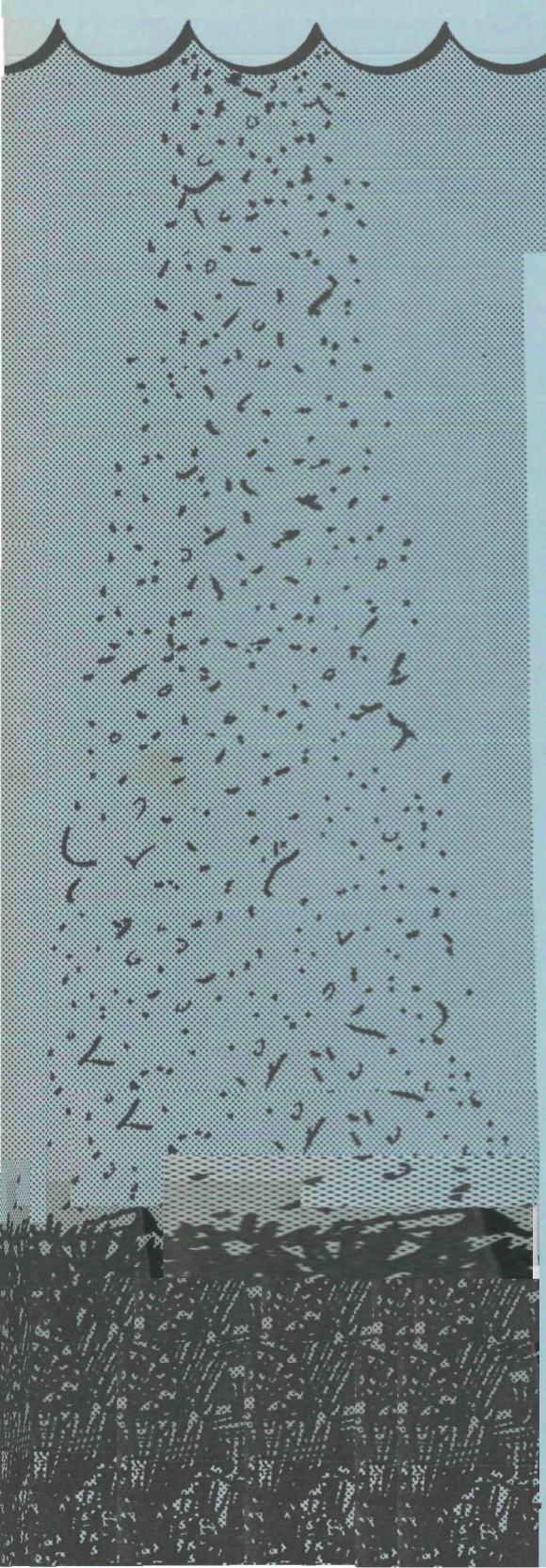

OCEAN DISPOSAL PRACTICES and EFFECTS

* A report to the Administrator of the Environmental Protection Agency by the President's Water Pollution Control Advisory Board.

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

OCEAN DISPOSAL PRACTICES and EFFECTS

*A report to the Administrator of the Environmental Protection Agency of a recent meeting held by the President's Water Pollution Control Advisory Board.

SEPTEMBER 26-29, 1972

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

THE PRESIDENT'S WATER POLLUTION CONTROL ADVISORY BOARD

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF THE
ADMINISTRATOR

Dear Mr. Administrator:

I am pleased to submit this report of the meeting of the President's Water Pollution Control Advisory Board on ocean disposal practices and effects held in New York City on September 26-29, 1972.

The Board met to explore and advise on the problem of ocean disposal not only as it relates to New York, but also as a national and international issue. The primary objectives of the meeting were to focus public attention on the topic, to explore alternatives to ocean dumping pollution, and to provide some insight for obtaining answers to unknown aspects of ocean disposal problems.

The Conclusions and Recommendations included as an Appendix to this report were formulated following a comprehensive briefing to the Board by representatives of Federal, State, and local government, a flyover by helicopter to view dumping practices in the New York Bight, and a full day of public testimony by experts in the field of ocean disposal.

As you are aware, since the meeting some of the Board's major recommendations have already been implemented through enactment of the Marine Protection, Research and Sanctuaries Act of 1972 and the Federal Water Pollution Control Act Amendments of 1972. The Board stands ready to help in any way possible to translate its remaining recommendations into action.

Respectfully submitted,

Alan Levin

Alan Levin, Executive Secretary
President's Air and Water Advisory
Boards

INTRODUCTION

The President's Water Pollution Control Advisory Board was authorized by the Water Pollution Control Act Amendments of 1956 (P.L. 84-660). The Board's authority was continued under the Federal Water Pollution Control Amendments of 1972 (P.L. 92-500).

The Board's mission is to advise, consult with, and make recommendations to the Administrator of the Environmental Protection Agency on matters of policy relating to water pollution control. Under this authority the Board regularly examines all phases of the national water pollution problem and from time to time holds public meetings to hear the views of individual citizens, various levels of government and private agencies and groups.

There are nine members, appointed by the President, who serve three years each. The Chairman is the Administrator of the Environmental Protection Agency, and the Secretary of the Department of Health, Education, and Welfare is an ex officio member. Three of the appointive terms expire each June 30 or at such time thereafter as successive appointments become effective. No member may succeed himself within one year of the date his term ends.

The Advisory Board holds four to six meetings a year. Usually two of these are held in Washington, D. C. for the purpose of reviewing clean water plans, policy and progress with the EPA Administrator. The other meetings are held in various regions of the country at the call of the Chairman, or at request of individual Board members or a State governor who feels that a particular water pollution problem should have the Board's attention. The regional meetings serve, first to inform the Board members on the various types of water pollution problems and control programs that exist throughout the Nation. Also, because they are open to the public, the regional meetings focus public attention on particular city, State or regional problems and stimulate action for pollution control in problem areas under review.

TUESDAY, SEPTEMBER 26, 1972:

The meeting was convened in the Environmental Protection Agency, Region II, New York City by Mr. A. James Barnes, Assistant to the Administrator, EPA in the absence of Administrator, William D. Ruckelshaus, permanent Chairman of the President's Water Pollution Control Advisory Board.

Board members present: Mr. Jack A. Beaver, San Bernardino, California; Mr. Frederick J. Conn, Jr., San Angelo, Texas; Mr. William D. Farr, Greeley, Colorado; Mr. Ray W. Ferguson, Ontario, California; Mr. Byron P. Jordan, New Orleans, Louisiana; Mr. Irvan F. Mendenhall, Los Angeles, California; Mrs. Samuel Rome, River Forest, Illinois; Dr. Mitchell G. Zadrozny, Chicago, Illinois. Mr. Richard S. Green represented the Secretary of Health, Education, and Welfare who is the ex officio member of the Board. Former Board member, Dr. Wallace W. Harvey, Jr., Manteo, North Carolina served as a consultant for the meeting. Not present was Mr. Thomas W. Gleason, New York, New York.

The following newly appointed members were sworn in by Chairman Barnes: Mr. Jack A. Beaver, Mr. Frederick J. Conn, Jr., and Dr. Mitchell Zadrozny.

After the swearing in ceremony and introduction of the Board members, Mr. Barnes emphasized the importance of the meeting as it related to the pending legislation on ocean dumping (The Marine Protection Research, and Sanctuaries Act of 1972). He also pointed out the inter-relationship between ocean disposal and other pollutents and that ocean dumping is merely a small part of the overall ocean disposal problem.

Following Mr. Barnes' statement, the Board heard from Mr. Jerome Kretchmer, Administrator, New York City's Environmental Protection Administration, who spoke on behalf of Mayor John V. Lindsay. Mr. Kretchmer referred to New York City's staggering environmental problems and emphasized that what the City needs from the Federal government is financial, technical, and legal assistance. He explained that although the Board is meeting on ocean dumping, New York City's fundamental problem is that of solid wastes. Mr. Kretchmer then reviewed the City's sewage sludge problems and some of the possible alternatives to ocean dumping, none of which, in Mr. Kretchmer's opinion, would allow an immediate change in the City's present practice of dumping. In the area of toxic metals, he stated that the City has acted to remove such metals discharged by companies into the City's sewer system. However, he strongly urged for the adoption of Federal standards in this area to avoid companies from "jumping" to other jurisdictions with less stringent standards. Mr. Kretchmer summarized the needs of New York City as follows:

(1) A joint Federal-City project to explore the environmental implications of expanding ocean disposal in such a way that there would be no harm to the ocean. This project could include a testing program of the effects of leaching or other escape of baled refuse, dumped beyond the continental shelf.

(2) Alternative methods of disposing of solid wastes. The City needs money for research and technology and a change in some restrictive Federal legislation in the recycling area. Methods should be explored of making solid waste a useful material for landfill in strip mines, quarries, and sand pits, etc.

(3) Federal legislation to set uniform standards to control discharge of heavy metals to avoid the threat of industries fleeing to less regulated sites.

(4) Federal legislation to provide funding for the disposal of sewage sludge should the current ocean dumping practices of New York City be altered in any way as a result of the Board's recommendations.

Finally, Mr. Kretchmer made a strong plea for Federal-City cooperation to work out short and long range solutions. "If a Federal-City partnership can find solutions now for New York, the problems of other urban coastal complexes can follow suit", Mr. Kretchmer concluded.

Mr. Gerald M. Hansler, EPA Regional Administrator, Region II, presented an overview of the ocean dumping problems in his region. Mr. Hansler concentrated on the sludge disposal problems and discussed some of the possible alternatives. He explained that incineration was tried but that this increased the particulate matter in the atmosphere thereby causing an air pollution problem. As a result, he has concluded that ocean dumping of sludge in the New York-New Jersey area should be regulated but not totally banned. Mr. Hansler also proposed the idea of experimenting with digested sludge and spreading it on land in low nutrient areas. He concluded that additional regulatory authority and technology are needed and especially the funds to develop such technology.

The Board then flew by helicopter to view dumping of sewage sludge, acid wastes, and dredge spoils in the New York Bight. Mr. Richard Dewling, Director of Surveillance, EPA Region II, conducted a briefing aboard the helicopter. Mr. Dewling pointed out that 5 or 6 barges a day each from New York City and New Jersey municipalities dump (50% digested, 50% raw sludge) into the New York Bight, but that there is no assurance that such barges go to the full 12 mile limit designated for such dumping. Mr. Dewling further stated that 70% of all the sludge dumping, by vessel or barge, in the country occurs there. He indicated that water quality

is not too adversely affected on the surface, but that bottom organisms such as lobsters, oysters and clams do not survive. The acid wastes dumping are industrial discharges with 90% originating from one company - National Lead. Mr. Dewling indicated 55% of all the acid dumped in the U. S. takes place in the New York Bight area. However, he did emphasize that such wastes do not have high levels of suspended solids and therefore the impact on the ocean bottom is minimized. Finally, the Board witnessed the dumping of dredge spoils from a U.S. Army Corps of Engineers barge. Mr. Dewling pointed out that the effects of such dumping are immediate oxygen depletion and that there have been citizen complaints during the summer from New Jersey shore residents as a result of dredge spoils washing up on beaches. Finally, it was explained that no sludge dumping by barge occurs on the West and Gulf coasts and that those areas employ submarine dumping by outfall with the sludge pumped out with the effluent.

The afternoon session of the briefing for the Board continued at Governor's Island. The first speaker was Mr. Richard Goodenough, Director, New Jersey Division of Marine Services who represented Mr. Richard J. Sullivan, Commissioner, New Jersey Department of Environmental Protection. Mr. Goodenough explained that as in many other States, New Jersey has reorganized its State pollution control agency to deal with the environment. The State has also recently passed a Clean Ocean Act to regulate pollutants that are dumped at sea. One of the problems facing New Jersey is trying to determine how far out to dump. As part of the new Act, rules and regulations have been proposed providing for licenses and permits for dumping. However, before such regulations are officially issued the State is required to hold public hearings.

Mr. Roger Strelow, Senior Staff Member of the Council on Environmental Quality summarized that ocean dumping has been an important concern to the Council ever since its formation early in 1970. In April of that year, in a special message to Congress, the President directed the Chairman of CEQ to work with other Federal agencies on a comprehensive study of ocean dumping to recommend further research needs and appropriate legislation and administrative actions.

Mr. Strelow then reviewed the magnitude of the problem as follows: Our oceans, containing 140 million square miles of water surface, cover more than 70% of the earth and are an important part of the overall world environment. They produce about two thirds of the oxygen we breathe and absorb a major part of the excess carbon dioxide in the atmosphere. The oceans also affect world climate and provide food, minerals and other necessities. Unfortunately, a very large portion of the world's pollution eventually ends up in the oceans. Much of our air pollution is either carried directly into the oceans by wind or washes into the ocean from the land with rain or snow. It is

estimated that more than 90% of the petroleum polluting oceans each year comes not from tanker breakups or other disasters but from the vaporization of gasoline and other petroleum products ashore. The amount of lead and DDT entering the marine environment from the atmosphere may equal or surpass the amount carried there from rivers. Pollution from rivers, however, is still the principal pathway by which most pollutants reach the oceans. Industrial waste effluents are the largest components of river-borne pollution entering the oceans in coastal and estuarine regions. Close behind are municipal waste effluents. Agricultural pollutants from land runoff add to the total. Some municipal and other wastes enter the ocean directly through submerged outfalls. Vessels contribute sewage and oil, and particularly appropriate for the Board meeting, substances purposefully transported from land for the purpose of disposal in the ocean. Altogether, these sources of pollution have created a disturbing condition, alarming scientists throughout the world.

Mr. Strelow continued by pointing out that ocean dumping is a small but potentially growing part of the overall ocean pollution picture. He stated that although domestic dumping off the Pacific Coast has declined the reverse may be true of the Atlantic Coast. We know even less of the trends in and volume of ocean dumping by other nations.

Mr. Strelow emphasized that in the U. S., we have controls over air and water pollution, but to permit a truly systematic and comprehensive control of pollution, we must have regulatory controls on ocean dumping as well. He referred to the ocean dumping legislation passed by both Houses of Congress, but temporarily held up because of jurisdictional squabbling between Congressional Committees.

Mr. Strelow briefly discussed current status - domestically and internationally - on ocean dumping controls. He mentioned the CEQ comprehensive study: Ocean Dumping: A National Policy issued in October 1970. The Council's study concluded that ocean dumping wastes are heavily concentrated and contain materials that have a number of adverse effects. The report further concluded that existing regulatory activities and authorities were not adequate to handle either the current or the potential expanded problem of ocean dumping. The report recommended legislation that would require a permit from EPA for all ocean dumping activities subject to U. S. jurisdiction. It also underscored the need for international action to protect the world's oceans. Finally, the report identified various areas of research needing attention in order to permit the most effective exercise of both national and international controls. On the basis of the Council's report, the President proposed a Marine Protection Act - the legislation currently pending approval. At the same time, he instructed the Secretary of State in coordination with CEQ to develop and pursue international initiatives for the world-wide control of ocean dumping. The U. S. has been working with other nations on an

international convention to control ocean dumping in accordance with a permit system to be administered by national authorities. The June 1972 United Nations Conference on the Human Environment called upon interested governments to convene a conference by November 1972 to negotiate a convention for signature before the end of the year. In the meantime, in February 1972, 12 European nations signed the Oslo Convention - a regional convention to curtail ocean dumping of hazardous wastes by ships and planes in the northeast Atlantic and the North Sea.

