumulation of sewage sludge on the bottom at the dumpsite after 50 years of dumping. Determining the extent of sludge dispersal is a major objective of the MESA research effort.

Another approach to determining the fate of material dumped in ocean waters is to analyze and interpret the distribution patterns of chemicals released from dumped material. Results of this approach are sometimes inconclusive in the New York Bight owing to the multiplicity of sewage sources and the dispersive and mixing processes in the Bight Apex. Almost all municipal wastes and other contaminants are concentrated in the Bight Apex where they are rapidly dispersed and mixed. This complicates identification of sources and makes age determination difficult. High concentrations of several heavy metals and organic compounds in topographic lows of the inner Bight result from an accumulation of dispersed fractions from many contaminant sources. To date, MESA investigators have defined two indicators of sewage-derived material (not of sewage sludge per se) that appear to be useful in distinguishing sewage-derived material from other contaminant sources. 1) The proportion or ratio of artificial sediment particles (primarily cellulose fibers from toilet paper and sootlike particles) to natural grains in sediment give an indication of the degree of contamination by sewage-derived material. 2) Two organic compounds, known to be derived from sewage, are found in Bight sediments -- the steroidal compounds coprostanol and 24 B-ethyl coprostanol. These may prove useful as sewage tracers.

Contaminate Sources

From the progress made in distinguishing among the several sources of contamination found in Bight Apex waters, sediments, and biota, it is clear that dumped dredged materials and municipal wastewaters contribute substantial proportions of the contaminant load in the Bight. The contribution from dredged material was determined by bulk sediment analysis which does not differentiate between natural occurrences of chemical constituents and contaminated forms. The combined inputs of dredged material and municipal

wastewaters are the major sources of suspended solids, organic carbon, nitrogen, phosphorus, coliform bacteria, lead, and several other contaminants (fig. 3).

Estimates of nutrient inputs to the Bight via the Hudson and Raritan Rivers indicate that riverine nutrient input is as much as five times greater than the nutrients in dumped sewage sludge.

Effects of Municipal Sludge

Several impacts of municipal wastes on the Bight have been clarified in the past year. These impacts concern biochemical activity in sediments as measured by oxygen uptake, oxygen concentrations of bottom waters during summer and fall, the productivity of phytoplankton, and several effects on living marine resources. The difficulties in distinguishing among the sources of mixed contaminants in the Bight complicate the determination of which contaminant causes particular effects. For instance, occurrences of fin-rot disease of fishes is associated with the accumulations of dumped and riverborne chemical wastes, but apparently involves bacterial or viral pathogens in some cases.

Based upon recent intensive sampling, MESA investigators have begun to quantify the degree of reduction in species diversity and abundance of bottom invertebrates in the harbors south of New York City and the Bight Apex where sediments are most heavily contaminated. Historical work on benthic macrofauna of the Bight and preliminary results of some MESA cruises have been summarized. Usually low densities of macrofauna were found in Raritan and Lower Bay, and in some sediments of the Bight Apex most modified by solid waste dumping. Some of these most contaminated areas also have unusually little diversity in species composition. The high contaminant levels and extended flushing time of the bays south of New York City limit the numbers and species diversity of bottom invertebrates throughout these bays. However, despite the great volumes of dumped and waterborne materials settling in the Apex, average and high densities of macrofauna are widespread, often with species diversities typical of unstressed areas.

Progress has been made in quantifying the relative importance of the several Bight waste sources in depleting the dissolved oxygen of bottom waters in summer and fall. The unusually small amounts of oxygen observed in the lower layer of the Apex water mass during summer and fall are sufficiently low to cause concern. Examination of available data pertaining to this problem has led to tentative conclusions that dumped sewage sludge and dredge material together account for only about 10 percent of the summer oxygen demand in the Apex. Riverborne carbon may contribute a significantly larger oxygen demand on Apex waters than the dumped materials. The production of photosynthetic carbon in the Apex supplied the major fraction of the oxygen demand in summer at which time seabed oxygen consumption is small, compared to oxygen consumption in the overlying water column. Therefore, cessation of dumping at the sewage sludge and dredge material dumpsites would not significantly affect the oxygen concentration in the lower water layer of

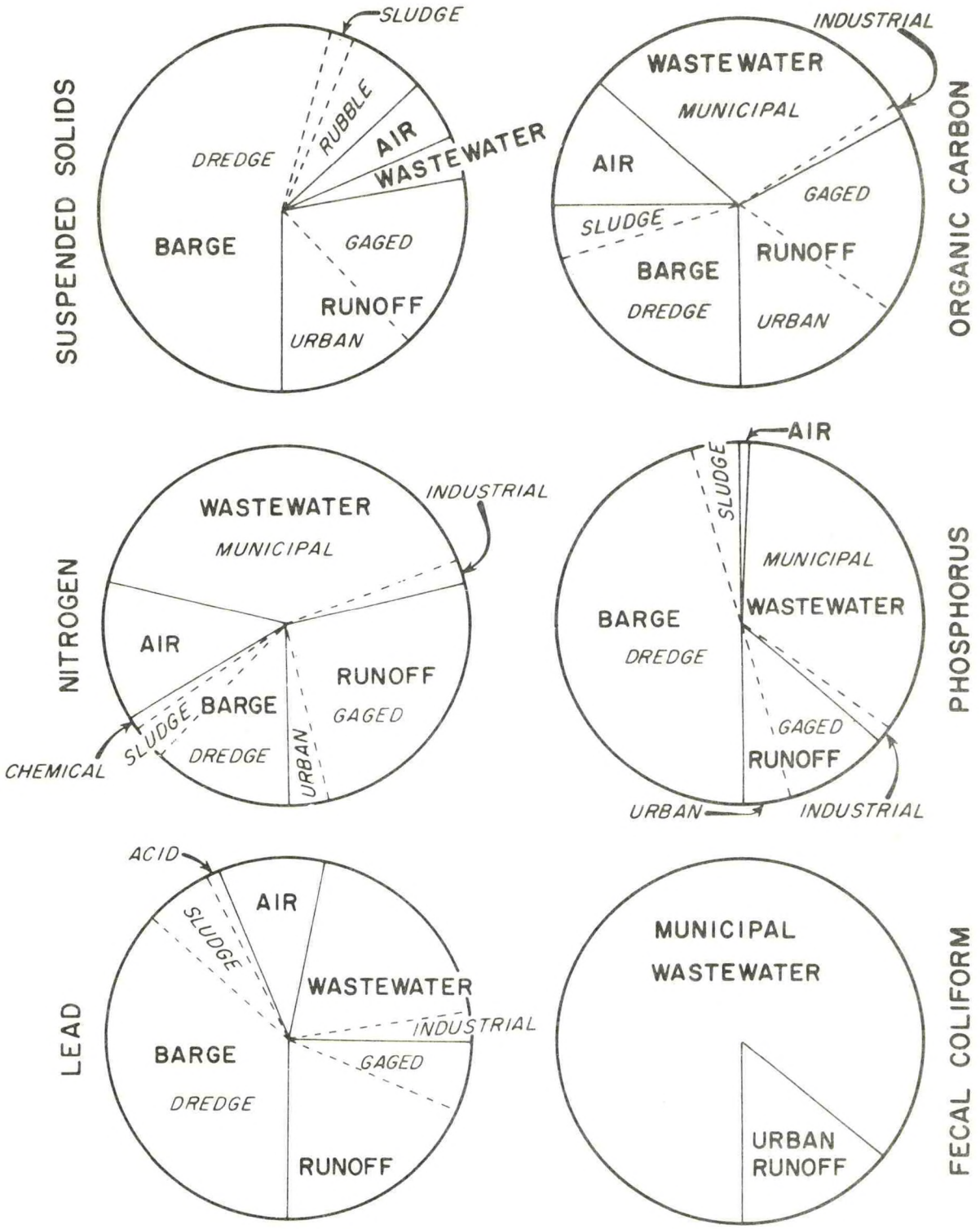


Figure 3.--Sources of contaminants in the New York Bight. (Source: National Oceanic and Atmospheric Administration)

the Apex in summer, apart from eliminating localized effects near the dumpsites. Moderate increases in the dumping would not have significant adverse effects on oxygen concentrations.