Mr. Strelow concluded that it may be that the oceans ultimately will provide the most environmentally acceptable repository for limited types of man-generated wastes, at certain sites and under certain conditions. However, the available evidence indicates that recycling of the materials or land disposal appear to be preferrable. The legislation and international convention should provide the mechanisms for requiring ocean disposal to be dealt with on this basis.

The next speaker, Mr. T. A. Wastler, Chief, Water Quality Protection Branch, EPA first discussed the scope of the ocean disposal problem. He indicated that the sum total of pollutants to marine waters is not known, largely due to the size and complexity of the problem, but some quantitative estimates of toxic constitutents developed by the National Academy of Sciences is impressive. In this regard, it is estimated that from 1/4 to 1/2 of fishing production is directly or indirectly dependent on estuaries. These are the areas in which we are concentrating our wastes, thereby inflicting an as yet undetermined stress on coastal marine ecosystems. There is little information about the fate of wastes materials after they reach the open ocean, but a few illustrations show that man's methods of waste disposal are impacting there as well.

Mr. Wastler pointed out that pollutants can enter the marine environment along many pathways, but there are three main ones. The first is as the residuum of pollutants from inland sources discharged to rivers which ultimately flow into the sea. The second pathway is as direct discharges into the ocean through ocean outfalls, and the wastes so discharged can contain the wide variety of polluting substances present in municipal and industrial waste streams. Direct dumping of wastes into the ocean is the third main pathway, and such wastes generally contain pollutants which are extremely difficult or uneconomical to treat by conventional means. Mr. Wastler then proceeded to discuss existing legislative authorities as follows: Continuous point source discharges of pollutants into "navigable" waters are controlled under existing laws by water quality standards set by State and Federal action. The existing Federal Water Pollution Act does not contain authority for EPA to regulate directly continuous point source discharges into the contiguous zone or to regulate the dumping of waste material into marine waters. Under present law,

discharge to navigable waters are controlled under Section 13 of the Refuse Act of 1899, however, the contiguous zone and the open oceans are not included in the law. Final authority for permitting the dumping and/or discharge of waste material into navigable waters is vested in the U. S. Army Corps of Engineers. Within the scope of existing laws, then, EPA has no effective means of controlling the dumping of wastes into the marine environment.

On the subject of anticipated legislation, Mr. Wastler reviewed the provisions of the proposed Marine Protection, Research, and Sanctuaries Act of 1972 (Ocean Dumping Act) under which the transportation and dumping of all materials in the open seas outside the limit of the territorial waters will be regulated by issuance of permits. This proposed legislation addresses itself specifically to the problem of ocean dumping, however, there is a close relationship between the responsibilities explicitly assigned in this legislation and the authorities involved in the extension of EPA authorities to the contiguous zone of the near-shore-oceanic waters, as is proposed in the current legislation to amend the Federal Water Pollution Act. In addition to these proposed laws, there already exists recognition of concern for the problems of the "estuarine zone" in authority to study this part of the environment and to make recommendations on how to use, develop, and preserve it under Section 5(m) of the existing Act and under Section 140(n) in the proposed amendments.

Mr. Wastler outlined some of EPA's past, present and proposed strategies in dealing with the marine environment. The past approach to combating marine pollution problems has been one of responsive enforcement. This approach is not, however, sufficient to cope with the existing and potential pollution problems of the estuarine, coastal, and oceanic environments. Mr. Wastler stated that the strategy necessary to cope with such problems, including ocean dumping must be one of correcting potential problems before they occur as well as making a direct attack on the problems that already exist. EPA's program strategy in implementing the Ocean Dumping Act of 1972 will be an integrated approach toward control and cessation of ocean dumping, using not only the new authorities of the Act, but also the other authorities EPA has, or expects to have, in the marine environment. Mr. Wastler stated the program consists of two phases. The first is a predominantly in-house effort during the first six months directed toward developing criteria guidelines and regulatons for the permit issuing system to become operational six months after enactment of the law. The second phase consists of the routine operation of the permit system while working with NOAA and the Coast Guard in developing information from which revisions to criteria can make the permit system more effective and which will also lead to a more integrated approach to the solution of all marine pollution programs.

Mr. Wastler then briefly outlined some of the responsibilities of other Federal agencies with regard to ocean dumping and particularly in reference to the proposed legislation:

(1) U. S. Coast Guard: The Ocean Dumping Act specifically charges the Coast Guard with the surveillance of ocean dumping operations and enforcement of the conditions under which specific ocean dumping permits will be granted.

(2) U. S. Army Corps of Engineers: The Corps has had special regulatory authority over ocean dumping for the port areas of New York, Baltimore, and Hampton Roads, Virginia, under the Supervisory Harbors Act of 1888; the Ocean Dumping Act of 1972 rescinds this authority. Section 4 of the Rivers and Harbors Act of 1905, and Section 13 of the 1899 Refuse Act which regulate ocean dumping in the territorial sea, are also superseded by the Ocean Dumping Act.

(3) Atomic Energy Commission: The Ocean Dumping Act of 1972 requires that the AEC consult with the Administrator, EPA prior to issuing permits for the ocean disposal of radioactive material and that the AEC, in issuing permits comply with standards set by the Administrator respecting limits on radiation exposures or levels, or concentrations or quantities of radioactive materials.

(4) National Oceanic and Atmospheric Administration: The Act specifically charges NOAA with responsibility for monitoring of dumping areas and for comprehensive research on ocean pollution.

(5) Department of State: The Act directs the Secretary of State, in consultation with the Administrator, to seek effective international action and cooperation to ensure protection of the marine environment.

(6) Other Federal Agencies: The Act directs the Administrator, in developing criteria for ocean dumping, to consult with the Secretaries of Commerce, Interior, State, Defense, Agriculture, HEW, and DOT, AEC; and other appropriate Federal, State, and local officials.

Mr. Arnold Joseph, EPA Office of Research and Monitoring outlined EPA's program of research related to ocean dumping. The Office of Research and Monitoring conducts two programs of scientific, marine pollution related research. These programs are known as "Ecological Effects" and as "Fate of Pollutants in the Marine Environment." Both have as a principal objective the development of scientifically sound marine water quality criteria to be used in establishing marine water quality standards. The Ecological Effects program involves studies on the effects of a wide range of pollutants on marine fishes and invertebrates. Pollutants studied include heavy metals, oil and oil spill dispersants, chlorine, and heat. Fundamental work on dissolved oxygen, salinity and pH requirements of organisms at several trophic levels is also conducted. Although none of the Ecological Effects research program has been directly concerned with dump site conditions and effects, the research

results on specific pollutants are applicable to dumping in so far as the same pollutants would be introduced by dumping.

The Fate of Pollutants program has been more directly concerned with ocean waste disposal problems. Its studies deal with the processes and mechanisms governing the introduction, transport, distribution and chemical transformation of pollutants in marine waters. Emphasis is given to development of predictive and descriptive math models for the fate of pollutants, and to developing guidelines for environmentally non-degrading waste dischrge practices. Also, under the Fate program there are several studies related to the sludge dumping problem. One involves the chemical characterization of municipal sewage sludges destined for sea disposal. Measurements are being made of heavy metals, persistent organics and other possible pollutants contained in the sludges. The other is a project in cooperation with the Navy's Fleet Numerical Weather Center to develop and test a computerized coastal circulation model that will predictably describe the mixing taking place over sludge dumping areas. More projects with a direct relationship to sludge dumping problems are contemplated, budgets permitting.

Mr. Joseph reviewed some other marine related programs of the Office of Research and Monitoring which include those of an engineering development nature to develop systems, mainly hardware, to control or abate oil and hazardous material spills and to treat shipboard sewage. There is also a substantial interest in developing alternate means of sludge disposal on land. These are addressed in the "Task Force Report on Sludge Disposal" by the Office of Research and Monitoring, April 1972. Mr. Joseph also mentioned a report, "Ocean Disposal of Barge Delivered Liquid and Solid Wastes from U. S. Coastal Cities" (1971), by the Dillingham Corporation of LaJolla, California. This work was supported by the Office of Solid Waste Management, EPA and comprehensively covers the logistics in 1968 of ocean-barge disposal of all classes of wastes.

Mr. Joseph emphasized that we are still some distance away from understanding the impact on or the capacity of the marine environment with respect to disposed wastes, and that there is no shortage of recommendations or ideas for research. He explained that the Office of Research and Monitoring has developed a work plan to implement the pending ocean dumping legislation. The program outlined would work toward seven objectives:

(1) Characterization of dump materials;

(2) Physical, chemical, ecological effects of past dumping;

(3) Toxic and/or beneficial effects of sludges, spoils;

(4) Testing protocols for potential waste disposers;

(5) Optimum dumping technology;

(6) Criteria for site selection and use; and

(7) Bioassays of pollution in dumped materials.

Mr. Joseph concluded by stating that in order to establish scientifically objective, quantitatively valid criteria, it is necessary to have accurate information and data on the materials to be dumped, particularly the physical and chemical forms of the ecologically disruptive constituents.

Mr. Martin Lang, Commissioner, New York City Department of Water Resources discussed the City's sludge disposal problems. Mr. Lang pointed out that it is his mission to protect and enhance receiving waters and that New York City is presently treating 75% of its wastewater. As a result some waterways, namely the East River, portions of New York Harbor and Jamaica Bay have reportedly had rising levels of dissolved oxygen. Mr. Lang's position is that it is better to dump sludge and preserve the more precious in-surface waters. It is Mr. Lang's view that the City's real problem is solid waste and if that problem is solved it will in turn solve the sludge problem. Mr. Lang discussed some of the alternatives such as incineration, however, he is not satisfied with the air pollution impact. Another alternative being considered is to use sludge as a landfill to build a park. Mr. Lang concluded with a discussion of the metal content in sludge. He emphasized that the metals input can be minimized, but it must be done in a rational manner. Further, he stated that what is needed are good data in relation to the amounts of concentration and effects, not emotion. Mr. Lang also stated that the toxic metals problem in sludge is not as severe in New York City as in some other large cities.

The day's final speaker was Dr. Roland Smith, Chief, Division of Living Resources, Office of Marine Resources, NOAA. Dr. Smith indicated that although NOAA has no direct responsibilities for regulating ocean dumping, the issue is of key importance to his agency. A major goal of NOAA is to develop programs to assure that the ocean environment and its resources are wisely used. NOAA's National Marine Fisheries Service has fisheries development responsibilities on which ocean dumping and other environmental quality issues bear directly. A second major goal of NOAA is to monitor and predict environmental conditions. In this regard the pending Federal ocean dumping legislation assigns important responsibilities for research and monitoring on ocean dumping to NOAA. Dr. Smith emphasized that in exercising these responsibilities, his agency expects to be able to provide information which will be of use to EPA and the Corps of Engineers in their regulatory programs. NOAA has already conducted studies on the effects of the dumping practices on the biota of the New York Bight.

Dr. Smith then described a major new program being developed by NOAA - the Marine Ecosystems Analysis Program (MESA). The program encompasses issues broader than ocean dumping, but it is the principal vehicle through which NOAA's ocean dumping responsibilities will be addressed. The objectives of MESA are to:

(1) Describe, understand, and monitor the physical, chemical, and biological processes of marine environments,

(2) Provide information and expertise required for effective management of marine areas and the rational use of their associated resources and,

(3) Analyze impact on marine ecosystems of natural phenomena or man-made alterations.

Dr. Smith explained that an aspect of the MESA program will be a systematic, comprehensive study of the New York Bight which is to be initiated this year. He stressed that the success of this project will be heavily dependent upon NOAA's success in developing effective relationships with the other agencies working in the Bight such as the U. S. and New York City Environmental Protection Agencies and the Corps of Engineers. As part of this effort, the Corps of Engineers and NOAA jointly sponsored an interagency meeting on September 12, 1972 to review the programs of the various agencies. As an outcome, NOAA is chairing an informal interagency task force which is to formulate recommendations for program coordination which all agencies concerned can review.

WEDNESDAY, SEPTEMBER 27, 1972:

The Board held a public meeting to hear testimony from invited experts in the field of ocean disposal. Eleven speakers presented statements before the Board. In addition, Senator William V. Roth (R) Delaware, entered a statement for the record. A list of the speakers and the organizations they represent is attached to this report as Appendix 1. A summary of the statements follows. Senator Roth's entire statement is included in this report as Appendix 2. A complete set of the other statements may be obtained from Alan Levin, Executive Secretary, President's Air and Water Advisory Boards, Office of the Administrator, Environmental Protection Agency, Room 1127, Washington, D. C. 20460.

Chairman Barnes introduced the Board members and reviewed the prior day's procedures for the public's information.

Mr. Henry Diamond, Commissioner, New York State Department of Environmental Conservation:

Commissioner Diamond welcomed the Board on behalf of Governor Rockefeller. He emphasized that this is a very important time for the future of water pollution control in the country in light of anticipation of amendments to the Federal Water Pollution Control Act. He pointed out that if the amendments are passed there will have to be a massive retooling job. Commissioner Diamond explained that New York State has come to the end of the first phase of its Pure Waters Program, has committed about $3 billion and has under way 348 sewage treatment plants across the State. In moving to the second stage the State has on the ballot this fall a bond issue calling for a $650 million appropriation for continuance of the State's share of the water quality program. Included are portions of the bond issue for solid wastes, for land acquisition and for air pollution control, thereby indicating the State's cognizance that air and water pollution and land use are closely interrelated.

Commissioner Diamond turned to the issue of sludge dumping and stressed that in order to cease this practice most of the sewage plants in the New York City area would have to be closed down causing disastrous consequences.

Another point emphasized by the Commissioner is the need for additional Federal funds for sewage treatment plant construction and the importance that actual appropriations of funds be commensurate with authorizations.

During the questioning following Commissioner Diamond's presentation, Mr. Barnes inquired as to the possibilities of land disposal of sewage sludge. Commissioner Diamond replied that there are some possibilities in certain parts of the State, but as for New York City land is enormously valuable and scarce.

Dr. John B. Pearce, Officer-in-Charge, National Marine Fisheries Service, Middle Atlantic Coastal Fisheries Center, Sandy Hook Laboratory, Highlands, New Jersey:

Dr. Pearce discussed the impact of ocean dumping in the New York Bight area. He explained that until recently the possible biological effects of ocean dumping had not been fully appreciated. In August 1968, the Sandy Hook Sport Fisheries Marine Laboratory initiated a biological census and hydrographic survey of the New York Bight to determine what effects these dumping activities have had on the marine resources of the New York Bight. These studies revealed that in the New York Bight dumping of contaminated dredging spoils and sewage sludge has had a demonstrated effect on the physical environment and bottom dwelling marine life. The levels of certain heavy metals are greatly elevated in the areas where sewage sludge and dredging spoils have accummulated. The sediments impinged upon by these wastes have a much greater amount of organic material associated with them. Bottom waters overlying the

disposal areas have lower levels of dissolved oxygen, particularly in the summer. Exceedingly, high counts of coliform bacteria were found in sediments collected from the areas impinged upon by sludges and spoils, Dr. Pearce continued. He also pointed out that the distribution of both heavy metals and coliform bacteria extend down the Hudson Shelf Valley, indicating that the effects of ocean dumping may extend seaward from the point of waste disposal. In summary, it is Dr. Pearce's contention that the 40 year practice of dumping sewage sludge and dredge spoils from five to 10 miles off the New Jersey coast had created a "dead sea" threatening New Jersey and New York beaches, marine life and the public health. Dr. Pearce then showed a series of slides illustrating some of the consequences of the present dumping activities in the New York Bight.

Mrs. Carl H. (Jean) Auer, Member, State Water Resources Control Board, Sacramento, California:

Mrs. Auer spoke about ocean disposal practices on the west coast concentrating her remarks on the State of California. She explained that although all three west coast States (California, Oregon, and Washington) have standards applicable to marine and/or estuarine waters, only California has a specific plan for discharge into the ocean. The plan was adopted on July 6, 1972.

Of the three west coast States, Washington's discharge to the ocean is the smallest with only one open ocean discharge of approximately 200,000 gallons per day. The discharge, which is municipal, is given primary treatment and discharged from an outfall approximately 300 feet long. There are four major ocean waste dischargers in Oregon, two municipal and two industrial. The industrial discharges, which total approximately 23 MGD, receive primary treatment. Of the municipal discharge one, totalling 0.75 MGD, receives primary treatment and the other, totalling 1.6 MGD, receives secondary treatment. Mrs. Auer pointed out that California discharges more than one billion gallons of effluent per day into the ocean. That is about 30 percent of the nation's total discharge to the ocean and more than two-thirds of the wastewater generated daily in the State. The major portion of these discharges receive primary treatment. Implementation of California's new ocean plan will bring the treatment level up to the equivalent of secondary.

The plan establishes certain beneficial uses of the ocean waters which must be protected: preservation of marine resources, esthetic enjoyment, recreation, navigation and industrial water supply. In addition, specific water quality objectives have been set forth to be maintained in the ocean itself. The plan also sets up a category for areas of biological significance. In these areas natural water quality conditions must be maintained and discharges are prohibited.

Several other features of California's plan were emphasized by Mrs. Auer. At present 30,000 pounds of toxic heavy metals are generated per day. Implementation of the plan will accomplish more than 90% removal. The plan also requires that wastes be discharged in deep water far from shore, with a 100-to-1 initial dilution of sea water to wastewater which must occur within seconds after the discharge.

As for implementation, the plan requires every discharger to submit for approval both a technical report on what he will do to comply and a time schedule for compliance. The State will review and revise these schedules, first at the Regional Board and then at the State Board level. The State believes that total implementation will occur by 1977, but Mrs. Auer emphasized strongly the need for additional Federal construction grant funds if the ocean plan is to be implemented fully by that date.

Mrs. Auer discussed some of the other difficulties in implementing the plan and conceded that often there is a difference in philosophies between the discharger and the State Water Resources Control Board. Nevertheless, the Board feels that the plan can be implemented. In this context, she emphasized that the new State law specifies that no discharge of waste into the waters of the State "shall create a vested right to continue such discharges." It is no longer necessary to prove damage to the environment before corrective action can be taken; a reasonable suspicion is enough. Mrs. Auer then discussed the effects of ocean discharge, and stated that although there are many unknowns, there is evidence that continuous ocean discharge can have an adverse effect on the environment. She indicated that there have been strong indications that waste discharges are causing the destruction of kelp beds, malformations of cancerous conditions in fish, and similar damage. She emphasized further that a new definition must be learned for assimilative capacity. In the past this level has been considered as the highest level beneath which things start to die. It should properly be defined as the level that will assure total protection of the environment. Mrs. Auer feels it is the responsibility of regulatory agencies, such as EPA and the State Board, to define goals and objectives to meet the new definition, and the responsibility of the engineering community to design the systems to get at the need.

In conclusion, Mrs. Auer urged the Advisory Board to recommend that the comprehensive concept underlying California's Ocean Plan be used in the Federal program as well.

Mr. Jon Lindbergh, Chairman, Oceanographic Commission, State of Washington:

Mr. Lindbergh noted that more than half of the world's population lives in close proximity to the oceans which comprise about 70% of the earth's surface and have traditionally used the oceans as an all purpose dump.

Mr. Lindbergh pointed out that although such occurrances as oil spills are spectacular and arouse public outcry, they are not as serious as the more subtle long range problems caused by ocean contaimination of pesticides and toxic and heavy metals which build up in the food chain of marine life. He emphasized that sheer numbers of men and their industries are now causing alterations in sea water and its confining beds that will lead inevitably to changes in sea life and resultant biological processes. On the other hand, he also pointed out that some changes in the sea can be beneficial and cited examples of a ship wreck, old car bodies or even an oil well that can induce prolific fish life in previously barren areas.

Mr. Lindbergh in conclusion urged the Advisory Board in its deliberations to consider the total picture, not only the obvious and spectacular problems of ocean dumping, but the long-term, subtle, and insidious problems.

Asked by members of the Advisory Board if he had any solutions, Mr. Lindbergh stated that there are no magic answers, and added that there is no way in which we can prevent all man-made contaminations from entering the sea, but it is vital that we examine the total consequences of what we put into it.

Dr. Donald P. de Sylva, Associate Professor of Marine Science, University of Miami, Miami, Florida:

In discussing the effects of ocean dumping in the southeastern United States, Dr. de Sylva reinforced several of Mr. Lindbergh's remarks, namely that the greatest threat to the oceans is not from sewage sludge, but from thousands of man-made chemicals that flow to the sea via rivers around the world. Most endangered he stressed are the coastal estuaries where 80% of the oceans' productivity occurs.

He also told the Board that swimmers and divers using some ocean waters on the Atlantic coast have become mysteriously ill and, in some cases died, as a result of diving and swimming around sewer outfalls in the ocean. Dr. de Sylva also cited a number of examples of ocean dumping by the Federal government.

Further, he stated that while all ocean dumping cannot be ceased immediately, there must be long-range programs which will favor recycling resource conservation, and more economic and environmently safe techniques of waste management. He indicated that until ocean dumping is ceased, we must be prepared to find a wide variety of pollutants gradually or even suddenly appearing in sea water, sediments, and in the marine organisms

we eat. It is especially important, Dr. de Sylva said, to note that ocean dumping is usually considered to be a purposeful practice whose source can be theoretically identified and controlled. Yet it is the sum of all sources of oceanic pollution which accumulate and concentrate in the marine environment.

In the area of research, Dr. de Sylva emphasized that there is a great deal more knowledge and study needed before any realistic analysis of the effects of ocean dumping can be proposed and evaluated. He stated that the nation's leading oceanographers are seeking funds for such studies and urged the Environmental Protection Agency along with such agencies as the Department of Health, Education, and Welfare, the Department of Defense, the Department of Interior, and the Atomic Energy Commission to support such research.

In summary, Dr. de Sylva stated that an analysis of ocean dumping is really a study of the dynamics of physical, chemical, biological, and geological processes. Field and laboratory research for American researchers is urgently needed now and nothing short of well-funded, long-term research will supply the answers we seek, Dr. de Sylva concluded.

Mr. Donald J. Benson, Seattle Metro, Seattle, Washington:

Mr. Benson's present responsibility is River Basin Study Coordinator for the Municipality of Metropolitan Seattle (Metro). However, since Mr. Benson formerly served as Executive Secretary of Northwest Pulp and Paper Industry, the Board requested that he concentrate his remarks on industrial practices of ocean dumping. In this context, he explained that in the Pacific Northwest, there are a number of major ocean outfalls that utilize salt water diffusion as an adjunct to land based treatment processes. These are continuous discharges, mostly industrial wastes from the pulp and paper industry. Included as ocean discharges are outfalls into Puget Sound. The bays and inlets of the Sound operate like estuaries, but the main body of water is similar in many respects to the open ocean. In the Sound, five major outfalls serve the pulp industry and three more are being planned. Several shallow outfalls to the Sound serve the petroleum refinery industry. Most of the communities and other industries along the Sound discharge treated wastes into relatively shallow discharges. The State of Washington policy now requires maximum diffusion and dispersement of such discharges. The proposed outfalls for the pulp industry require comprehensive field studies to determine current and wind patterns utilizing both the drops and sophisticated metering instrumentation. A new petroleum refinery with a shallow outfall to Puget Sound has received one of the few Federal permits under the 1899 Refuse Act on the condition that an unprecedented detailed and intensive biological and bioassay monitoring system be established. The monitoring program also included computer models of the outfall and receiving water system to estimate probable impact conditions of wind and tide. The model includes functions of nearby outfalls to predict any overlapping of discharges.

In an example cited by Mr. Benson, two pulp mills at Everett, Washington solved a serious oxygen depletion and fish passage problem in the 1950s by jointly constructing a 3000 foot outfall and diffuser section to a point 300 feet deep in the Sound. A Federal study in 1967 indicated biological damage from this practice, but the mills continue to disagree that any substantive harm is resulting from the practice. Nevertheless, Mr. Benson stated the mills were ordered to install recovery equipment for the spent liquor being discharged. One mill has announced that it must close and the other is under construction with a $60 million facility. Mr. Benson said it is unfortunate that the system required utilizes the spent liquor as a fuel with the recovery of sulfur as sulfur dioxide in the stack gases. The mill is located at the downtown Everett Waterfront, and through the years a very tight sulfur dioxide control system has been developed that meets Federal secondary ambient SO_2 standards. The recovery unit will increase the potential SO_2 emission from the pulp mill complex about five to tenfold. This will require the installation of emission controls well beyond the usual for such mills to meet ambient standards. The net result will be a substantial increase in the emission of SO_2, but below levels that can be expected to exceed ambient standards. Mr. Benson's point in discussing this example is that interrelated environmental decisions were lacking.

In conclusion, Mr. Benson stated that he had reviewed the CEQ recommendations for a national policy on ocean discharges and feels that it is a good one. However, he offered the following suggestions for modifying the policy:

(1) The policies relating to specific types of waste should allow for an overall impact analysis to ensure that available alternate techniques do not cause even more severe environmental impact in all cases. The policy provides for this with radioactive wastes and toxic industrial wastes.

(2) The jurisdiction for regulation of ocean discharges should remain with the prevailing water pollution control agencies, rather than establishing new jurisdictions.

(3) Research on ocean outfalls should be greatly expanded as articulated by the CEQ policy. Particular emphasis might be placed on the development of operational biological monitoring techniques and the development of computer simulator models for the design and operation of outfalls.

Dr. C. H. Ward, Professor of Environmental Science and Biology, Rice University, Houston, Texas:

Dr. Ward's statement dealt with a review of current dumping practices off the coasts of New Orleans, Louisiana, and Galveston, Texas and a discussion of procedures used to evaluate impact of ocean disposal.

Current Dumping Practices:

Dr. Ward stated that dumping in the Gulf has gone on in an essentially unregulated fashion since World War II. Records of the Corps of Engineers' district offices in Galveston show that since 1952, 20 companies have been allowed to dump off Galveston. In 1970, five industrial firms were dumping. Today, as far as is known to the Corps, no companies, municipalities, or governmental agencies are dumping in Galveston Bay or off shore, with the exception of dredge spoil resulting from maintenance of the Houston Ship Channel and the new construction at Morgans Point. All "letters of no objection" (to dumping) to the companies were withdrawn last spring. Prior to withdrawal of the five "letters" the Corps specified that all dumping would occur off the continental shelf at depths not less than 107 fathoms (642 feet).

Dr. Ward reported there have been numerous reports since 1958 of shrimp fishermen netting drums of chemical wastes in shallow waters close to shore. In 1970, the New Orleans Corps Office had five "letters of no objection" on record and these letters are still in effect. However, two of the five companies have since voluntarily stopped their ocean disposal. The disposal site designated by the New Orleans Corps is in excess of 400 fathoms of water in a 20 square nautical mile area about 50 miles south of South Pass off the Mississippi Delta. This area is well off the Continental Shelf. Yet, Louisiana shrimpers have also had a long history of snagging drums in shallow waters filled with chemical wastes. In citing these several examples, the point made by Dr. Ward is that the Corps has no jurisdiction or authority outside territorial waters. They can not legally issue permits for ocean disposal, only "letters of no objection". Violators of the "letters" cannot be prosecuted nor can dumpers without "letters". As a consequence, there is every reason to believe that we have no idea what is being disposed of in the Gulf, Dr. Ward stated. He emphasized that the Corps records do not reflect current practice. If they did, off shore disposal companies would not be prospering.

Dr. Ward urged congressional action to control off shore disposal. Until Congress provides applicable legislation, he recommended an immediate moratorium on dumping on the Continental Shelf. Nevertheless, Dr. Ward

indicated that he hoped that Congress will recognize that ocean disposal of some types of wastes, regulated by proper authority, may for the forseeable future, represent the most desirable alternative with regard to protection and preservation of the environment.

Turning to another point, Dr. Ward indicated that he does not know of a single published report of an investigation on the biological effects of off shore disposal of wastes in the Gulf. However, he said there are two broad scope research programs in the Gulf that could reasonably be expected to yield data applicable to judging biological effects of ocean disposal. Studies in the Texas A&M Sea Grant Program have been limited to mechanical and engineering aspects of handling dredge and hazardous materials in coastal zones. The Gulf Universities Research Corporation is conducting NSF sponsored physical oceanography studies in Gulf continental waters. In addition, they are conducting research sponsored by a group of oil companies designed to evaluate environmental effects of oil drilling operations on the shelf. The American Petroleum Institute is funding another group of biologists to study the effects of oil and oil spills on the physiology and ecology of marine organisms.

In summarizing, Dr. Ward stated that applicable technical information does not appear to be available nor is it being collected in a systematic approach.