Alternative Sewage Sludge Disposal Sites Study

In 1974, EPA Region II determined that the volume of sewage sludge being dumped at the existing sewage sludge dumpsite could triple in volume over the next few years owing to the upgrading of sewage treatment plants in the New York-New Jersey metropolitan area. Concerned that the existing New York Bight sewage sludge dumpsite might not be able to accommodate a three-fold increase in the volume of sewage sludge, EPA Region II requested that the NOAA MESA New York Bight Project undertake indepth evaluations of two areas for dumping of municipal wastes (fig. 4). NOAA agreed to undertake efforts to acquire, analyze, and evaluate data relevant to the environment/ecosystem in and around the two proposed areas. This investigation of the proposed alternate sites was a major NOAA-MESA effort during 1975.

In late 1975, NOAA gave EPA a report on the biological, chemical, geological, and physical oceanographic data and studies, and conclusions and recommendations concerning the suitability of the two proposed areas for locating an interim alternate dumpsite for sewage sludge. EPA used this report as input in preparing the Environmental Impact Statement on selection of an alternate sewage sludge dumpsite. NOAA, on the basis of this report and results of its other studies in the New York Bight, recommended that:

> "The sewage sludge dumpsite should not be relocated. The responsible public health agencies still have no evidence that the existing dumpsite poses a threat to the health and well-being of people using the beaches. There was also no evidence of massive migration of dumped sewage sludge toward the beaches of Long Island or New Jersey. Additionally, moving the dumpsite would not result in any significant overall improvements of the water quality of the Bight Apex because the effects of the dumped sewage sludge are masked by the larger mass emission rates of pollutants from shoreline outfalls, rivers, and embayments."

PHILADELPHIA DUMPSITE INVESTIGATION

Before the beginning of the EPA Ocean Dumping Permit Program, Philadelphia had been dumping sewage sludge at a location about 11 nmi seaward of the mouth of Delaware Bay. In April 1973 EPA required the city to use a site farther seaward, about 50 nmi southeast of the mouth of Delaware Bay. Philadelphia has used this designated site to the present time. The site is only about 5 nmi south-southeast of a site being used by DuPont for the disposal of waste acid (fig. 5).

The close proximity of these dumpsites makes it logistically economical to study both at the same time. Findings related to the DuPont acid waste site are discussed, in part, in this section.

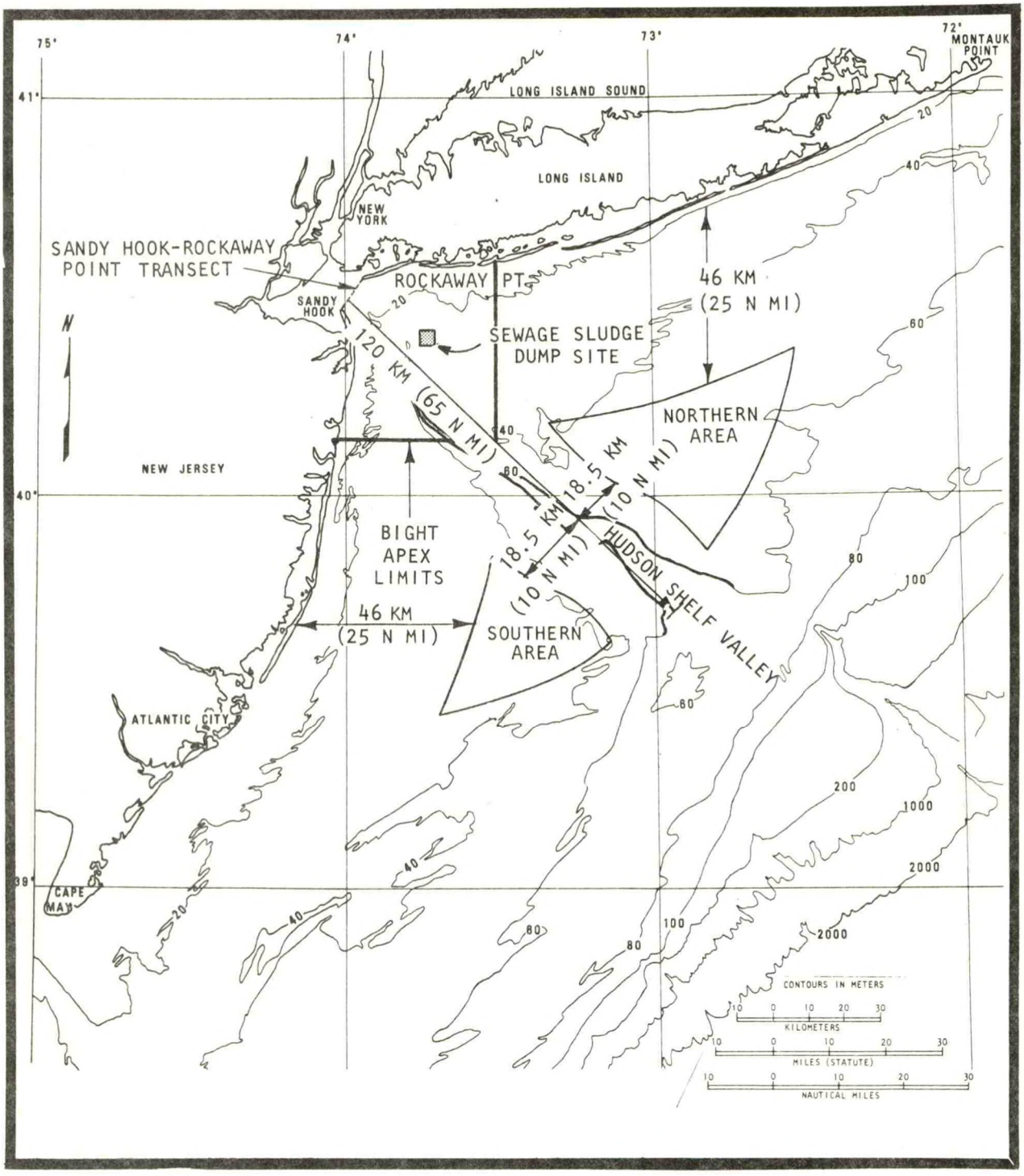


Figure 4.--Location of existing and proposed northern and southern sewage sludge dumpsite areas in the New York Bight. (Source: National Oceanic and Atmospheric Administration, 1974)