Procedure for Evaluating Environmental Impact of Ocean Dumping:

Dr. Ward indicated that the procedure established for preparation of Environmental Impact Statements under the National Environmental Policy Act (NEPA) of 1969 is too narrow in scope since NEPA prohibits preparation of the EIS whose focus is out of context with the environmental problem and the affected area. He pointed out that the Gulf is a finite resource of inestimable value as a whole functioning eco-system. He stressed that the practice of judging the environmental impact of national policy (in this case dumping) on finite resources by reviewing individual actions under that policy must be stopped. He recommended that some segment of the Federal structure should accept the responsibility to act as the lead agency in preparation of an EIS that addresses the entire problem of ocean dumping. In conclusion, Dr. Ward urged the Advisory Board to use its influence to see that both the spirit and the letter of NEPA are adhered to in all questions relating to water pollution control.

Mr. Donald L. Corey, Supervising Sanitary Engineer, Massachusetts Division of Water Pollution Control, Boston, Massachusetts:

Mr. Corey opened his presentation by stating that Massachusetts has long recognized here dependence on the ocean for food, production, commerce,

recreation and other benefits. Representatives of the Massachusetts Division of Water Pollution Control have been engaged, in a continuing effort to abate problems of ocean dumping off the Massachusetts coast. This has involved a cooperative effort with other State and Federal agencies. Mr. Corey categorized dumping off the Massachusetts coast into three classes of wastes: sewage sludge, hazardous wastes, and dredge spoils. He described the policies and plans being implemented in each of these categories in order to provide some insight into the problems which his regulatory agency has faced. He then summarized what Massachusetts believes are major considerations in arriving at a satisfactory solution.

Sewage Sludge:

At the present time digested sewage sludge is discharged through ocean outfalls from two major treatment plants in Massachusetts. The total quantity discharged is approximately 30,000 tons (dry basis) annually. Through two contracts, the Massahcusetts Division of Water Pollution Control has developed a mathematical model which, in conjunction with sample analyses, has shown that the present practice of sludge discharge violates certain water quality criteria for class SB waters. Class SB waters should be suitable for bathing and recreation, including water contact sports, industrial cooling, excellent fish habitat, good aesthetic value, and suitable for certain shellfisheries. The practice of sludge disposal through ocean outfalls directly interferes with these assigned uses. Recognizing the inadequacy of these sludge disposal practices, the Metropolitan District Commission (MDC) engaged a consultant to study alternate sludge disposal methods by incineration or other means. Through a recently executed Memorandum of Agreement between the Division of Water Pollution Control, MDC, the U. S. EPA and others, a schedule has been established for construction of facilities for sludge disposal. Construction is to be completed by May 1976. Upon construction of these facilities, the State anticipates termination of ocean disposal of sewage sludge in Massachusetts waters.

Hazardous Wastes:

A limited program of off-shore hazardous waste disposal is presently being conducted in Massachusetts Bay. Wastes include those materials which because of chemical, flammable, explosive or other characterisitcs, constutute a danger or potential danger to public health, safety or welfare to the environment. Materials presently disposed of include explosives, reactive metal wastes (i.e., sodium, magnesium, potassium) and chemical wastes. Only one contractor is authorized to dispose of hazardous wastes in this manner since it presently represents the least potential hazard compared to other alternatives. However, Mr. Corey explained comprehensive legislation has been passed which would regulate the disposal of such wastes. Hearings on the proposed regulations have been announced and the State intends to have them implemented by the end of 1972. The regulations

will apply to disposal of hazardous wastes at land sites as well as in off shore areas. When the regulations are effective over a 75% reduction in the volume of hazardous wastes dumped will be achieved. The following materials will continue to be disposed of at sea under State regulation until suitable alternative methods are developed:

(1) Sodium and other highly reactive metals and their compounds (these are naturally present in sea water, and land disposal may result in conditions dangerous to humans due to the intense reaction with water).

(2) Laboratory quantities (1 liter or less) of chemicals, or equipment contaminated with chemicals, which are not highly toxic (disposal in sanitary landfill sewage treatment plant or by mixing may produce unpredictable results).

(3) Explosives.

Mr. Corey pointed out that no readioactive wastes are presently disposed of in Massachusetts waters.

Dredge Spoils:

The most significant current ocean dumping problem in Massachusetts waters concerns disposal of dredge spoils. The largest volume of dredge spoils originates from Federal harbor and channel projects initiated by the Corps of Engineers. The spoils from many of these Federal projects are typically polluted, Mr. Corey explained.

Some progress has been made in the last several years to bring this problem under greater control. Copies of applications for dredging permits are forwarded by the Corps to a number of State and Federal agencies for review and comment; environmental impact statements for Federal projects are similarly forwarded by the Corps. The Criteria for Determining Acceptability of Dredged Spoil Disposal, which were developed as guidelines for the EPA have provided useful limits on certain chemical parameters to be checked on each project.

It has been the State's experience that land disposal of polluted dredge spoils is impractical in most cases; however, in several small projects where acceptable land disposal sites have been available this has been the preferred location. Mr. Corey detailed some of the needs faced by regulatory agencies as follows:

(1) The number of dumping grounds for polluted dredge spoils and the size of such grounds should be minimized, preferably within presently designated dumping grounds.

(2) The criteria established by EPA for dredged spoil disposal should be reviewed and revised as appropriate.

(3) Effective monitoring of the environmental effects of ocean disposal of dredge spoil materials is presently inadequate. The monitoring work should include seasonal biological, chemical, physical and geological observations of ocean bottom, sea water, nutrients and biota, the character of all materials to be dumped and the character of the spoil grounds before, during and after spoil discharges should also be evaluated.

In summarizing, Mr. Corey outlined the following specific problems in Massachusetts, but also typical of other coastal areas:

(1) Elimination of off shore disposal of certain wastes will require substantial financial assistance from Federal and State governments.

(2) A research and monitoring program for ocean dumping is essential in order to rationally determine key criteria which must be considered in regulating waste disposal at sea.

(3) An overview must be maintained by regulatory agencies to ensure that decisions are coordinated and are environmentally sound.

Finally, Mr. Corey concluded that State regulatory agencies have experienced the financial crisis in administration and enforcement of water pollution abatement laws that all branches of State government currently face. Ultimate solution of the overall problems of ocean dumping will require major applications of funds, new technology and continued dialogue and cooperation between regulatory agencies at the State and Federal levels.

Dr. Thomas D. Hinesly, Soil Ecologist, Agronomy Department, University of Illinois, Urbana, Illinois:

Dr. Hinesly spoke on the practices and effects of municipal sludge utilization on land as an alternative to ocean dumping. In lieu of summarizing his prepared statement, Dr. Hinesly showed a series of slides illustrating the effects of sewage sludge disposal on land. Accordingly, Dr. Hinesly's entire prepared statemrnt is included in this report as Appendix 3.

An important point emphasized by Dr. Hinesly, is that amounts of sludge will increase as wastewater treatment facilities are upgraded. Tertiary treatment, for example, will retain between 95 and 98 percent of incoming effluent as fresh sludge. Instead of incineration, Dr. Hinesly said,

thousands of acres of land scarred by coal strip mining would provide more than enough area to receive nutrient rich treated sludge as fertilizer

Mr. Kenneth L. Johnson, Director, Air and Water Programs Division, Environmental Protection Agency, Region II, New York City:

Mr. Johnson spoke on incineration as an alternative to ocean dumping of sewage sludge. As a result of the concern regarding adverse environmental effects which might result from sewage sludge incineration, EPA established in June 1971 a Task Force to assess such concerns. After a program of testing and evaluation, the Task Force established the following conclusions and recommendations.

Conclusion 1: When properly operated, today's sludge incinerator systems, which have been designed to meet exisitng air quality standards, have been shown to produce acceptable stack emissions of particulate matter, nitrogen oxides, sulfur oxides and odors. Most sludge incinerators which are in existence today, however, do not incorporate high efficiency particulate matter control devices.

Conclusion 2: Small, but measurable, quantities of specific metals which are known to accumulate in the human system, and which are known to be toxic at certain levels, were found in the input sludge, stack emissions, scrubber water, and residue of those incinerators which were subjected to comprehensive testing. These same metals were also found in each instance where only the sludge alone was analyzed.

Conclusion 3: Small, but measurable quantities of specific organic chemical compounds including various pesticides and polychlorinated biphenyls, which are known to accumulate in the human system were found in all of the sludge samples analyzed. It should be expected that, under conditions of poor combustion, such compounds could be emitted from the stacks of sewage sludge incinerators.

Conclusion 4: It was impossible for the Task Force to accurately establish the potential for health effects which might be associated with sewage sludge incineration because: (a) there are insufficient health effects data relating to low atmospheric concentrations of suspected pollutant materials, and (b) there are insufficient stack gas sampling and analysis methods sophisticated enough to produce accurate information regarding quantity, size distribution, and constituent quality related to size, of the particulate matter emitted by sewage sludge incinerators.

Recommendation 1: Incineration should be accepted as an ultimate disposal method for sewage sludge, provided that the incinerator is properly designed and operated, and provided that controls are enforced to minimize the quantities of objectionable materials present in the input sludge to the incinerator.

Recommendation 2: EPA should, immediately, require that jurisdictions, which are to receive Federal construction grants, possess enforceable industrial waste ordinances designed to minimize the amounts of objectionable materials introduced into the treatment system.

Recommendation 3: Federal legislation should be enacted which would control, through a national permit system, all industrial liquid discharges.

Recommendation 4: EPA should, immediately, require that jurisdictions, which are to receive Federal construction grants for facilities incorporating sludge incinerators, guarantee an incinerator design which will assure the optimum combustion of any organic compound present in the sludge.

Recommendation 5: EPA should, immediately, require that jurisdictions, which are to receive construction grants for facilities incorporating incinerators, guarantee an incinerator design which will assure compliance with State and local air pollution control regulations and Federal new source performance standards.

Recommendation 6: EPA should engage in research and development projects to:

a. Accurately assess human health effects of incineration.

b. Produce more effective and accurate stack sampling and analysis techniques.

c. Improve existing sewage sludge incinerator and pollution control designs, with regard to impact upon environmental quality.

In summary, Mr. Johnson pointed out that pollutant emissions to the atmosphere from sludge burning should not be considered extraordinary when compared against the emissions from other combustion processes, such as solid wastes. Further, he explained that air pollution problems, especially in urban areas, are caused by the sum total of many individual sources. Accordingly, any new particulate matter, even relatively small ones such as sludge incinerators, and emissions of heavy metal and pesticides added to urban atmospheres should be a cause for concern.

Mr. Johnson concluded by stating that at a time when ocean dumping of sewage sludge is being phased out, it would be extremely beneficial if new environmentally sound methods of ultimate sludge disposal could be developed. He suggested examination of such potentially beneficial practices as controlled pyrolysis, perhaps combining a load of sludge and solid waste.

During the questioning, Chairman Barnes pointed out to the Advisory Board that in thinking about some of the alternatives to sludge dumping we should consider what kind of energy means will be used and what impact that may have back in the atmosphere. Mr. Johnson agreed, emphasizing that we might solve one environmental problem and create more.

Dr. Austin N. Heller, Secretary, Department of Natural Resources and Environmental Control, State of Delaware:

Although not originally scheduled to speak, Dr. Heller requested that he make a statement before the Board on behalf of Governor Peterson of Delaware and was granted the time by Chairman Barnes.

Dr. Heller opened his remarks by stating that the probable deleterious effects of ocean dumping is but a phase of Delaware's broader interest in protecting its coastal environment. This led to the passage of Delaware's Coastal Zone Act of 1971.

Delaware is deeply concerned with the problem of ocean dumping since such dumping has not been accompanied by valid scientific study and evaluation of ecological effects. The State is also concerned at the lack of a single, responsible regulatory agency, and Dr. Heller stressed the need for comprehensive Federal legislation which would provide for a single national agency to regulate waste disposal in the territorial waters of the U. S.

Dr. Heller outlined several immediate needs. The first is for a more precise knowledge of what man dumps into the sea. Continuous monitoring of water conditions would be a second step. He stated that, in the interest of safety, one thing that could be accomplished now, would be to dump sludge in water twice as deep as the present practice. This, he suggested, should increase the dilution and reduce the rate and amount of on shore drift.

Dr. Heller explained the State is experimenting with a project, involving solid waste reclamation and sewage sludge disposal, which shows considerable promise. He described the project as basically a solid waste reclamation plant capable of separating and recovering the components of solid waste in a form which will allow their diversion back into the consumer market, e.g., humus, glass, paper, carbon, ferrous and non-ferrous metals, and energy. The process uses sewage sludge as a diluent. The mixture of domestic waste and sewage sludge is shredded, milled, pulped and digested by aerobic bacteria in a controlled atmosphere. One of the products is a pathogen-free humus-type of material. The State is hopeful that the plant will be funded by an EPA grant and become a demonstration plant.

Dr. Heller concluded by pointing out that the project would solve two major environmental problems in one plant in a single process: Combining biodegradable refuse with sewage sludge to produce a marketable pathogen-free humus. He proposed that this would seem to offer a reasonable alternative to those who are told to stop ocean dumping.

THURSDAY, SEPTEMBER 28, 1972

Before beginning its deliberations, the Advisory Board heard from two additional speakers.

Mr. Albert Printz, Director, Refuse Act Programs, Office of General Counsel, EPA:

Mr. Printz provided the Board with a brief status report of the Refuse Act Permit Program.

From the standpoint of background information, in December 1970, President Nixon signed Executive Order 11547 establishing an industrial effluent control program based on permits issued under the 1899 Refuse Act. The program is administered jointly by the Corps of Engineers and EPA, with the latter being responsible for determining the permit conditions necessary to maintain the desired receiving water quality.

Mr. Printz explained the Permit Program received a major setback in the form of an injunction against issuing permits imposed as the result of a suit filed in the District of Columbia, commonly referred to as the Kalur decision. The lifting of the injunction is contingent upon revising the Program regulations to provide that (1) permits could not be issued for discharges into non-navigable waters, and (2) Environmental Impact Statements be prepared in accordance with the National Environmental Policy Act of 1969. In considering the appeal, EPA and the Corps of Engineers took into account the passage of new water legislation (since enacted) that would bring relief. In anticipation of the legislation, EPA adopted as a policy the application of the best practicable control technology currently available by 1976 as a pre-requisite for the receipt of a permit under the Refuse Act. EPA then moved into a program to internally identify what constitutes the "best practicable control technology currently available" (BPCTCA) for 20 different industries. In defining BPCTCA, EPA utilized the ground rules set out in the House Committee Report, i.e., levels demonstrated on either the basis of actual performance, demonstration or pilot studies. The technical aspects were discussed with selected representatives of the concerned industry.

The guidance was then distributed to the regions and allowed EPA to get a major jump on fulfilling the requirements of the new legislation. The new legislation will require defining not only BPCTCA for many of these industrial sectors, but also the best available treatment and new source performance requirements, Mr. Printz concluded.

Major General Richard H. Groves, Division Engineer, North Atlantic Division, Corps of Engineers:

General Groves discussed the responsibility of the Corps in the New York Bight area. He explained that the Corps's primary responsibility is for maintaining navigation in U. S. territorial waters and that it operates a permit program for ocean dumping of dredge spoil under section 13 of the Refuse Act. The Corps also has had special regulatory authority over ocean dumping for the port areas of New York, Baltimore, and Hampton Roads.

The General emphasized that the Corps realizes its contribution to the ocean dumping problem, but that there are no suitable alternatives available to dredge spoil dumping at this time. For example, dredge spoil could be hauled 100 miles out to sea and dumped off the Continental Shelf, but the equipment to do this does not exist, and it would increase costs; digested sludge and dredge spoil could be spread on land, but this also would be very costly.

General Groves concluded by emphasizing that since the Corps' basic mission is to maintain navigation, it would just as soon get out of the responsibility for issuing permits.

Following the presentations by Mr. Printz and General Groves, the Board devoted the remainder of the day to the formulation of conclusions and recommendations and also adopted one resolution (Appendix 4).

FRIDAY, SEPTEMBER 29, 1972:

The Advisory Board concluded its meeting with a press conference held at EPA Region II. Chairman Barnes opened the press conference by emphasizing that based on the testimony presented there is marked need to obtain a much better idea of what is going into the ocean. He also stressed the need for better control of toxics and heavy metals. He placed further emphasis on the pending legislation on ocean dumping and amendments to the Federal Water Pollution Control Act.

The Board then presented it Conclusions and Recommendations which are included in this report as Appendix 5.

The meeting was adjourned at 11:30 a. m.

PROGRESS:

Since the meeting of the President's Water Pollution Control Advisory Board on ocean disposal, both the Marine Protection Research and Sanctuaries Act of 1972 and the Federal Water Pollution Control Act Amendments of 1972 have been enacted into law and thereby several of the Board's major recommendations have been implemented.

In addition, the 91-nation Convention on Dumping of Wastes at Sea was held in London in November. Agreement was reached on the final text of an ocean dumping treaty which generally prohibits the dumping of extremely hazardous material such as radioactive waste, biological and chemical warfare agents, oil, pesticides, and durable plastics. Less harmful materials, auch as lead, copper, scrap metal, and fluorides, could be discharged only under special permits. Enforcement and punishment would be left to individual countries. The agreement takes effect when ratified by 15 countries.

PRESIDENT'S WATER POLLUTION CONTROL ADVISORY BOARD
September 28, 1972 - New York, New York

SPEAKERS PRESENT FOR PUBLIC MEETING:

Mr. Henry Diamond, Commissioner
N. Y. State Department of
Environmental Conservation
New York, New York

Dr. John Pearce
Sandy Hook Laboratory
NOAA
Highlands, New Jersey

Mrs. Jean Auer, Member
California State Resources
Control Board
Sacramento, California

Mr. Jon Lindbergh, Chairman
Oceanographic Commission
State of Washington

Dr. Donald P. de Sylva
Associate Professor of Marine Science
University of Miami
Miami, Florida

Mr. Donald J. Benson
Seattle Metro
Seattle, Washington

Dr. C. H. Ward
Professor of Environmental
Science and Biology
Rice University
Houston, Texas

Mr. Donald L. Corey, Supervising Sanitary Engineer
Massachusetts Division of Water Pollution
Control
Boston, Massachusetts

Dr. Thomas Hinesly, Soil Ecologist
Agronomy Department
University of Illinois at Urbana
Urbana, Illinois

Speakers (continued):

Mr. Kenneth L. Johnson, Director
Air and Water Programs Division
Region II, EPA
New York, New York

Dr. Austin Heller
Department of Natural Resources
and Environmental Control
Dover, Delaware
(Represented Governor Peterson of Delaware)

ENTERED STATEMENT FOR THE RECORD

Senator William V. Roth
Delaware

STATEMENT OF
SENATOR WILLIAM V. ROTH
SUBMITTED TO PRESIDENT'S WATER POLLUTION CONTROL ADVISORY BOARD

September 27, 1972

Mr. Chairman,

I appreciate your courtesy in allowing me to submit these remarks for your consideration. I know you are all busy, and I thank you for taking the time to read what I have to say.

My purpose in submitting these remarks is, quite frankly, to ensure that the interests of my small State of Delaware are not overlooked during your consideration of this problem. While ocean dumping concerns all Coastal States, Delaware's interest is, I believe, more intense for two reasons: first, because we have exercised more restraint in the development of our coastal areas than some States, we believe Delaware has more to lose than many of our neighbors; and, second, because Delaware is surrounded by great metropolitan areas over which we have little or no control, we feel more threatened.

As you may know, the Cities of Philadelphia and Camden annually

barge about 120 million gallons of treated sewage to an ocean site 14 miles off the coast of Rehoboth Beach, Delaware's principal recreation area. Although the impact of such dumping is scientifically undetermined at present, I personally believe that while doubts remain, Delaware should not be compelled to bear the risk so that other States can save money by dumping sewage in the nearby coastal waters rather than disposing of it through other costlier, but safer, methods. The citizens of Delaware have sacrificed a great deal to preserve our coastal areas, and we believe that the off-shore disposal of sewage and other waste matter jeopardizes what we have consciously fought to retain: a relatively clean and pure environment.

I must admit that a scientific study commissioned by the City of Philadelphia purports to show that there is no environmental or ecological damage as a result of the City's dumping practices. But, as far as I am concerned, Mr. Chairman, this study is grossly inadequate. As a matter of fact, one scientist with whom I spoke (who is associated

with neither Delaware nor Philadelphia, but who is an acknowledged expert on the effects of ocean dumping) told me that the study was "fast and dirty." Yet, despite its inadequacies, the study's results are widely and highly touted as firm scientific proof of the safety of ocean dumping. Specifically, Mr. Chairman, I have these criticisms of the study conducted by the Franklin Institute:

The focus of the report was on conditions in and around the dump site itself. The most important conclusion was that the dump site is almost completely free of sludge. But for Delaware's purposes this means only that the material has been swept away by currents at the dump site; we must know where it goes.

Because the sludge dumped by Philadelphia is highly resistant to further decomposition (it is the residue of attack by extremely high concentrations of bacteria at temperatures around 100°F. for about 30 days) it is likely to persist in the natural marine environment. To ensure that it presents no danger to Delaware, we must know where it is transported by the dump site currents and its ultimate fate. These are questions which the study has not considered, but there is some evidence from the study itself, that the ultimate fate of some sludge is to be washed up on Delaware's ocean beaches.

Page A-1 of the study reports the results of sea bed drifter recovery. Since sea-bed drifters move with the currents within one or two feet of the bottom, when they are washed up on shore their distribution gives a rough idea of how sludge particles might be expected to move. Of 180 drifters released at the dump site, 33 (or 18 percent) were recovered. The others either drifted out to sea or were trapped in low places or

deposition sites between the dump location and the coast. Some drifters may be dislodged during storms and washed up at a much later date, but of the 33 that were recovered, 17 (or 52 per cent) were found on Delaware's Atlantic Coast; and, 14 of these 17 were found on the 14 mile stretch between Cape Henlopen and Indian River inlet. Thus, 43 percent of the drifters recovered were found in an area that includes some of Delaware's principal bathing beaches. On page 4-2 of the report, the author states, "There is no specific section of the shoreline that receives more than its share of drifter recoveries." Clearly, this is not so.

The City of Philadelphia dumps approximately 500,000 tons of sludge every year. (Reference page 4-16 of Report dated February 1972.)

If we assume (and this correlation is by no means certain) that the amount of sludge washed up between Cape Henlopen and the Indian River Inlet is proportionate to the number of drifters washed ashore, then

39,000 tons of sludge are deposited along this stretch of beach each year. (If 14/180's of the drifters wash ashore at this point, then 14/180's of 500,000 tons of sludge should also come ashore.) This would mean that over 1,000 pounds of liquid sludge per linear foot of beach is deposited. And, if the liquid sludge is 10.8 per cent solids, then 108 pounds of solid sludge a year are deposited on every linear foot of beach between Cape Henlopen and the Indian River Inlet. I should add that the behavior of drifters in the surf zone can be expected to differ from the behavior of sludge particles. Therefore, it is likely that an unknown fraction of the 108 pounds per linear foot is carried north toward Cape Henlopen by the longshore drift.

If dumping is to continue at the present site, we determine where the sludge is going, since it seems quite likely that an appreciable portion moves toward shore. To do this, we must find some unique chemical or physical characteristic of the sludge, so we can differentiate it from

the natural sediments and trace its movements after being dumped. Heavy metal concentrations (i.e. lead, copper, silver) were found to be useful for this purpose in a similar study in the New York Bight.

Some work which bears directly on this problem has been carried out in the College of Marine Studies of the University of Delaware, and other work is presently in progress. When we have found a unique "fingerprint" for the Philadelphia sludge, we can begin to look for it in a much wider area along the Delaware Coast where sludge particles might be expected to settle. In addition, long term current meter measurements (on the order of one year due to seasonal current variations) should be made at and around the dump site to see where the sludge moves when currents carry it from the site. If a unique fingerprint for the sludge can be found, the first part of a study could begin to yield results within about three months. The current meter study would require at least one year.

At present, there is not enough information about the behavior

of digested sludge in general, and about Philadelphia sludge in particular, to assess its danger. We must know the levels of heavy metals, pesticides, and other harmful substances in the sludge, and their rate of release in the marine environment. Further, we must know where the majority of the sludge is deposited, and what marine animals metabolize it. Finally, the effects on Delaware's beaches and human users must be ascertained if sludge dumping is not to harm the tourist industry by real or imagined sludge contamination.

I should point out, Mr. Chairman, that I am a layman and the preceding analysis of the Franklin Institute's findings was provided by a group of scientists at the University of Delaware. I have included this analysis, not to generate a scientific dispute, but to illustrate the pitfalls of accepting the conclusions of a scientific study merely because it is "scientific." I personally have discussed the scientific aspects of ocean dumping on numerous occasions with men whom I respect highly. Based on these discussions, I am satisfied that until we are able to obtain conclusive

scientific evidence, ocean dumping practices should be modified substantially or halted completely. Ocean dumping should certainly be banned off recreational areas while study is proceeding.

I could say much more on this subject, but I know you all have great demands on your time. I appreciate your consideration of my comments.

Practices, Economics, and Effects of Municipal Sludge Utilization on Land as an Alternative to Ocean Dumping

T. D. Hinesly

Factors Contributing to Sludge Handling Problems

The disposal of wastewater treatment plant residues is the most difficult and increasingly costly problem confronting major sanitary district staffs. For cities of over 50,000 populaton the average per capita suspended solids load at wastewater treatment plants was found to be 0.25 pounds per day on a dry-weight basis (Loehr 1968). Plants receiving large quantities of industrial waste may have average per capita loadings approaching twice the average value. For example, the Metropolitan Sanitary District of Greater Chicago has an average per capita loadings of about 0.4 pounds per day. It is expected that the average per capita loadings will increase because the installation of garbage grinders in homes will augment suspended solids by an average of 60 percent, (American Society of Civil Engineers Manual, 1959). However, at the time Loehr collected his data, only about 12 percent of the homes were equipped with garbage grinders.

At present the activated sludge treatment process is most frequently used for secondary treatment of wastewater. From the standpoint of suspended solids removal, the process when preceded and followed by sedimentation, is about 85 to 95 percent efficient. Eventually, as wastewater treatment facilities are upgraded to include tertiary treatment processes, the efficiency for suspended solids removal should be at least 98 percent. Therefore, it is likely that in the near future, somewhere between 95 to 98 percent of the per capita loading reaching the wastewater treatment plant will be retained as fresh sludges.

Along with the increase in quantities of wastewater given tertiary treatment for improved removal of solids, higher priorities are also likely to be given to reducing phytoplankton nutrients to lower concentrations in effluent. The removal of nutrients will require the addition of chemicals such as the dosing of effluents with lime or alum to precipitate soluble phosphates. Added chemicals which cannot be economically regenerated for recycling will add materially to the solids handling problems. Assuming an average wastewater flow of 135 gallons per capita per day (Loehr 1968), a chemical dosage of only 50 ppm will increase the per capita per day suspended solids in fresh sludge by 0.05 pounds.

Considering the trend toward greater usage of garbage grinders, tertiary treatment processes, and chemicals for reducing nutrient concentrations in effluents an average value of 0.35 pounds per capita per day of solids as fresh sludge would appear to be a conservative estimate of production, at least for the larger advanced wastewater treatment plants. For each million population served by sewers, about 175 dry tons of fresh solids will be removed from about 135 million gallons of wastewater requiring treatment each day. Therefore, municipal sludge handling problems will increase, even if our sewered population should remain static.

Kinds of Sludges Generated

The solids separated from wastewater during sewage treatment are a complex array of organic and inorganic residues. Upon reaching the wastewater treatment plant, about 60 percent of the suspended solids load is removed by sedimentation. The solids portion removed by this sedimentation is called primary sludge. The solids not removed by the primary treatment sedimentation process are transferred to another tank as a constituent of the effluent where they are mixed with large quantities of aerobic microorganisms and large volumes of air. The microorganisms use the oxygen in the air to convert part of the organic waste into carbon dioxide and water to obtain energy, while converting another large portion into new cells.

The portion of the waste converted into new microbial cells and collected by sedimentation after removal from the aeration tank is called activated sludge. To maintain a microbe population in the growth phase a portion of the activated sludge is recycled to the aeration tank, but for the most part it is wasted and thus often referred to as waste activated sludge. The primary sludge and the waste-activated sludge generated during secondary treatment when taken together, make up the fresh sludge discussed above.

In the United States many attempts to spread primary or raw sewage sludge on land have ended in failure. Waste-activated sludge has been successfully used as a fertilizer material only after heat drying and then at only light applications which could be thoroughly incorporated with soil. Such biologically unstable materials as primary and waste-activated sludge cannot be spread on land or lagooned because of odor and fly problems. In some of the older literature, waste activated sludge is sometimes referred to as aerobically digested sludge. Waste activated sludge is highly unstable with regard to further biological degradation and should not be referred to as a digested sludge. To stabilize waste activated sludge sufficiently for land surface application by an aerobic process would require a detention time of about 20 days (Irgens and Halvorson 1965). Studies at the University of Wisconsin have demonstrated the adaptability of an aerobic digestion process to the stabilization of mixtures of raw and waste activated sludge (Norman 1961). Aerobic digestion of primary sludge has been evaluated by Viraraghenen (1965) for average climatic conditions in the vicinity of Madras, India.