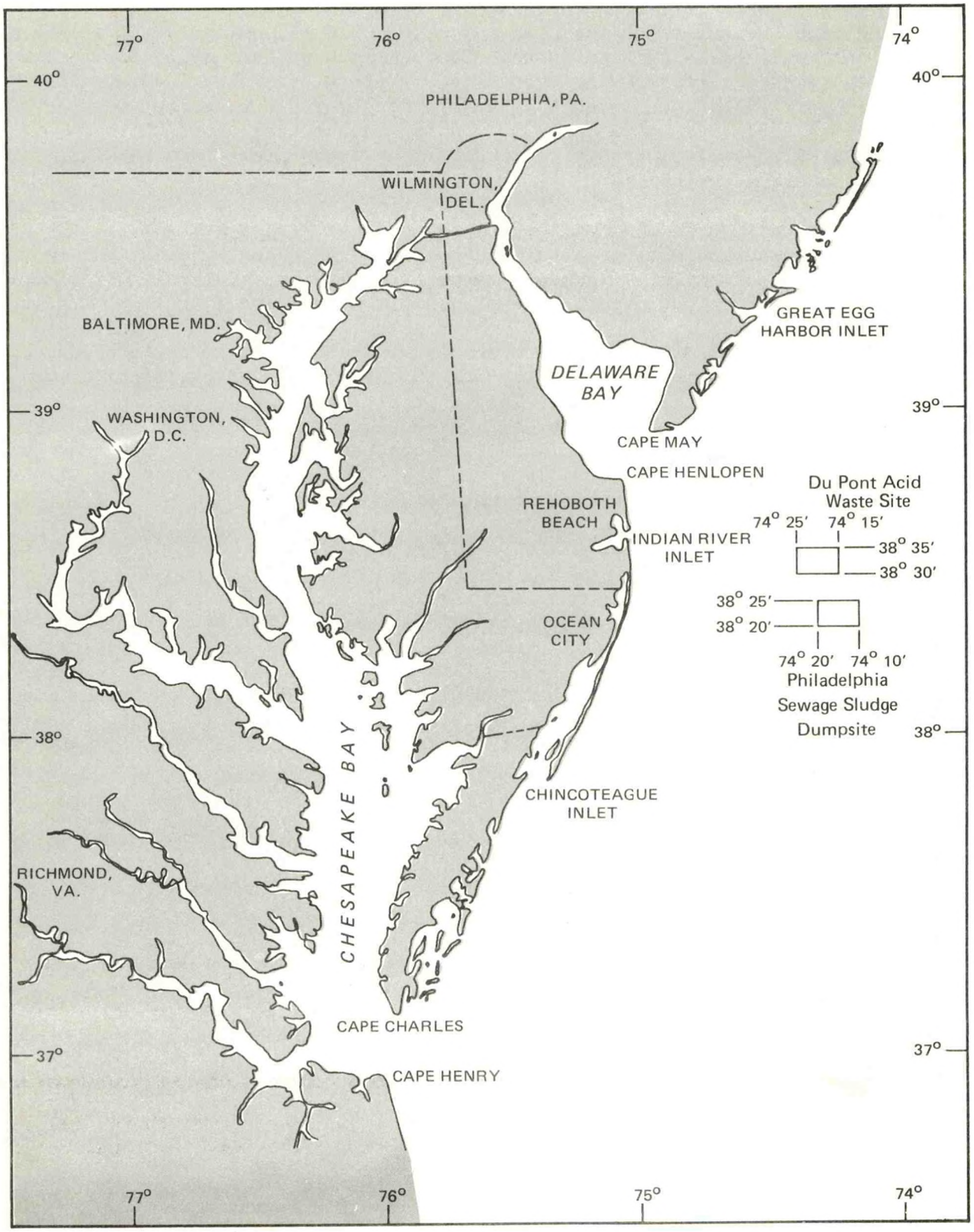


Figure 5.--Location of Philadelphia sewage sludge dumpsite and close proximity of the DuPont acid waste dumpsite. (Source: National Oceanic and Atmospheric Administration)

Before the use of the present dumpsite for Philadelphia sewage sludge, a single baseline survey of the site was made. Since then, surveys have been on a quarterly basis. These surveys frequently have been of a cooperative nature, involving representatives of other Federal agencies, universities, and industry. Thirteen investigative offshore surveys have been completed since 1973. Six were made in 1975. During each survey about 20 to 24 stations were sampled, primarily to determine amounts of trace metals in sediments and in organisms.

The difference in composition of wastes at each site makes it possible to use different constituents as tracers to describe the movement and dispersion of each waste. By using this technique, statistically significant differences have been found in the geographic distribution of trace metals in shellfish. Sediments and benthic shellfish were sampled and subjected to chemical analysis for the presence of heavy metals characteristic of dumped material from the two sources. Results of these analyses correlated with hydrological data for the area. They indicate that heavy metals can be used to trace material from each source. The biological uptake of potentially toxic heavy metals by scallops and clams has been documented. Some contaminated samples were collected well beyond the areas assigned for waste disposal. The limits of waste dispersion are not yet known.

MUNICIPAL WASTES - FATE AND EFFECTS RESEARCH

In addition to the site-specific investigations, a large portion of the Federal effort is directed to investigating fate and effects of municipal wastes. This effort is largely under the aegis of EPA and is a combination of in-house Governmental research, and grants and contracts. To a lesser degree, NOAA through the National Sea Grant Program sponsors research into the fate and effects of municipal waste disposal in the ocean. The following studies highlight research on the fate and effect of sewage sludge relative to ocean dumping, or research that can be directly applied to ocean dumping situations:

- EPA-funded research by the Southern California Coastal Water Research Project has studied the input of DDT and PCBs into Southern California marine waters. The work, to date, indicates that municipal wastewater discharges in Southern California and atmospheric fallout are the prevalent sources of DDT and PCBs. Available data indicate that surface runoff, industrial waste inputs, and antifouling paints are less significant sources. Other persistent organics under study include HCB and di- and trichlorobenzene. Additionally, investigators at the Southern California Coastal Water Research Project are studying how ocean outfalls affect 1) the structure of benthic infauna and fish communities; 2) the incidence of diseases, including fin rot and tumors in flatfish; and 3) historical trends in the diversity and stability of marine ecosystems in the Southern California Bight. They also have examined the recovery of benthic infaunal assemblages

following the cessation of an outfall discharge. More work in this area is planned to focus on epifaunal rocky bottom assemblages.

- EPA-sponsored research at the University of Rhode Island is emphasizing the biological effects of wastes at both ecosystem and species levels. Microcosm models of lower Narragansett Bay follow natural flushing rate, temperature, salinity, and light regimes while being subjected to stresses that mimic natural mortality and sewage disposal. Thus far the model system has been satisfactorily tested for reproducible results and field verification is underway. Another URI researcher is concentrating on the uptake of trace metals by benthic species from clean and polluted pore waters within benthic sediments. The concept of these experiments is to determine the extent to which benthic species act to cleanse sediments of entrapped heavy metals by translocating the metals into overlying waters or into the marine food web.

- An EPA-sponsored study at Fordham University entitled "Biological Analysis of Primary Productivity and Related Processes in New York Harbor as Reflective of Changing Water Quality" is designed to investigate those processes and factors that might contribute to massive algal blooms. This study will provide information relevant to the kinds of treatment required for municipal waste discharges. In addition, the study will investigate whether the water quality of the New York harbor region is being affected by materials flowing into the area from offshore sludge dumping sites.

- Under an EPA grant, researchers at Harvard University are studying the ability of native marine microorganisms to kill human pathogens released to the marine environment through ocean outfalls. These results are being incorporated into a mathematical model of the fate of coliform bacteria in the sea.

- An EPA-sponsored study of toxic metals in domestic and industrial sewage is in progress at Massachusetts Institute of Technology (MIT). The reactivity and fate of concentrated heavy metal wastes dissolved in acid that are dumped into seawater is a complex problem that must be understood to establish safe disposal practices. Transport of toxic metals depends upon their solubility in seawater and their mobilization in the sediment and ecosystem. The MIT approach uses computer modeling of chemical solubilities, and field data from a specific study of ocean dumping, to determine which chemical, physical, hydrographic, and biological factors govern the transport and translocation of toxic metals dumped at sea.

- Models are being developed to simulate trophic levels; concentrations of sewage sludge; mortality, growth, and reproductive success of affected organisms; and bioaccumulation

of trace metals. Through an interagency agreement between EPA and Energy Research and Development Administration (ERDA), the Puerto Rico Nuclear Center's research reactor is used for neutron activation analysis of heavy metals from sludge as they are incorporated into biological systems. To evaluate metal uptake and concentration where it occurs, mixed plankton, benthic infauna, and epibenthic marine organisms are analyzed following exposure to metal-laden sludge.

- In Florida, NOAA Sea Grant researchers at the University of Miami studied the water circulation and fate of waste effluents in shallow bays and estuaries, including die-off rates of bacteria. Also, the State University System of Florida is studying the effects of sewage pollution abatement in Hillsborough Bay, Tampa, Florida. Plans are to replace the present primary treatment with tertiary treatment in 1976. The data will serve to determine the effects of pollution abatement.

- Sea Grant studies to develop numerical models to predict circulation and dispersion processes in coastal waters such as Massachusetts Bay are continuing at MIT.

In addition to the sponsored research previously described, a large portion of Federal research is an in-house effort being made by the EPA Environmental Research Laboratories. Current investigations include:

- The impact of different thicknesses of sewage sludge on the survival of representative invertebrates has been studied to determine the capacity of the marine benthos to assimilate sewage wastes. This research led to a preliminary design for a multispecies bioassay for materials dumped at sea.

- Indices of population dynamics and community structure, including measures of species composition, diversity, richness, dominance, density, and biotic homogeneity, are being reviewed to determine those most suitable as indicators of the effects of ocean dumping.

- Sampling methods for the benthos, plankton, and fish communities at ocean disposal sites are being developed to provide a basis for statistically valid analyses of the health of marine ecosystems.

- A survey of the dynamics of benthic communities and pollutant levels in a clean area of the New York Bight is in the third year of a long term study and will provide a baseline against which changes in biotic conditions at disposal sites in the Bight can be assessed.

- A biomonitoring system using the caged animal concept has been developed. The primary purpose is to show the feasibility of such a system in determining zones with high pollutant bio-availability around submerged discharges of waste. The concept

uses a taut line buoy system, from which nylon mesh bags are supported at selected depths, and a metal cage rests directly on the bottom. The organism selected was a mussel (Mytilus californianus), a ubiquitous species that readily concentrates chlorinated hydrocarbons and rapidly responds to environmental levels of such pollutants. Field results indicate a direct relation between uptake of DDT and PCBs and proximity of bio-indicators to contaminated sediments or wastewater plumes. Plans are to use this monitoring system near three major submarine outfalls, including a sludge discharge line that has significantly high concentrations of PCBs and DDT. This planned effort should shed some light on the degree to which sediments are contaminated by sewage effluent and sewage sludge discharge, and make it possible to assess whether selected sediments are a major source of chlorinated hydrocarbons in the biota.

MUNICIPAL WASTES - ALTERNATIVES RESEARCH

The EPA is the lead agency for exploring alternatives to offshore disposal of municipal waste. This section describes current EPA research on the problem of sewage sludge disposal. In recent years EPA, through its Washington Headquarters, regional offices, and field centers, has carried out a continuous program of in-house and contract research into new methods of handling the many wastes being produced by our Nation, including those that are currently being disposed of in coastal waters.

Five million dry tons of municipal sewage sludge are now generated per year. It is estimated that the amount will double in the next 8 to 10 years. The obvious question of all concerned with wastewater treatment is "What do we do with the sludge?" Currently sludge is being disposed as follows: about 15 percent by ocean dumping, 35 percent by incineration, and 50 percent to the land (25% by land application and 25% by landfill). Historically, inland cities and rural communities have preferred land application.

The primary objective of the EPA sludge management program is to develop new and improved technology and management schemes that will enable communities to solve their problems of disposing the residues and byproducts of wastewater treatment in a cost-effective and environmentally acceptable manner. There are four technical areas of the sludge management R&D program: 1) processing and treatment, 2) conversional utilization, 3) disposal, and, finally, 4) health and ecological effects of each system. Although each of the program areas have separate goals all are intimately interrelated, especially the health and ecological aspects.

Methods relating to the processing and treatment, conversion, and utilization, and disposal technical areas of the program are considered under the topics of processing and treatment, conversion processes, and land application.

Processing and Treatment

The goal of processing and treatment is to develop technological alternatives that can be used to prepare sludge for land application and conversion processes and that minimize the total cost of handling, using, or disposing sludge. Ordinarily sludge must undergo some processing or treatment to prepare it for ultimate disposition. For example, conventional dewatering devices leave sludge too wet for optimum incineration or disposal as landfill. Processed sludge also may have residual pathogens that make it unsatisfactory for land disposal. Furthermore, the marketability or acceptance of some newly developed technology is slowed by the need to further evaluate operational and maintenance aspects of the systems.

The EPA program is designed to address the technological, environmental, and economic problems associated with processing and treatment. The effort is focused on alternatives to mitigate the problem areas. These efforts currently aim to:

- Characterize the nature of, and the dewatering properties of, "new" sludges using existing, upgraded, and new technology.
- Develop hardware capable of producing a substantially drier sludge cake.
- Develop and define performance of existing and new processes for stabilizing sludge (anaerobic digestion, autothermal thermophilic aerobic digestion, thermoradiation, electromagnetic radiation, etc.).
- Investigate ways to minimize energy consumption while simultaneously maximizing fuel production (activated carbon enhancement, solar heating, etc.)
- Determine cost and environmental impact of sludge processing systems.

Conversion Processes

Problems and technological inadequacies that require research and development related to conversion processes are the dependency of sludge incineration on fuels that are in critical supply, such as oil and natural gas, and societal and institutional objections to siting and sludge conversion facilities. Additionally there is a low level of technology applicable to pyrolysis and starved-air combustion of sludge and insufficient information on composition and characterization of stack particulates and pollutants. Based on these shortcomings in technology the objectives in conversion processes are aimed at reducing the volume of solids ultimately destined for land disposal while at the same time reducing the cost of the conversion process, and dependency on fossil fuels and attendant emmissions to the atmosphere.

Current program activities directed toward these objectives aim to:

- Develop techniques for substitution of more abundant, less costly supplemental fuels such as coal and solid wastes for incineration and co-incineration;
- Develop processes and hardware for pyrolysis, co-pyrolysis, and starved-air combustion;
- Characterize emissions to determine levels of potential pollutants (gaseous, liquid, solid) contained in emissions from sludge conversion facilities; and
- Establish "least cost" approaches to sludge conversion.

Land Application

The deepest involvement in ecological and health implications occurs when considering land applications as a sludge management practice. Most options for utilization or disposal eventually focus on land application; therefore, this technique has had more scrutiny and controversy than any other sludge management option. The principal objective relating to land-application is to develop methods and technology to control the transformation and/or movement of pollutants through the soil, plants, groundwater, and human food chain. A number of other Federal agencies including the Food and Drug Administration and the U.S. Department of Agriculture are cooperating with EPA on this research.

It is anticipated that the accomplishment of the primary objectives will permit the establishment of management schemes for a variety of sludges with optimum combinations of soil and vegetation. Practices can then be defined for applying sludge to the land for purposes of reclamation of marginal or submarginal land, agricultural uses for both food and fiber, and landfill disposal.

Current program activities directed toward the land application related objectives include:

- Evaluation of current knowledge of potential health effects.
- Determination of viral contamination of ground and surface water of a land reclamation site.
- Development of methods for isolating viruses and chemicals.
- Characterization of type, quantity, and biological persistence of biologicals, trace metals, and other organic and inorganic substances in the environs of a sludge-disposal site.

- Determination of the potential of biological, metal, and organic substances entering the human food chain when digested sludge is used as a fertilizer.

- Study of heavy metal uptake by beef cattle grazed on sludge-treated pasture.

CHAPTER IV

INDUSTRIAL WASTE RESEARCH

There are nine designated sites for ocean disposal of industrial waste. Both NOAA and EPA are conducting research on ocean dumping of industrial wastes. Investigations at specific sites have focused on the DuPont acid waste site and Deepwater Dumpsite 106. Investigations at the DuPont dumpsite are normally undertaken in conjunction with surveys of the nearby Philadelphia municipal waste dumpsite (described in Chapter III).

DEEPWATER DUMPSITE 106 INVESTIGATION

NOAA, at the request of EPA, initiated in 1974 a series of three seasonal investigations of Deepwater Dumpsite 106 (DWD 106) to assess the impact of present dumping activity and to provide a comparative base for future assessments. Because of the nature and volume of materials dumped at this site, and because of the site's location relative to nearby metropolitan areas, dumpsites in the New York Bight, potential offshore development, and the complex biology and oceanography of the region's waters, the evaluation of impacts from dumping here is of high priority to EPA.