In the older literature, discussions regarding sludges from Imhoff tanks are often confused with those concerned with sludges from heated anaerobic digesters; both simply referred to as anaerobic digested sludge by some authors. While some

degree of anaerobic sludge stabilization is accomplished in Imhoff tanks, it may or may not be comparable to that accomplished in a heated anaerobic digester where environmental conditions are maintained near optimum for rapid biological degradation of organic sludge constituents. Lohmeyer (1959) reviewed the literature pertaining to heated anaerobic digestion and presented recommendations for managing digesters to obtain the best overall results with the least difficulty. In a later literature review, Pohland (1962) discussed anaerobic decomposition in terms of two phases which he designated as first, liquefaction and hydrolysis, the second being fermentation and gasification. A rather heterogeneous group of bacteria convert the proteins, carbohydrates, and lipids contained in the waste largely to fatty acids, carbon dioxide and ammonia nitrogen during the first stage. During the second stage strict obligate anaerobic bacteria convert the fatty acids produced during the first stage to methane and carbon dioxide. Toerien and Hatingh (1969) reviewed the literature toward presenting the current state of knowledge about the microbiology and biochemistry of the anaerobic digestion process and to identify areas needing further research. They state that it seems probable that fungi and protozoa do not play significant roles in the degradation of organic matter during anaerobic digestion. Andrews (1969) presented a dynamic model for the anaerobic digestion process, which has usefulness in predicting the results of changes made in the operation of digesters.

The above reports regarding aerobic and anaerobic digestion processes for raw (primary) and waste activated sludges are sufficient to emphasize the attention that has been given to organic waste stabilization. Some of the reasons given for stabilization of sludges are that it promotes rapid dewatering, reduces the initial bulk of solids for more economical handling, destroys pathogenic organisms for health protection, and noxious odors are eliminated. Another most important reason for stabilization is the elimination of housefly infestations of stored waste.

Apparently the housefly will readily breed in raw, waste activated or partially digested sludge, but not in a well digested sludge (Goudey 1932) (Von Zuben, et al. 1951) (Wolf 1955).

To overcome some of the objectionable characteristics of primary and waste activated sludge, the use of heated anaerobic digesters have proven to be most satisfactory and economical (Lynam, et al. 1972). Heated anaerobic digestion of sewage solids is used to accomplish two primary objectives. First, about 50 to 70 percent of the organic fraction of sludge solids are biologically converted to methane and carbon dioxide, reducing the amount of total solids that must be handled by about 40 percent. After digestion, the organic fraction of the remaining solids is sufficiently stabilized against further biological degradation so the material can be lagooned, dewatered on open drying beds, or applied on the surface of soils without causing noxious odors or fly breeding problems. By anaerobic digestion the projected sludge handling problem may be reduced from 175 to 105 dry tons per day per million population.

Cost of Sludge Disposal

Cost for the incineration of sludges (includes wet-air oxidation, multiple-hearth, and fluidized-bed) range from 30 to 42 dollars per dry ton as reported by Burd (1968) and from 50 to 57 dollars as reported by Bacon and Dalton (1966). Because these estimates were made from data collected several years ago they are probably on the low side. If the greater cost for minimizing air pollution and increased cost resulting from inflation are considered, the cost for incineration of sludge solids today is probably greater than 60 dollars per dry ton. Furthermore, incineration does not provide for a permanent solution to the solids handling problem. The ash accumulating from the oxidation of fresh sludges amounts to 30 to 35 percent of the original dry weight and presents some of the same

disposal problems as those encountered with the original material.

Waste activated sludge has sometimes been heat dried and sold as a low grade organic fertilizer. Dry, waste activated sludge contains about 4 to 6 percent nitrogen, 3 to 7 percent P_2O_5 equivalent and 0.25 to 0.6 percent K_2O equivalent. Thus, from the standpoint of a fertilizer, the inconvenience and cost of supplying sufficient quantities of dried sludge to satisfy the nutrient requirement of most crops is too great to expect an increase in its marketability. Even before it was necessary to consider the installation of equipment to reduce air pollution Bacon and Dalton (1966) reported that the net cost for disposing of 250 to 300 dry tons of sludge as a fertilizer material was 45 dollars per dry ton.

Burd (1968) reported a cost of 50 dollars per dry ton for drying and applying sludge on land and 25 dollars per dry ton for the application of dewatered sludge on land. He also concluded that the cost for disposal of dewatered sludge in landfills was about 25 dollars per dry ton. Cost estimates for permanent lagooning of digested sludge range from 12 (Burd 1968) to 49 (Bacon and Dalton 1966) dollars per dry ton. A number of variables determine the actual cost of land disposal schemes but the major variables are the initial cost of land and distances sludge must be transported from the wastewater treatment facility to the disposal site. Whether sludges are applied on or near the soil surface, dumped in landfills or held in lagoons all are aesthetically unacceptable because, if for no other reason, the land is condemned to a singular low degree of usage.

In the last few years a great deal of attention has been given to the old idea of utilizing digested sludges as a source of nutrients to grow crops and as a soil amendment to ameliorate physical conditions in severely disturbed lands that adversely affect the establishment and growth of plants. It is not nvisioned that disposal by utilization can be carried out without cost to the sanitary district. On the otherhand, contrary to strictly land disposal schemes,

it is envisioned that the solids will be utilized in such a manner that land usage is either not changed or in the case of land reclamation the number of alternative land uses are increased. In 1968, members of Harza Engineering Company estimated the cost for pumping digested sludge containing 3 to 5 percent solids a distance of about 50 miles and distributing it on land in amounts just sufficient to supply the nitrogen needs of nonleguminous plants. On the bases of a 6 percent interest rate and amortization of all construction costs over 50 years, and including maintenance and operation of the sludge distribution equipment, they estimated the cost for sludge disposal by agricultural utilization to be 22.30 dollars per dry ton. Wirts (1956) estimated the cost for pumping digested sludge to be 10 to 15 cents per ton mile. He pointed out that cost depends on the tonnage pumped and suggests that a connected population of 2 million people is an economical starting point for considering pumping distances of 50 to 100 miles. At the present time, sludge is being transported from the Metropolitan Sanitary District of Chicago wastewater treatment plants to an agricultural utilization site 160 miles downstate by a unit train. The unit train contains 30 tank cars, each having a 20,000 gallon capacity. By another contract, sludge is being barged 180 miles from Chicago to a land reclamation site. While transportation costs vary with the solids content of the digested sludge they have generally ranged from 30 to 35 dollars per dry ton during these short period (3 years) rail and barge haul contracts. With a continuous or sustained operation, transportation cost by rail and barge could be considerably reduced. On a sustained operational basis it does not appear unreasonable to consider transportation distances of 200 miles from large municipal waste treatment facilities when contrasted to cost for alternative methods of sludge disposal.

Land Requirements

If all municipal waste waters generated in the continental United States

were given secondary treatment and the resulting solids stabilized for utilization as a fertilizer and soil amendment about 10 to 12 million dry tons of solids would be available each year. The utilization of the solids in amounts just sufficient to meet the needs of nonleguminous crops for supplemental nitrogen would require an annual application of about 10 to 15 dry tons per acre. Thus, not more than one million acres of land would be required at any one time to utilize the total continental United States production of sludge solids. Only enough sludge solids would be available to treat slightly more than 0.2 percent of the 465 million acres of cropland or slightly less than 0.06 percent of the total 1,904 million acres contained in the continental United States. However, because of its potential as a source of sorely needed stable organic matter, municipal sludge exhibits its greatest value as a resource when used as an amendment for the reclamation of surface-mined lands. Since over 0.5 million acres of land strip-mined for coal prior to 1964 already exists in various states of devastation, while another 0.5 million acres have been or will be stripped during the 20-year period from 1964 to 1984, there is no scarcity of land which needs the nutrients and organic matter supplied in sludge. About 30 percent of the country's population are within economical sludge pumping distances to land strip-mined for coal in Illinois, Indiana, Kentucky, Ohio, West Virginia and Pennsylvania.

Those who express concern about the contamination of soils with constituents of municipal sludges probably are not aware of the relatively small amount of land needed. Confusion often exists between land requirements for sewage effluent disposal or renovation and that needed for solids utilization.

Criteria for Selection of Sludge Utilization Sites

For utilizing digested sludge as a soil amendment and fertilizer, the following criteria for site selection are recommended (a) The site should be located

where utilization of the sludge offers maximum benefits to the local agricultural economy, consistent with reasonable costs to the particular sanitary district. The local populace must be able to weigh the benefits to be realized from the sludge utilization program against the assumed or real stigma attached to an area that becomes the receptor of waste from a large municipality. People living in areas devastated by surface mining activities readily recognize the benefits to be realized by utilization of digested sludge to reclaim land. (b) To ensure that sludge applications are made under uniformly controlled conditions the land must be susceptible to purchase or long term lease by the sanitary district. (c) To minimize sludge distribution cost all lands in the site should be contiguous, at least to the extent that the disturbance to existing residents is minimal. Surface mined lands offer the best possibilities for obtaining large contiguous acreage. There is little or no disturbance of existing residents, because this occurred during the stripping process. It is envisioned that much of the land will be repopulated with farm operators as the land is reclaimed to a high state of productivity. (d) Soil depths should not be less than six feet to permeable bedrock. Water tables should be capable of being maintained to average depths of at least 6 feet from the soil surface. Such minimum soil depths, with good management practices, will provide protection from ground water pollution. (e) Land slopes should not be so steep as to prohibit the establishment of water management and erosion control structures at a reasonable cost. Slopes up to 18 percent may be acceptable where "push-up" terraces with permanent vegetated or sodded back slopes can be established. Unconsolidated geological materials must be sufficiently deep to bedrock in the borrow area so that after terrace construction a minimum 6 foot depth to bedrock is maintained.

Environmental Benefits and Public Health Protection

1. Chemical and Physical

In Table 1 some average concentration values are presented for several chemical elements found in digested sludge from the Calumet and Stickney wastewater treatment plants. Sludges from both of these treatment plants have been used in the research conducted during the last five years by members of the Agronomy Department, University of Illinois.

Table 1. Composition of anaerobically digested sewage sludges from MSD of Chicago, Calumet and Stickney treatment plants. Samples obtained during 1971 (Calumet late in year).

	Means (Wet Weight)	
Element	Calumet	Stickney
Cd ppm	3.0	14.0
Mn "	8.0	18.0
Ni "	3.0	15.0
Zn "	83.0	223.0
Cu "	16.0	67.0
Cr "	26.0	194.0
Fe "	726.0	2100.0
Pb "	16.0	75.0
Hg "	0.063	0.275
Na "	98.0	131.0
P "	757.0	1141.0
Ca "	963.0	1289.0
Mg "	180.0	484.0
K "	195.0	390.0
N %	0.09	0.156
% Solid	2.05	4.36
% Volatile	58.0	48.0

Anaerobically digested sludge, as it comes from digesters, contains 3 to 5 percent solids as finely divided and dispersed particles. It looks like crude oil and has an odor which many people describe as earthy or tarry. It can be easily

transferred by pipes using ordinary pumping techniques and equipment. When applied to cropland at the rate of 2 inches per acre, it will supply all of the major essential nutrients, including the following: 200 to 350 pounds of ammonium nitrogen per acre; about the same amount of organic nitrogen some of which will be slowly released in a form available to crops; 250 to 450 pounds of phosphorus, of which about 80 percent is in the organic matter; and 40 to 80 pounds of potassium. Sulfur will also be supplied in amounts adequate for crops. The amounts of calcium and magnesium supplied will exceed the average annual losses of these elements by leaching in humid regions.

High application rates of digested sludge on cropland can cause obvious nitrate problems. To determine maximum sludge loading rates on soils, total and soluble nitrogen contents must be known. The soluble nitrogen in anaerobically digested sludge is in the ammonium nitrogen form, but under proper soil aerobic and temperature conditions it is rapidly converted to mobile nitrate-nitrogen. Thus, the loading rate of sludge on cropland is limited by the amount of soluble nitrogen plus an annual mineralization of about 4 percent of the organic nitrogen supplied by sludge applications. If loading rates are based on the amount of nitrogen furnished to meet crop needs and losses by volatilization, soluble phosphorus applications will also be at low enough levels that phosphorus will not present a eutrophication threat to water supplies. When sludge loading rates are based on safe nitrogen application rates the capacity of most soils other than sands to inactivate phosphorus by adsorption and conversion to sparingly soluble precipitates or compounds is great enough to maintain phosphorus levels in drainage water to less than 1 ppm.

When the main objective is land reclamation, sludge loading rates may be considerably greater because disturbed lands generally have small or nonexistent organic nitrogen reservoirs. The amelioratory effect of organic matter on the

physical properties of soil materials may make it desirable to increase sludge loading rates on marginal or severely disturbed lands above those recommended for productive agricultural lands. However, as the highly stabilized sludge organic matter accumulates in soils with succeeding applications, the slow mineralization of organic nitrogen must be taken into account to prevent excessive losses of nitrate nitrogen to water supplies, within or adjacent to the treated areas.

Many toxic and nontoxic organic waste materials occurring as constituents of sludge arise as discharges from industrial processes such as the chemical production of textiles, plastics, pharmaceuticals, detergents, and pesticides. After a period of acclimation, some organic toxic substances, such as phenols and formaldehyde, can be almost completely removed from wastewater by biological treatment, even though at sufficiently high concentrations they are bactericidal (Jackson & Brown 1970). Others, which are nonbiodegradable under aerobic conditions, may be removed from effluent with or by absorption on sludge sediments and later biologically degraded during anaerobic digestion of the solids. Of all the organic materials, polychlorinated biphenyls (PCB's) have been of greatest concern to those involved with municipal waste utilization. Many sludges contain 1 to 4 ppm or more and like other chlorinated hydrocarbons, PCB's are only very slowly degraded by microorganisms. Where we have applied 115 dry tons of digested sludge a small increased concentration of PCB's was found in the soil but they were not taken-up in detectable concentrations in soybean and corn plant tissues. Since bacteria are the first group of soil microorganisms to be decreased by abnormally high concentrations of chlorinated hydrocarbons we have made total counts from soil samples collected from plots which have been treated with up to 136 dry tons of sludge over a period of 4 years. Total bacteria populations were found to be higher in soils treated with sludge. The positive correlation between total bacteria and amounts of applied sludge was highly significant. It appears that sludge applications have modified the soil environment in a manner that favors the maintenance of a highly active population of bacteria resulting in a greater rate of pesticide degradation than might be expected in soils not treated with sludge.