The dumpsite is 106 nmi southeast of Ambrose Light and 90 nmi due east of Cape Henlopen, Delaware. It is used by more than 25 different dumpers in the New York-New Jersey area to dispose of various industrial chemicals. Wastes are dumped just beneath the sea surface by a barge moving at a speed of 3 to 5 knots. Typical waste materials include: hydrochloric acid byproducts, inert ore slurry from production of titanium dioxide pigments, residual sludge from galvanizing and plating operations, liquid wastes from production of textile manufacturing and from etching and photographic processes, water solutions of inorganic salts, and similar materials derived from diverse manufacturing processes.

The major findings from the first NOAA seasonal baseline study in May 1974 were published in 1975. These findings indicate that little if any of the dumped materials reach the bottom in the vicinity of the site. This does not imply that pollutants and their effects cannot be transferred by organisms within the ecosystem and through the food chain. A second seasonal baseline study in July 1975 used a research submersible and a surface vessel. Data from this survey are being processed, and reports are being prepared. Preliminary findings from this operation were used, together with prototype information from the 1974 studies, to design studies for 1976.

These seasonal baseline studies are needed to describe prevailing environmental conditions and their normal variations. An important objective in establishing baseline data is to statistically define natural variation, both spatial and temporal, against which the data from later monitoring surveys can be compared to determine deviations or trends from a norm.

INDUSTRIAL WASTE - FATE AND EFFECTS RESEARCH

In addition to studies at specific sites, EPA is performing or sponsoring a number of fate and effects research projects on industrial wastes. The projects are largely aimed at perfecting appropriate bioassay techniques and methods of predicting impacts.

Bioassays have been under development to establish potential toxicity of a given waste to species indigenous to the dumpsite. EPA's Region II has employed bioassays on a zooplanktonic copepod, a phytoplanktonic diatom, and a fish to determine the manner of dumping to be employed by an applicant as an ocean dumping permit condition. Although it is recognized that bioassays employing representative indigenous species do not guarantee the integrity of an ecosystem, it is often the only available index of environmental safety. Applied conservatively to permit conditions, bioassay results plus a judgmental safety margin in rate of waste disposal may be the best available information on which to regulate ocean dumping. As part of the research effort, a manual of standard bioassay techniques has been compiled and revised as the state of knowledge has advanced.

Man's effects on the marine environment are being investigated by sediment core analysis. The history of pollutants, other than heavy metals, including petroleum, PCBs and DDT, plutonium isotopes, and man-mobilized minerals, is being studied through a grant to the University of California. The historical changes in these materials, in sediment cores, are being used to predict future environmental levels, given past and present usage patterns. Variation in pollutant concentration with depth indicates that recent sediments are most polluted. Environmental management of waste disposal depends upon predictive capabilities developed by such methods.

INDUSTRIAL WASTE - ALTERNATIVES RESEARCH

Research being conducted by EPA on alternatives to ocean dumping of industrial wastes, like research on municipal wastes, is not directed, in most cases, at the ocean dumping problem but has been undertaken to meet other goals. The major areas being investigated include alternate methods of disposal, effects of alternate methods of disposal, resource reuse or recovery, and detoxification.

One alternate method of disposal being investigated is ocean incineration. A technical report (EPA-430/9-75-014) has been completed on the ocean incineration of toxic industrial wastes carried out in the Gulf of Mexico. This report evaluates ocean incineration as a method for disposal of some organic chemical wastes. As a result of the information gathered during the research and interim permit burns, and anticipating that other permit applications will be submitted for disposal of selected organic wastes by incinerator ships, guidelines are being developed for interim operations, monitoring, sampling, and analysis protocol. Final requirements will not be established until additional investigations and studies are completed.

Related to ocean incineration is the completed research that deals with the incineration conditions necessary for safe disposal of pesticides. This involved both laboratory and field (an experimental incinerator) conditions. The goal of the research was to determine the time-temperature conditions needed for the thermal decomposition of pesticides. Reports are nearly complete on the various research projects relating to the thermal destruction of pesticides. They contain information on efficiencies of combustion, residence time, and other conditions for safe incineration.

A technical and economic study has been completed on the feasibility of using chlorinalysis to convert highly toxic wastes, such as chlorocarbons and pesticide residues, into useful industrial chemicals, such as carbon tetrachloride. This research demonstrated the feasibility of exhaustive chlorination as a resource-saving method to convert certain herbicides into useful and marketable products. The conversion scheme is completely closed-loop with minimal environmental risk.

Environmental problems relating to landfills are being investigated. Studies are underway to assess the hazards associated with land disposal of selected industrial wastes, including the potential for migration of hazardous materials through soil. Information has been obtained on various landfill liner materials for leachate containment. A bibliography on the migration, transformation and soil retention of hazardous materials has been completed. Natural and synthetic sorbants are being evaluated as treatment media for leachates from industrial wastes. The long-range goal is to identify materials that can be placed in the bottom of landfills to remove contaminants from industrial waste leachates before they enter the soil. Sorbants, such as flyash and natural zeolite, are being tested with leachates from calcium fluoride, and metal finishing and petroleum sludges. Landfilling as a method for disposal of sludges having high ash content has been evaluated and an appropriate disposal manual has been prepared.

Several studies are examining the feasibility of treating a variety of wastes to produce less toxic or more useful products. Among the treatment techniques being evaluated to remove the biorefractories are ozonation, carbon adsorption, solvent extraction, anaerobic/aerobic treatment, and air stripping. A study with the U.S. Army to obtain data on detoxification techniques for hazardous and toxic wastes is being carried out to determine which techniques are most effective in making these materials less hazardous.

A contract is underway to develop and demonstrate through a bench-scale chemical degradation process a treatment for DDT, toxaphene, chlordane, PCBs, and hazardous chemical manufacturing and processing wastes. Two processes for treatment of heptachlor-endrin wastewaters are also being investigated. Catalytic hydrogenation of chlorinated compounds is being studied. Some of the desired reactions are being observed, however, the products are at times toxic in themselves.

Waste acid disposal is a large problem that has stimulated various investigations. One is a study to demonstrate the effectiveness and economics of a novel process for recovering phosphoric acid from bright finishing solutions used in the preparation of aluminum. The process will remove aluminum

from the waste phosphoric acid, thereby permitting reuse of the acid in the bright dipping operation.

A method is being evaluated for the conversion of ferrous sulfate from spent "pickle liquor" to iron oxide and reuseable sulfuric acid. A ferric nitrate intermediate, produced by continuous ion exchange, will be decomposed to produce the oxide and nitric acid for recycling. A full-scale system will then be installed in a steel mill so that the total closed-loop system can be studied.

The New Jersey Zinc Company is conducting a pilot plant study of a new approach to the recovery of sulfuric acid from the waste acid stream generated during production of titanium dioxide pigment by the sulfate process. The study will evaluate total evaporation of the waste acid stream and subsequent reconcentration, in two stages, of the clean acid back to the 90 to 95 percent concentration necessary for reuse in the digestion process.

The principal objective of another project is to demonstrate, in a plant scale continuous operation, the technical and economic feasibility of using a process and equipment for the recovery and regeneration of waste hydrochloric acid "pickle liquor" in a closed-loop system in which no noxious pollutants escape into the environment. The process is expected to yield 18 to 20 percent hydrochloric acid for recycling and ferric oxide of desired particle size.

A comprehensive compilation of available information regarding the injection of industrial hazardous wastes into deepwells has been completed. The limited assessments that have been made indicate that deepwell injection of selected wastes is environmentally safe, provided sound engineering and geologic practices are followed in constructing and operating the well.

A technique is being tested to effectively fix hard-to-manage hazardous wastes. The material is encapsulated and then subjected to leaching tests.

With the advent of more stringent air quality standards there has been an increase in the number of flue gas cleaning (FGC) systems (scrubbers). The majority of these are lime/limestone wet scrubbing systems that produce a calcium/sulfur byproduct. Because of environmental and economic concerns, there has been increased research on the disposition of this flue gas desulfurization (FGD) waste. A broad-based study is underway to (1) identify environmental problems associated with FGC waste disposal by comparing FGC waste chemical/physical characteristics with current, proposed, or potentially applicable environmental standards; and (2) assess current FGC waste disposal methods, including feasibility, performance, and costs, by conducting laboratory studies of wastes, providing engineering support, and performing chemical/physical analyses for the Shawnee field evaluation, and evaluating other available data and conducting engineering cost studies of disposal methods.