Heated anaerobically digested sludge is outstanding in its ability to increase the humus content of soils. For example, in 1941 a study was initiated at the Rothamsted Experiment Station in England to compare the effects of four types of organic manures with inorganic nitrogen fertilizers on market-garden crops (Mann, et al. 1962)/(25). The organic manures were farmyard manure, digested sewage sludge, a compost of straw and farmyard manure, and a compost of straw and sewage sludge. Each of the organic manures was applied at the rate of 15 and 30 tons per acre per year. After nine years, nitrogen in the top 9 inches of soil was 0.088 percent where inorganic nitrogen, the familiar fertilizer source, had been applied as compared to a value of 0.089 for control plots. At application rates of 15 and 30 tons per acre per year of digested sludge, the nitrogen content in the soil surface was 0.176 percent and 0.247 percent respectively. These data indicate that the amounts of nitrogen in the sewage-sludge plots increased about three times as much as in the corresponding plots treated with farmyard manure and compost made from straw and farmyard manure. The surface soil in sewage-sludge treated plots contained about 50 percent more nitrogen than plots treated with equivalent amounts of compost made from straw and sewage sludge. Following the first nine years, treatments between 1951 and 1960 with digested sewage sludge produced only a slight increase in soil nitrogen percentages. However, nitrogen contents remained at a considerably higher levels in sewage-sludge treated plots than were obtained with either farmyard manure or compost.

In 1960, Jansson (1960) investigated some specific properties of the humus fraction of fresh cow dung, well-rotted farmyard manure, and digested sewage sludge. He found that the size of the lignin-like complex in farmyard manure and digested sludge was somewhere between fresh plant residues and developed soil humus, but fresh cow dung was similar to fresh plant residues. Jansson stated that "the oxidation rate of the farmyard manure and the sludge is similar to that of the humus of an acid podzol" (acid forest soil).

More recently we have found that 136 dry tons per acre of anaerobically digested sludge incrementally applied during four years on Blount silt loam soil increased its organic carbon content from 1.2 to 2.4 percent in the surface 6 inches. Furthermore, we have found that the humic-acid extracts from heated anaerobically digested sludge gave an infrared spectrographic pattern that was similar to that of extracts of the natural organic matter contained in an Elliott silt loam soil (1971).

Lunt (1959) reported that digested sludge had a very favorable effect on several soil properties. He reported a moderate increase of 3 to 23 percent in moisture holding capacity, non-capillary porosity, and cation exchange capacity following the incorporation of digested sludge into soils. Furthermore, he found an increase in soil aggregation ranging from 25 to 600 percent which could be attributed to the digested sludge additions.

The results of the studies described above indicate that the organic material produced in a 15-day heated anaerobic digestion process has properties very close to that of natural soil organic matter or humus. Digested sludge is one of the few materials that can be used to effect a rapid increase in the humus content of soil. It is the only substance with these properties that is available in quantity.

To reestablish soil organic matter contents in severely disturbed or eroded lands to levels equivalent to those characteristic of productive soils will take many years under normal cultural practices. For example, in nature the time necessary to build up soil organic matter profiles to a point of equilibrium with its environment has been estimated to be not less than 200 nor more than 1,000 years from studies conducted on soil profiles in Columbia and California (Jenny 1950). Considering the importance of soil organic matter as a storehouse of slowly available plant nutrients, a source of cation exchange capacity, and a promoter of stable soil structure, two centuries is too long to wait for natural processes to build up

the soil organic matter levels in unproductive lands while we seek ways to dispose of a material which can be used to effect a beneficial, immediate change.

Some waste treatment plant sludges contain higher concentratons of chromium, zinc, copper, lead, nickel, mercury, and cadmium than are found in typical agricultural soils. Berrow and Webber (1972) reported the results from analyses of 42 sewage sludges collected from rural and industrialized city wastewater treatment plants in England and Wales. On a dry matter basis they found the sludges contained consistently greater concentrations of silver, bismuth, copper, lead, tin and zinc than are present in typical agricultural soils. In a small number of sludges, boron, cobalt, molybdenum, chromium and nickel were present in sludges at greater concentrations than found in typical scils. They correctly point out that the amount of trace elements present in soluble or available form is more important in relation to uptake by plants than is the total content. Thus, they assessed the solubility of several trace elements by extracting with 2.5 percent acetic acid. In Table 2 their extractability data and some of ours are presented by decreasing solubilities of several elements. It would appear from these data that we must be mainly concerned with first six elements presented in Table 2.

Table 2. Trace elements extracted by 2.5 percent acetic acid from 42 sludges in England and Wales (Berrow and Weber 1972).

Element	Mean Content extractable	Mean soluble % of total content
	ppm/dry matter	
*Cd	144	65
Mn	300	56
Ni	190	46
Zn	1540	44
Co	8.8	32
**B	10	25
Cu	96	6.9
V	3	4.8
Cr	22	3.1
Fe	650	2.8
Pb	20	2.8
Mo	0.12	1.9
Sn	0.58	0.5

* Unpublished 0.1 N HCl data
** Hot water extractable

On the basis of total and extractable concentrations of trace elements in sludges, Berrow and Webber speculate that where sludges are used over a period of several years to fertilize crops some of the accumulating trace elements may give rise to toxicity problems in plants. From the results of chemical analyses of samples collected from soils contaminated with trace elements by air pollution and the use of municipal compost and sludges, Purves (1972) speculates that a "general enhancement of the level of potentially toxic trace elements in plants grown in urban areas could lead to deleterious effects both on the plants and on the health of those eating them." During five years of research using digested sludge we have not yet created trace element toxicities in various feed grain and forage crops nor have levels of any element increased in plant tissues to the extent that they would present a hazard to animals consuming the produce. Furthermore, LeRiche (1968) analyzed soils and crops from a market garden experiment at Woburn, England where 568 tons of sludge per acre had been applied between 1942 and 1961. While there was an increase in the uptake of some elements by vegetable crops grown on the sludge-treated plots, as can be seen in Table 3 from the average values of his reported results, he reported that there was no evidence that crop yields were affected.

The behavior of such trace elements in soils and their uptake by crop plants are influenced by several factors. One of these is soil pH. Most heavy metal toxicities in terrestrial plants have been associated with pH of less than 5. Liming soils can, to a large extent, control the uptake of many trace elements.

Practices which promote better soil aeration, such as drainage and structure development may lead to decreased solubilities of some trace elements. According to Jenne (1969) oxides of iron and manganese act as "sinks" for heavy metals and the extractability or leachability of the metals is determined by the Eh (reduction-oxidation potential) and pH of the system. Keeping the iron and manganese hydrous

Table 3. AVAILABILITY OF TRACE ELEMENTS AND THEIR UPTAKE BY VEGETABLE CROPS GROWING ON A SOIL TREATED WITH 568 TONS/ACRE OF SEWAGE SLUDGE (LeRiche, 1968, Harpenden, England)

---Parts per million (dry matter)---

			Co	Cr	Cu	Mo	Ni	Pb	Zn
0.5N ACETIC ACID EXTRACTABLE	SEWAGE	1958	-	4.5	18	-	51	3.5	750
		1959	-	2.5	22	-	49	3.0	850
	SOIL 1959	TREATED	-	2.8	20	-	17.5	5.0	395
		UNTREATED	-	0.5	5.0	-	4.3	1.2	87.5

------Parts per million (dry matter)------

				Co	Cr	Cu	Mo	Ni	Pb	Zn
TOTAL CONTENTS	LEEKS 1960		TREATED	0.16	0.54	16.0	1.10	6.95	1.60	135
			UNTREATED	0.18	0.71	5.75	0.50	2.0	1.15	46
TOTAL CONTENTS	GLOBE BEETS 1960	TOP	TREATED	<0.1	1.0	10.0	0.7	16.5	2.6	510
			UNTREATED	<0.1	0.9	9.0	0.5	3.2	2.4	219
		ROOT	TREATED	<0.1	0.8	18.0	0.3	13.0	1.6	250
			UNTREATED	<0.1	0.3	11.0	0.1	1.7	0.9	103
TOTAL CONTENTS	POTATOES 1961	TOP	TREATED	0.35	3.00	8.3	0.98	5.25	2.60	270
			UNTREATED	0.38	1.70	4.3	0.38	1.70	2.80	90
		ROOT	TREATED	0.02	0.03	9.5	0.28	0.58	0.19	28
			UNTREATED	0.03	0.09	9.5	0.40	0.25	0.25	30

-----Parts per million (dry matter)-----

				Co	Cr	Cu	Mo	Ni	Pb	Zn
0.5N ACETIC ACID EXTRACTABLE	SOIL 1967		TREATED	-	2.6	58	-	8.1	4.2	275
			UNTREATED	-	0.9	14.5	-	3.4	1.6	84
TOTAL CONTENTS	CARROTS 1967	TOPS	TREATED	<0.08	0.88	9.9	0.85	3.00	1.7	99
			UNTREATED	0.06	0.41	8.2	0.58	1.14	1.09	48
		ROOTS	TREATED	<0.05	0.07	4.6	0.12	2.00	0.07	42
			UNTREATED	<0.05	0.03	6.3	0.13	1.45	0.06	34

oxides in soils and sediments in the form of thin coatings on silicate minerals instead of discrete crystalline minerals permits a chemical activity in far greater proportion than would be expected on the basis of their concentrations alone. As the solubilities of iron and manganese compounds are increased by reducing conditions the heavy metals originally adsorbed on the surfaces of their oxides are displaced by hydrogen and the metals become more mobile in soils.

Some heavy metals may form inert and insoluble compounds with clays and organic compounds. Thus many trace elements are less available to growing plants than the total concentrations of these elements would indicate.

When grown on the same soils, tissues from different crop species, and even different varieties of the same species, differ markedly in concentrations of nutrient and pollutant elements (Gabelman, 1970). The selection of crops thus affords a control over the entrance of undesirable amounts of trace elements into food chains. With regard to selection, Gabelman says, "The ease of discovery of these genetic differences within species has been surprising. We have been too conservative in assessing this potential."

Perhaps we have not observed trace element toxicities in plants by the use of stabilized sludge because it may contribute toward establishing a better balance of nutrient availability and uptake by crop plants. We have learned from greenhouse and other studies that there are many synergistic and antagonistic interactions between various ionic metal species in sludge and soils affecting the absorption of chemical elements by plant roots and their translocation within plants. As we learn more about interaction effects, we may be able to decrease abnormal uptake of one trace element from soils by supplying another to the soil or crop.

Clearly if or when a trace element problem does occur as a result of utilizing municipal sludges as a fertilizer and/or soil amendment, there are management

practices available which can be introduced to alleviate the situation. Except perhaps in coarse sandy textured soils the heavy metals will move very little with percolating water. Thus, most of the trace elements will remain at the point of application unless they are transported away in an adsorbed phase on eroded sediments. By establishing erosion control structures and practices, complete control can be maintained over all elements applied on land as a constituent of sludge except some anion and anion forming species such as nitrate, sulfate, chloride, boron, etc. At any rate those chemical elements which present the greatest potential hazard to animals will be retained in place and can be managed if the need develops. To a large extent the opportunity to manage trace elements is lost once they are disposed of in water environments.

2. Biological

Although no incidence of disease is known to have been traced to the use of digested sludge as a fertilizer or soil amendment, it is still one of the greatest sources of concern for many. From a rather extensive literature it appears that most of the intestinal bacterial pathogenic are either destroyed or their populations are reduced to very low levels by heated anaerobic digestion of sewage solids. Results from several studies indicate that the pathogenic organisms of tubercle bacillus, Taenia saginata, Ascaris lumbricoides and hookworm are not destoyed as rapidly in a heated anaerobic digester as are the commonly used pathogenic indicator organism, Escherichia coli or fecal coliforms.

One of the most crucial questions which could not be answered from a search of the literature was that of the fate of viruses during the anaerobic digestion of sewage solids. Even if viruses were not recovered from digested sludge, one could not be sure that they were not present in an adsorbed phase on the solids. To answer the question regarding the survival of viruses in the heated anaerobic digester environment we initiated some laboratory studies using a swine enterovirus (ECPO-1) which has bio-physical properties similar to human enteric viruses. After gas production had stabilized in 6 laboratory scale digesters, fed with a mixture

of primary and waste activated sludge, they were inoculated with 10^5 plaque forming units of the swine virus. After inoculation, 20 ml of fluid was periodically withdrawn from the digesters and mixed with milk and fed to germ free piglets. The feces from the piglets was then collected and assayed for the viable virus. The viruses were not found in the feces of piglets fed sludge material which had been inoculated and digested for a period of time of 5 days or longer (Meyer, et al. 1971). It thus appears that a 14 day heated anaerobic digestion period would provide a considerable margin of safety with regard to the destruction of viruses.

As Berg (1966) suggested, perhaps the simplest method for reducing viruses and other pathogenic organism in sewage is by long storage of the material. From laboratory studies Berg (1966) determined the time in days required for a 99.9 percent reduction in the number of virus and bacteria by storage at different temperatures. The die-away data presented in his Table 5 is exhibited here as Table 4. On the basis of these and other data it appears that an additional margin of safety against pathogenic contamination of the environment could be achieved by holding digested sludge in reservoirs for a minimum period of two months before it is applied on land.

After sludge is applied on the soil surface, die-away of many pathogenic organism will occur fairly rapidly as seen from the data in Table 5. The rapidity with which fecal coliform die-away occurs after digested sludge is applied on soil surfaces can be discerned in Table 5. Furthermore, it has generally been concluded that wastewaters percolating through unsaturated soil materials are purged of pathogenic organisms within the first five foot depth (Butler, et al. 1954). If this is true for wastewater applications it would surely be applicable in the case of sludge utilization. Since sludge solids are rapidly filtered and clog the surface of soils, the rate of water infiltration during sludge applications is exceedingly low in comparison to that from wastewater applications.

Table 4. Effect of Storage: Laboratory Study Demonstrating Days Required for 99.9% Reduction of Viruses and Bacteria in Sewage (Berg, 1966)

	No. of Days Temperature ^{o} C		
Organism	4^{o}	20^{o}	28^{o}
Poliovirus 1	110	23	17
Echovirus 7	130	41	28
Echovirus 12	60	32	20
Coxsackievirus A9	12	..	6
Aerobacter aerogenes	56	21	10
Escherichia coli	48	20	12
Streptococcus faecalis	48	26	14

Table 5. Disappearance of fecal coliforms in the sludge cake covering a soil surface.

Days after sludge application	No. of fecal coliforms per gm sludge cake (dry weight)
1	3,680,000
2	655,000
3	590,000
5	45,000
7	30,000
12	700

Therefore, frequent applications of sludge can be made only when the evapotranspiration potential is relatively high. That is to say, sludge is most likely to be applied on agricultural lands during the late spring, summer, and early fall seasons when evapotranspirational potentials generally exceed actual soil moisture losses. For the most part sludge will be applied when ambient temperatures favor a rapid die-away of bacterial and viral pathogenic organisms.

Like many of the potential chemical water pollutants, lateral movement of pathogenic organisms which might survive the digestion and storage period, can occur only if excessive soil erosion processes are permitted to operate on the sludge utilization site.

Conclusion

Stabilized municipal sludges can be beneficially utilized as a fertilizer and soil amendment. With proper selection and/or modification of the utilization site to ensure that sludge constituents are not eroded from the point of application, adjustment of sludge application rates to crop requirement for the soluble nitrogen supplied, and the establishment of sound crop and soil management practices stabilized sludges are a resource too valuable to be dumped in oceans, burned, or permanently lagooned.