During the Shawnee field evaluation project on FGD waste disposal, three processes for chemical fixation of scrubber wastes are being evaluated

in three separate disposal ponds. Samples of leachate, runoff, and ground water as well as core samples of the waters and soil are being collected and analyzed. A waste characterization project of lime/limestone wet scrubbing consists of efforts to (1) identify waste materials from the Shawnee facility and correlate the physical/chemical properties of the materials with the scrubber operating conditions; (2) identify waste materials from other (full-scale) facilities and correlate properties with scrubber operating conditions; and (3) suggest, if feasible, a means of controlling waste characteristics to improve the economics of disposal and utilization.

Another project involves laboratory and field studies to evaluate current commercial (first generation) and new, not yet commercial (second generation) processes for treatment of several industrial wastes, including FGC wastes. The first generation processes will be evaluated through laboratory studies of leaching columns, physical testing of samples of several chemically treated FGC wastes, and small field studies of selected treatment processes. In addition, visits will be made to existing full-scale disposal sites for complete evaluation (including soil coring) of current disposal methods. The second generation processes will be restricted to those which are chemically and operationally defined. Candidate processes will be screened via economic analysis, physical testing, and resistance to pollutant leaching.

A study of attenuation of FGC waste leachate by soils is being made to determine the extent to which heavy metals and other chemicals in FGC wastes can migrate through the soil in land disposal sites. At least six scrubber wastes and three coal fly ashes will be tested under this project, which includes the following efforts: (1) physical and chemical characterization of the wastes; (2) leachate studies in columns with the wastes applied to several soil types; (3) long term permeability tests with selected clays; and (4) identification of soil attenuation coefficients for specific chemicals. The characterization tests have recently been completed; permeability tests are underway.

The use of lime/limestone scrubbing wastes as a filler material and source of sulfur for fertilizer is being investigated. The contractor is making (1) pilot plant tests of fertilizer production using lime/limestone scrubbing wastes, (2) tests of compatibility factors involved in storage and mixing of this fertilizer material with conventional fertilizer, (3) field plot tests using fertilizer from the pilot plant, (4) economic/marketing studies, and (5) determinations of the amounts of trace and/or toxic elements in conventional fertilizer.

An evaluation of alternative sites for FGD waste disposal is being made to identify, assess, and demonstrate, on a pilot scale, alternate FGD waste disposal methods (other than local ponding and landfilling). The initial effort, currently near completion, consists of an evaluation and assessment of the compatibility, capability, and adequacy of deep and surface coal mines, oceans, and other potential disposal sites for handling and disposal of untreated FGD wastes. Although environmental effects and operational safety are major initial considerations, the assessment also includes an economic study of alternate methods and study of applicable

Federal and State regulations. Based on the initial efforts, recommendations and conceptual designs for the pilot demonstrations will be made.

The pilot demonstrations, expected to get underway in 1976, will be on a scale such that design data for full-scale operations can be obtained. The mine study, consisting of tests on small plots at an existing coal mine, will include monitoring for pollutants, characterizing pollutants, identifying limits of physical-chemical characteristics of the wastes, and determining waste/mine interactions. The ocean study, consisting of tests in a tank that can simulate the ocean environment, will include settling and dissolution characteristics and, in general, any conditions or factors that would place stress on the ecosystem.

Closely related to EPA's research on ocean dumping alternatives is the Maritime Administration (MarAd) Chemical Waste Incinerator Ship Project. MarAd is presently considering Federal support of the development of a U.S. capability to incinerate toxic chemical wastes at sea. Federal support could be by the sale of National Defense Reserve Fleet (NDRF) vessels for conversion to chemical waste incinerator ships and/or the granting of government mortgage loan guarantees for conversion or construction of such ships. The sale of any NDRF vessel would be to a U.S. flag ship operator under competitive bid procedures; the conversion or construction would take place in a U.S. shipyard. U.S. flag incinerator ships would be subject to extensive design, construction, and operational requirements of the U.S. Coast Guard and MarAd regarding the vessel and of EPA requirements concerning the incinerator system and the burn area. A draft Environmental Impact Statement on this project was filed by MarAd on December 1, 1975 (MA-EIS-7302-76-08D) (NTIS-PB-246/728/AS).

CHAPTER V

SURVEILLANCE AND MONITORING

Surveillance of ocean dumping activities and monitoring of oceanic conditions and the effects of dumping are major considerations of the Coast Guard, NASA, NOAA, and EPA research and development programs.

OCEAN DUMPING SURVEILLANCE SYSTEM

Coast Guard research conducted solely "in-house" is directed toward more efficient and cost-effective means of carrying out its role of surveillance and enforcement in the ocean dumping program. Some research and development effort has been aimed at remote sensing and "tagging" of dumped materials; however, the primary R&D goal has been to develop a "black box" navigation recording unit that will be required on vessels engaged in ocean dumping. The first prototype Ocean Dumping Surveillance System (ODSS) was tested and evaluated on two dumping vessels during 1975.

ODSS is designed as a sealed, tamper-proof unit to record the position and time of the dumping vessel. The prototype system consists of a low-cost, dual-channel LORAN-C receiver, and two data recorders, which record position and time in both manual (printed tape) and computer (punched tape) format for confirmation of the vessel's track by the Coast Guard. Ultimately the system is expected to have a computer-compatible magnetic tape recorder. The LORAN (Long Range Aid to Navigation) receivers continually indicate signals from two LORAN stations. These give the dumper an accurate two-line navigation fix as often as desired. An effort is being made to reduce the cost of the system so that dumpers can be required to procure and maintain their own systems. As now planned, the system should cost less than $10,000.

Results of ODSS tests were encouraging. Some deficiencies in the system necessitated further development of system components; however, the concept appears feasible. When operational, in 1977 or 1978, ODSS should help the dumper comply with his permit and help the Coast Guard ensure that he does. Ultimately the system is expected to include a dump mechanism sensing device to further reduce operator interface.

REMOTE SENSING RESEARCH

Recognizing that remote sensing could play an important role in achieving MESA Program objectives, the NOAA National Environmental Satellite Service (NESS) initiated remote sensing studies as a continuing program activity. NOAA requested that NASA assist in the remote sensing studies. The NASA objectives in this cooperative program were to: (1) investigate the role of remote sensing in defining the circulation in the New York Bight and the application of the information to monitoring and managing ocean dumping, (2) investigate the capability of remote sensing to obtain coastal zone information, such as baseline information for environmental impact statements, and (3) assist NOAA in incorporating the capability for remote sensing and modeling in its design of an integrated monitoring system. To

achieve these objectives NASA has been conducting laboratory and field research on spectral signatures of oceanic pollutants and algae, analytical studies to develop and validate oceanic circulation, investigation of dispersion and wave refraction models, developmental studies on remote sensors for water pollution monitoring, and joint field experiments to evaluate remote sensing techniques in the coastal environment.

This cooperative program began in April 1973, when NASA joined in the first MESA remote sensing experiment in the New York Bight. Multispectral scanner and photographic instrumentation were used aboard NASA aircraft and satellites to observe major circulation features and detect waste materials dumped in the New York Bight. NOAA made concurrent "surface truth" measurements. These were used to correlate airborne observations with measurements of water parameters in-situ. Results from this field experiment demonstrated the potential of remote sensing for providing environmental data that cannot be attained by conventional techniques.