References

Andrews, J. F. (1969). "Dynamic Model of the Anaerobic Digestion Process," Proc. Amer. Soc. Civil Engi., Sanit. Engi. Div., SA1, p. 95.

ASCE (1959). "Sewage Treatment Plant Design," ASCE Manual of Engineering Practice, No. 36, p. 6.

Bacon, V. W. and F. E. Dalton (1966). "Chicago Metropolitan Sanitary District Makes No Little Plans," Public Works 97, p. 66.

Berg, G. (1966). "Virus Transmission by the Water Vehicle. II. Virus Removal by Sewage Treatment Procedures," Health Library Science 2 (2), p. 90.

Berrow, M. L. and J. Webber (1972). "Trace Elements in Sewage Sludge," Journ. Sci. Fd. Agric. 23, p. 93.

Burd, R. S. (1968). "A Study of Sludge Handling and Disposal," Fed. Water Pol. Control. Admin., Pub. WP-28-4.

Butler, R. G., G. T. Orlob and P. H. McGauhey (1954). "Underground Movement of Bacterial and Chemical Pollutants," Journ. Amer. Water Works Assoc., 46 (2), p. 97.

Gabelman, W. H. (1970). "Alleviating the Effects of Pollution by Modifying the Plant," Hort. Science 5, p. 16.

Goudey, R. F. (1932). "New Thoughts on Sludge Digestion and Sludge Disposal," Sewage Works Journal, 4 (4), p. 609.

Irgens, R. L. and H. O. Halvorson (1965). "Removal of Plant Nutrients by Means, of Aerobic Stabilization of Sludge," Applied Microbiology, 13 (3), p. 373.

Jackson, S. and V. M. Brown (1970). "Effect of Toxic Wastes on Treatment Processes and Watercourses," Water Pollution Control 69, p. 292.

Jansson, S. L. (1960). "On the Humus Properties of Organic Manures," Kungl. Lantbr. hogsk. Ann. 27, p. 51.

Jenne, E. A. (1968). "Controls on Mn, Fe, Co, Ni, Cu, and Zn Concentration in Soils and Water: the Significant Role of Hydrous Mn and Fe Oxide," Advances in Chemistry Series, Amer. Chem. Soc., p. 337.

Jenny, H. (1950). "Causes of the High Nitrogen and Organic Matter Content of Certain Tropical Soils," Soil Sci. 69, p. 63.

LeRiche, H. H. (1968). "Metal Contamination of soil in the Woburn Market-Garden Experiment Resulting From the Application of Sewage Sludge," Journ. of Agriculture Science 71 (2), p. 205.

Loehr, R. C. (1968). "Variations of Wastewater Quality Parameters," Public Works, May.

Lohmeyer, George T. (1959). "A Review of Sludge Digestion," Sewage and Industrial Waste, 31 (2), p. 221.

Lowe, W. (1970). "The Origin and Characteristics of Toxic Wastes, with Particular Reference to the Metal Industries," Water Pollution Control, 69, p. 270.

Lunt. H. A. (1959). "Digested Sewage Sludge for Soil Improvement," Conn. Agri. Exp. Sta. Bull. 622, p. 30.

Lynam, B. T., Ben Sosewitz and T. D. Hinesly (1972). "Liquid Fertilizer to Reclaim Land and Produce Crops," Water Research 6, p. 545.

Mann, H. H. and H. D. Patterson (1962). "The Woburn Market-Garden Experiment: Summary 1944-60," Report of the Rothamsted Experiment Station.

Meyer, R. C., F. C. Hinds, H. R. Isaacson and T. D. Hinesly (1971). "Porcine Enterovirus Survival and Anaerobic Sludge Digestion," Presented at the International Symposium of Livestock Wastes, Columbus, Ohio, April 22.

Norman, John (1961). "Aerobic Digestion of Waste Activated Sludge," Thesis, University of Wisconsin.

Pohland, F. G. (1967). "General Review of Literature on Anaerobic Sewage Sludge Digestion," Engineering Extension Bulletin, Series No. 110, Purdue University, Lafayette, Indiana.

Purves, D. (1972). "Consequences of Trace-Element Contamination of Soils," Environ. Pollut. 3, p. 17.

Toerien, D. F. and W. H. J. Hattingh (1969). "Anaerobic Digestion I. The Microbiology of Anaerobic Digestion," Water Research 3 (6), p. 385.

Viraraghavan, T. (1965). "Digesting Sludge by Aeration," Water Works and Wastes Engineering 2 (9), p. 86.

Von Zuben, F. J., L. J. Ogden and R. E. Peel (1952). "House Fly Breeding at Sewage Treatment Plants in Texas," Sewage and Industrial Wastes, 24 (10), p. 1303.

Wirts, J. J. (1956). "Pipeline Transportation and Disposal of Digested Sludge," Sewage and Industrial Wastes, 28 (2), p. 121.

Wolf, H. W. (1955). "Housefly Breeding in Sewage Sludge," Sewage and Industrial Wastes, 27 (2), p. 172.

RESOLUTION:

Recognizing the substantial labors of Congress and the President to bring to the people of the United States an adequately funded and conscientiously written statute for a more vigorous national attack on our environmental problems, the President's Water Pollution Control Advisory Board urges the Congress to enact promptly and the President to sign the proposed 1972 Amendments to the Federal Water Pollution Control Act.

CONCLUSIONS AND RECOMMENDATIONS

of the

President's Water Pollution Control Advisory Board

Meeting on Ocean Disposal

September 29, 1972

The President's Water Pollution Control Advisory Board met in New York City from September 26-29, 1972 to explore and make recommendations to the Administrator of the Environmental Protection Agency, and in turn, the President on the subject of ocean disposal as a national issue. Based on comprehensive briefings by representatives of Federal, State, and local agencies, a flyover to view the sewage sludge dumping, dredge spoil dumping, and acid waste dumping in the New York Bight and a full day of public testimony from experts in the field of ocean disposal and alternatives the Board has reached the following conclusions and recommendations:

I. CONCLUSION:

The Board recognizes that unrestricted ocean dumping poses real and potential pollution problems to the marine environment and its resources. At the same time, there is evidence which indicates possible beneficial uses of some wastes and dredge spoils under carefully selected and controlled conditions.

RECOMMENDATION:

The Board recommends immediate Congressional Action in its current session on enactment of the Marine Protection Research, and Sanctuaries Act of 1972 (Ocean Dumping Bill) which has been agreed to by the House and Senate Conferees. It is important that the U.S. demonstrate its earnest intention to control ocean dumping prior to the forthcoming International Ocean Dumping Convention. At the same time, the Board recognizes that the present version of this legislation will likely create a duplication of responsibilities in EPA and the Department of Commerce for research and monitoring and for seeking alternatives to ocean dumping, assuming passage of the 1972 Amendments to the Federal Water Pollution Control Act. Accordingly, it is recommended that this apparent redundancy be eliminated and all responsibilities for establishment, and enforcement of marine water quality criteria and associated research and monitoring activities be centered in EPA.

II. CONCLUSION:

The Board concludes that ocean dumping is only one of many pathways through which wastes reach the marine environment, and that effective control of marine pollution requires legal authorities beyond those provided by the Ocean Dumping Bill.

RECOMMENDATION:

The Board recommends enactment during the current session of Congress of the proposed 1972 amendments to the Federal Water Pollution Control Act as reported out this week by the joint Senate-House Conference Committee.

III. CONCLUSION:

The Board concludes that under the existing Federal Water Pollution Control Act no agency has the authority to establish Water Quality Standards in the area between the 3 mile and the 12 mile line in the so-called contiguous zone. Neither the new Water Bill nor the Ocean Dumping Bill remedies this, although each requires discharge permits to be issued to protect the Water Quality in the contiguous zone.

RECOMMENDATION:

The Board therefore recommends that EPA seek remedial legislation to require the establishment of Federal Water Quality Standards for the waters of the contiguous zone.

IV. CONCLUSION:

The Board has heard convincing evidience that the presence of toxic substances, primarily the heavy metals, in municipal sewage creates special problems in the ultimate disposal of the resulting sludge from treatment plants. These substances have an adverse effect through their possible entry into the marine food chain when ultimate disposal of sludge is to the ocean. Similarly, adverse effects follow from discharge to the atmosphere of these substances if incineration is selected as the method of sludge disposal. Even when sludge disposal is to land, the presence of these toxic materials complicates the problem and introduces difficulties in the ultimate use of land.

The Board has learned that the heavy metals in municipal sewage derive from a wide variety of sources within the cities, but that the most concentrated source and the one that lends itself principally to control is through the components of industrial waste in municipal sewage.

RECOMMENDATION:

The Board recommends that the EPA press for a requirement that all industrial wastes containing significant amounts of toxic substances, including heavy metals, be pretreated for the removal of such substances before being discharged to municipal sewage systems.

V. CONCLUSION:

After hearing a presentation upon the known and speculative effects of emissions from sewage sludge incinerators as an alternate to ocean dumping, the Board at this time has reservations about the recommended approval of such incinerators pending the development of more sophisticated type of equipment for the measurement of the emissions of toxic discharges.

RECOMMENDATION:

The Board recommends that EPA actively pursue the development of more accurate emission measuring equipment so as to provide adequate assurance that such incinerators not pose unacceptable threats to human health or to air quality.

VI. CONCLUSION:

The Board concludes that considerably more and better scientific data and information are needed to establish ocean disposal criteria and guidelines to safeguard the marine environment.

RECOMMENDATION:

The Board recommends all deliberate speed in the completion of an inventory of the ocean bottom and the coastal waters (territorial and contiguous seas) of the United States and its territories in order to establish base-line data to which future comparisons can be referred. The inventory, or base-line data, should include, but not be limited to, the subsurface and bottom ocean currents, upwelling, temperatures and chemical composition of the waters, seasonal changes, distribution of existing aquatic life food chains and aquatic migration patterns.

The Board further recommends that EPA take the lead and in cooperation with NOAA, the Corps of Engineers, Coast Guard and other interested agencies plan and conduct a program of research and monitoring which will lead to improvement of marine water quality criteria, selection and use of ocean dumping sites, provision of guidelines for proposed disposal operations, and assurance of non-degradation and enhancement of environmental quality of the oceans.

VII. CONCLUSION:

The Board's discussions frequently focused on the fact that the United States has become an urban society. More than thirty percent of our population lives in the large metropolitan centers. Many cities are located on large rivers, lakes or oceans. The problems of sewage sludge disposal are compounded because of lack of suitable disposal sites.

Usually within a reasonable distance sometimes across State lines there are areas of low quality land, abandoned strip mines, or other low value areas with potential for enhancement that could be used for sludge disposal.

Proper use of sludge disposal could reclaim these lands and make them available for future food production or recreation.

RECOMMENDATION:

The Board recommends that where available Federal or State lands of relatively low value be utilized for experimental sludge spreading programs.

VIII. CONCLUSION:

The Board recognizes the necessity for dredging to maintain navigational channels.

At the same time, testimony has been presented indicating that a number of environmental problems are associated with the practice of indiscriminate dredging and the ocean disposal of polluted dredge spoils.

RECOMMENDATION:

In many areas there are continuing approved coastal land development projects. Where possible or feasible, dredge spoils should be used as fill in such land recreation projects. The Board suggests cost benefit studies to ascertain the value of environmental enhancement resulting from containment versus dumping of dredge spoil. Studies should also be undertaken to determine the feasibility of treating dredge spoils to remove solids and other components, which might be deleterious to the ecosystem, prior to ocean disposal.

IX. CONCLUSION:

The Board recognizes that the oceans are a food source and may benefit from some by-products of our present civilization that may be thought of at present as pollution material. It furthur recognizes that some of these substances may be utilized as nutrients for the ocean and may enhance or revitalize certain areas of the ocean. The Board also recognizes the recreational value of the ocean and has observed the value of reef building by selected material being placed in known barren areas to enhance the marine environment.

RECOMMENDATION:

The Board recommends that the Federal government's research activities include efforts to explore more fully those conditions under which nutrient-rich wastes can be effectively utilized to improve the marine environment.

X. CONCLUSION:

The coastal waters of various regions of the U.S.A. vary greatly as to physical and ecological characteristics (such as currents, temperatures, bottom geology, etc.) as well as in their proximity to population concentrations. The continental shelves represent the most fertile locations for marine resource development and recreational purposes; yet here are located the waters most apt to be subject to effluent discharges and ocean dumping. Also the geography of our nation finds at many locations State and various municipal jurisdictions closely grouped at or on concentrated harbor, river and other disposal locations.

RECOMMENDATION:

The Board recommends that the Federal government continue to insist on regional approaches and insure consistency in the application of standards of treatment, disposal and controlled dumping procedures applicable to all State and local agencies in the coastal region and/or on the river or estuarine systems. Separate regional standards must also be applied to such divergent coastal conditions as exist in the N.E., S.E., Gulf States, California, N.W., Alaska, and Hawaii.

XI. CONCLUSION:

Certain coastal States have presented to the Board substantial evidence they have recently enacted stringent State environmental standards for shoreline protection.

RECOMMENDATION:

The Board recommends that State governments should intensify their efforts to enhance the quality of their own shoreline and depend not solely on Federal legislation.

Federal encouragement of, and priority cooperation with all such States, should hasten the time otherwise required to correct the current abuse of the nation's coastal waters.

XII. CONCLUSION:

The Board heard testimony on the wastewater management problems of the City of New York, specifically noting that 480 million gallons/day of raw sewage and another 420 mgd of inadequately treated sewage are discharged to the Hudson River, East River, and harbor waters. In addition to public health hazards and general environmental degradation, the raw sewage discharges result in the annual deposi-

tion of 2.3 million cubic yards of sludge which must be dredged and removed from the harbor bottom. From existing plants, the city barges large quantities of digested and undigested sludge each day for disposal in the New York Bight. The City has developed engineering plans to build two new secondary treatment plants and upgrade existing plants and may construct an additional plant in Staten Island. The City estimates that it can end sludge dumping at sea in from 10 to 15 years, but in the interim as its treatment plants go on stream, the quantity of digested sludge is expected to at least triple.

RECOMMENDATION:

The Board recommends that the construction of facilities to end the unacceptable practice of discharging raw sewage into any harbor is mandatory. While the Board cannot condone years of failure to comply with acceptable health and welfare standards, we recognize the funding limitations available to the City and urge as a priority the construction of sewage treatment plants with sludge digestion. Federal assistance for such plants must be contingent upon EPA approval of the ultimate method of sludge disposal to assure non-violation of environmental protecion regulations - whether disposal is through incineration, marine disposal, land disposal, or other means.

In the absence of an immediate solution to the present practice of raw sewage discharge, a moratorium on new building construction should be enforced to the extent that increased raw sewage discharges, and over loading of sewers and treatment plants will not occur.

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