NOAA and NASA personnel began planning and carrying out a cooperative program to explore more fully the use of remote sensing for making environmental measurements in coastal waters. After laboratory studies and further development of remote sensing techniques, additional field experiments were planned. During April 7 to 17, 1975, a second cooperative experiment on remote sensing was made in the New York Bight. Improved multispectral photographic sensors in conjunction with new microwave techniques were used during NASA aircraft flights. Results were correlated with satellite overpasses to study surface and subsurface (10 meters) circulation features, surface wind speed and direction, ocean color (with emphasis on sediment and chlorophyll), sea-surface temperature, and spectral signatures of acid waste and sewage sludge. Another objective was to develop interpretive techniques for multispectral data analysis. NOAA made simultaneous "surface truth" measurements from buoys, ships, and helicopters to correlate the remote and in-situ measurements. Analysis of the data from this experiment is not yet complete; however, preliminary results show that cloud-free spectra of acid waste, sewage sludge, sediment, and chlorophyll were obtained. Spectral signatures extracted from these data were used to develop algorithms for data analysis and interpretation. These algorithms can be used to automatically map and discriminate between major near-surface pollutants in the New York Bight (fig. 6).

Two additional cooperative field experiments were made during 1975. In September 1975, a passive microwave technique for remote, all-weather measurements of sea-surface temperature and salinity was evaluated during flights over disposal sites for sewage sludge and acid waste in the New York Bight. An airborne 11-channel multispectral scanner also was used in this experiment to obtain more detailed spectral information on the sewage sludge and acid waste in ocean water. Later in the fall, NASA and NOAA Atlantic Oceanographic and Meteorological Laboratories (AOML) measured bottom-water movement in the New York Bight. Acoustic tracking experiments were performed with a small NASA-developed acoustic tracking pinger. Seabed drifters were deployed near the sewage sludge dumpsite and monitored continuously

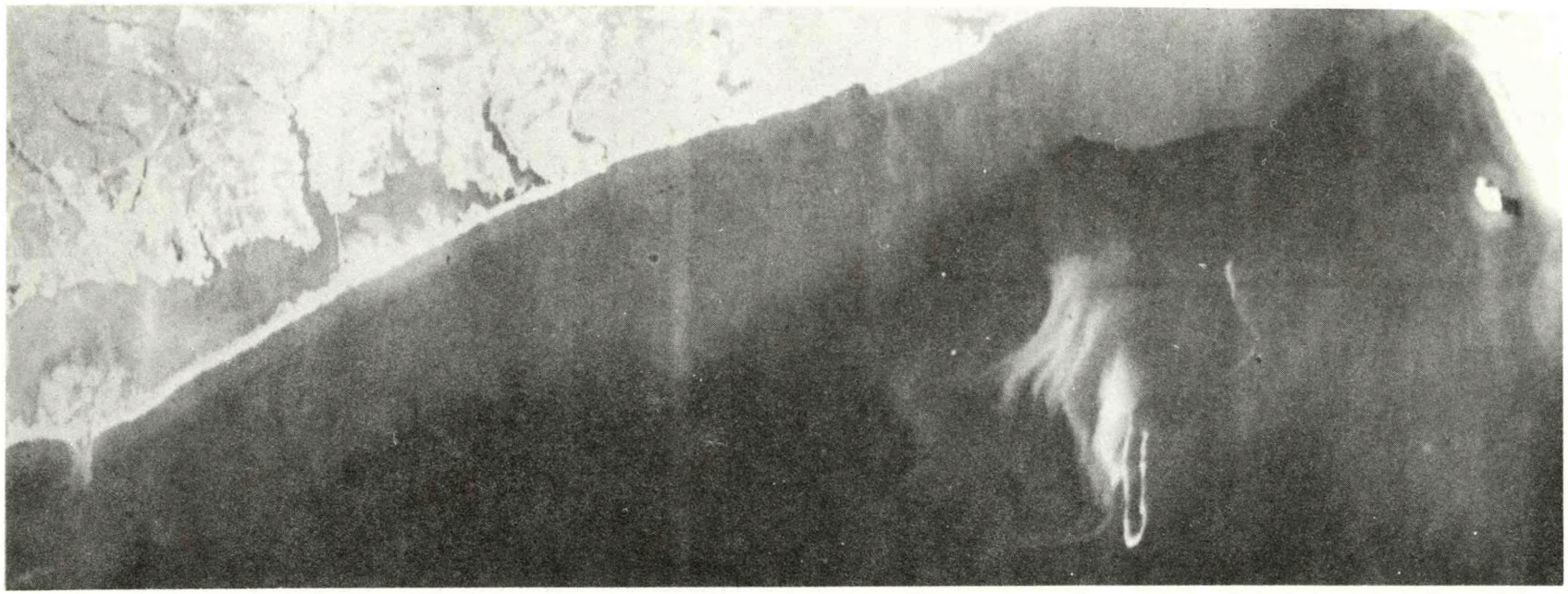


Figure 6.--Enhanced scanner image of New York Bight, April 9, 1975--portion of shore of Long Island and New Jersey shore from Barnegat Inlet to just south of Sandy Point. Newly dumped acid waste is sharp "U". Earlier dumped acid drifts and diffuses to the west. This westward drift is characteristic of nearly all imagery for this area. The square shaped pattern north of the acid waste is a sewage sludge dumpsite. The bright area along the New Jersey shore is the normal flow pattern of Hudson River plume. The high relative reflectivity of the plume is due to the relatively high particulate load where the Hudson River discharges. (Source: National Oceanic and Atmospheric Administration)

by sonar on a surface vessel until bottom-water movements were determined. The results showed a slow, generally northward movement of bottom waters during the fall of the year. Application of this technique for measuring bottom-water movement is less costly than conventional current meter arrays.

Currently, NOAA and NASA personnel are analyzing the results of previous laboratory studies and field experiments and formulating plans for the next phase of this cooperative program. Results to date demonstrate that remote sensors can monitor a variety of water pollution parameters; e.g., chlorophyll, sediment, acid waste and sewage sludge, and thus make a major contribution to a system to monitor ocean dumping. Additional studies in the next phase of this program will obtain information on the extent to which remote sensing techniques can provide quantified information on specific pollutants and further develop remote monitoring applications to ocean dumping.

Cooperative programs between NASA and EPA began in June 1972, when EPA requested that NASA assist them in evaluating remote sensing techniques for water quality monitoring, including techniques which could be useful for monitoring waste dumping in estuaries and coastal waters. During the first phase of this program (1972 and 1973) about a dozen different remote sensors were evaluated individually in laboratory and field tests to determine their ability to detect and quantify the surface concentrations of key water-quality indicators. These techniques included a four-color laser system, multispectral scanners, multispectral photography, dual differential radiometer, passive microwave radiometer, thermal imagers, and infrared photography. The results from these tests indicated that, while most of the techniques studied provided useful information, the multispectral scanner techniques held the greatest promise for detecting and quantifying pollutants in estuarine and coastal waters.

The next phase of the program was a coordinated field test in local estuarine waters to collect, over the same geographic area, data using both of these techniques simultaneously. A concurrent ground truth program, conducted jointly by NASA, Old Dominion University, and the Virginia Institute of Marine Sciences, was a key element in this coordinated field test. On May 28, 1974, multispectral scanners of NASA aircraft and satellites and multispectral cameras aboard NASA aircraft were flown over a segment of the James River between Hopewell and Norfolk, Virginia. Another field experiment was made on August 28, 1975, wherein these multispectral scanner and photographic devices were flown over the acid dumpsite 40 miles off the east coast of Delaware and over an industrial organic waste-discharge plume in the Delaware Bay. NASA and the University of Delaware carried out a major ground truth program to support the experiment. Data from this experiment substantially expanded the amount of remote spectral information and ground truth on wastes discharged in coastal waters. These results, coupled with results from the NOAA activities previously discussed, will provide a data base from which an assessment can be made of the ability of multispectral remote techniques to monitor ocean dumping.

WATER QUALITY MONITORING BUOY

Shipboard monitoring of ocean disposal sites on a large scale is prohibitively expensive and provides at best a very limited number of data sets. Recognizing the limitations of shipboard monitoring, NOAA developed a buoy-mounted Water Quality Indicator System (WQIS) capable of measuring chlorophyll, conductivity (salinity), dissolved oxygen, pH (acidity), temperature, and water turbidity. The WQIS was installed on a 16-foot disc buoy (EB 52). Additionally, the buoy was instrumented to measure wind speed and direction, air pressure, and temperature.

During the spring of 1975 the NOAA Data Buoy Office deployed and tested the EB 52 buoy water quality monitoring systems near Bay St. Louis, Mississippi (fig. 7). Following this testing period the buoy was recalibrated and refurbished to support a study by NOAA Data Buoy Office at a mooring site close to the DuPont acid waste site and the disposal area for Philadelphia municipal sewage sludge.

The buoy (EB 52) with the Water Quality Indicator System was deployed in early August 1975 at about 40 nmi southwest of the mouth of Delaware Bay. The deployment was accomplished by the USCG cutter *Sassafras*. Water quality and meteorological data were reported every 6 hours in a self-initiated mode and transmitted via HF radio link to the Miami Shore Collection Station. The buoy operated on station from August to October 1975. During this period EPA collected comparative observations on shipboard. Data collected during this initial test are being analyzed.

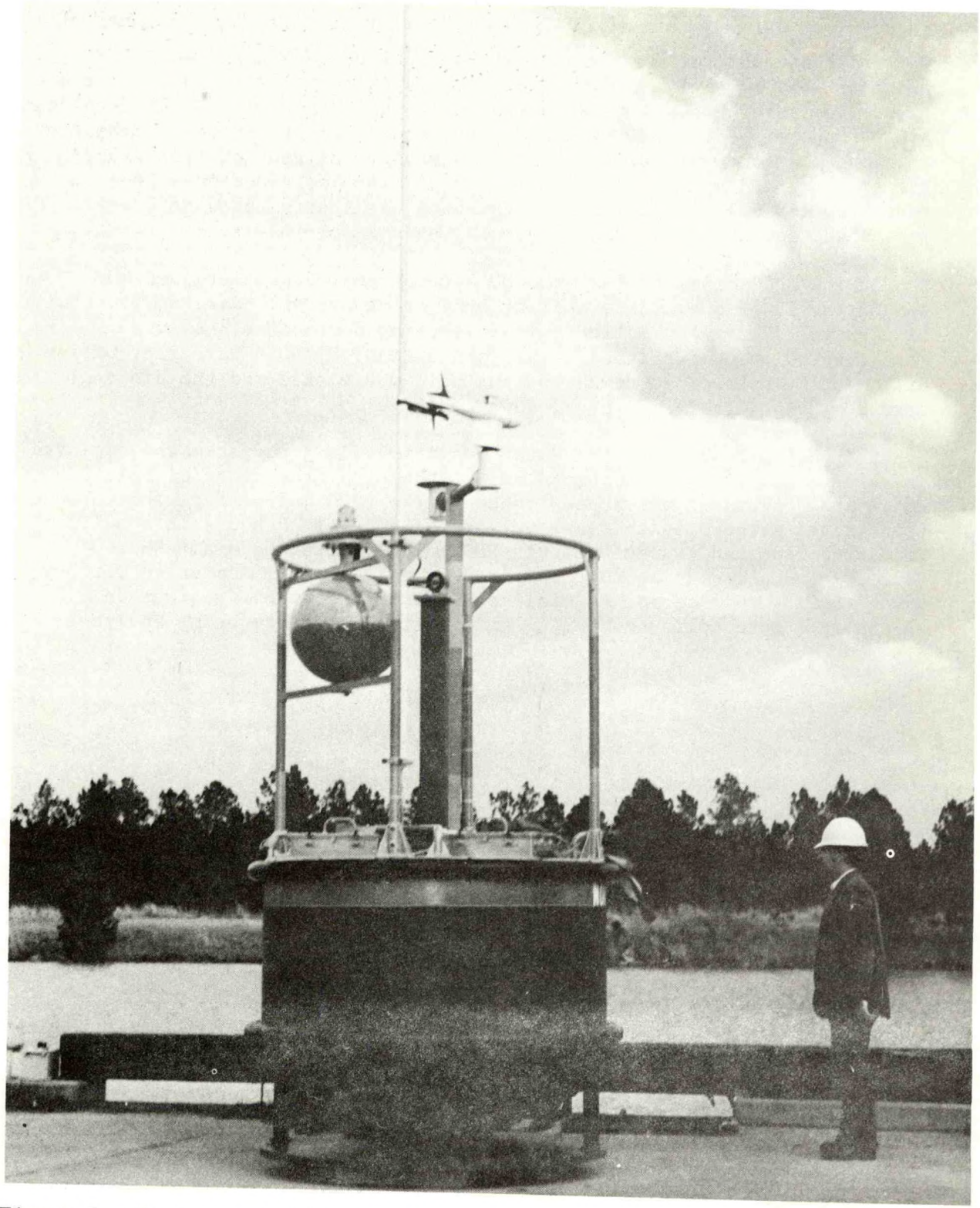


Figure 7.--Environmental buoy EB52 containing Water Quality Indicator System, before tests in National Space Technology Laboratories' barge canal near Bay St. Louis, Mississippi. (Source: National Space Technology Laboratories)

APPENDIX A.--Title II of "Marine Protection, Research, and Sanctuaries Act of 1972" (P.L. 92-532)--and Amendments

TITLE II—COMPREHENSIVE RESEARCH ON OCEAN DUMPING

Report to Congress.

SEC. 201. The Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the Administrator shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters where the tide ebbs and flows or into the Great Lakes or their connecting waters and shall report from time to time, not less frequently than annually, his findings (including an evaluation of the short-term ecological effects and the social and economic factors involved) to the Congress.

SEC. 202. (a) The Secretary of Commerce, in consultation with other appropriate Federal departments, agencies, and instrumentalities shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, overfishing, and man-induced changes of ocean ecosystems. In carrying out such research, the Secretary of Commerce shall take into account such factors as existing and proposed international policies affecting oceanic problems, economic considerations involved in both the protection and the use of the oceans, possible alternatives to existing programs, and ways in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind.

(b) In carrying out his responsibilities under this section, the Secretary of Commerce, under the foreign policy guidance of the President and pursuant to international agreements and treaties made by the President with the advice and consent of the Senate, may act alone or in conjunction with any other nation or group of nations, and shall make known the results of his activities by such channels of communication as may appear appropriate.

Annual report to Congress.

(c) In January of each year, the Secretary of Commerce shall report to the Congress on the results of activities undertaken by him pursuant to this section during the previous fiscal year.

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(d) Each department, agency, and independent instrumentality of the Federal Government is authorized and directed to cooperate with the Secretary of Commerce in carrying out the purposes of this section and, to the extent permitted by law, to furnish such information as may be requested.

Inter-agency agreements.

(e) The Secretary of Commerce, in carrying out his responsibilities under this section, shall, to the extent feasible utilize the personnel, services, and facilities of other Federal departments, agencies, and instrumentalities (including those of the Coast Guard for monitoring purposes), and is authorized to enter into appropriate inter-agency agreements to accomplish this action.

Federal-State cooperation.

SEC. 203. The Secretary of Commerce shall conduct and encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and to promote the coordination of, research, investigations, experiments, training, demonstrations, surveys, and studies for the purpose of determining means of minimizing or ending all dumping of materials within five years of the effective date of this Act.

Appropriation.

SEC. 204. There are authorized to be appropriated for the first fiscal year after this Act is enacted and for the next two fiscal years thereafter such sums as may be necessary to carry out this title, but the sums appropriated for any such fiscal year may not exceed $6,000,000.

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*Sec. 3(a) of the Act reads: "Administrator" means the Administrator of the Environmental Protection Agency.

**P.L. 94-62, Section 2, amended Section 202(c) of the 1972 Act by striking "January" and inserting "March". Section 3 of P.L. 94-62 amended Section 204 of the 1972 Act by authorizing $1,500,000 for the transition period (July 1 through September 30, 1976). P.L. 94-326, Section 3, amends Section 204 of the 1972 Act by authorizing $5,600,000 for fiscal year 1977.

*U.S. GOVERNMENT PRINTING OFFICE: 1976 210-801/401 1-3