for one purpose and result in a whole generation of things that cause results later.

I am interested in the chairman's use of the word "effluent" because it is the problem of affluence and effluence that causes these troubles.

Somebody tried to explain to me the possible difference between reverse osmosis and retro osmosis. If you would like to take a chance at that sometime, I would like to see it in the record.

We are getting into a field where it is entirely new language, which is what I am pointing out.

Dr. WEINBERGER. A personal note. I certainly appreciate the opportunity of being here. I must say it is always a very stimulating experience, and I mean it very sincerely.

Mr. DADDARIO. We will not trouble you further this morning, Dr. Weinberger, but I do think we can proceed later and perhaps get some of these statements into the record.

We, therefore, will continue with Dr. Pecora.

## STATEMENT OF DR. W. T. PECORA, DIRECTOR, GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR; ACCOMPANIED BY FRANK CLARKE, ASSISTANT DIRECTOR FOR ENGINEERING

Dr. PECORA. Mr. Chairman, as Director of the U.S. Geological Survey, I appear before you merely to emphasize the fact that ours is an old-line agency that has been gathering, acquiring information and data for almost 90 years and making it available to all users, planners, and managers of our earth's resources.

Among the resources, of course, water is our principal concern. With the permission of the Chair, may I introduce into the record my prepared statement and then use some highlights from it with the thought of saving time that is available for this session.

In the process of acquiring information and data for general use, one needs to have a whole series of continuing recording stations and in this direction we have somewhat in the order of 8,000 recording stations for quality and quantity of surface waters, and something like 15,000 observation wells for the ground water.

Mr. DADDARIO. Dr. Pecora, we can assume that we have many of our streams properly monitored? What do these figures in fact mean?

Because we have so many, it sounds as though we are doing a good monitoring job. Are we or aren't we?

Dr. PECORA. Let me evaluate that for the committee. With the background information acquired over several decades we have an excellent record in many places throughout the country of the variation and the norm that are to be expected in certain streams. We are nowhere near a satisfactory status. We are planning additional monitoring stations because of the changes that are taking place through population explosion in many areas of the country.

One must always think in terms of a frame of reference. For example, we have instituted a program of benchmark stations in areas that are almost completely free from human effects to determine the change in time at such stations, this serves as a frame of reference. In areas of urban expansion or in the stress areas, in suburbia or rurbia, our aim is to develop a background frame of data so the changes in time

will be recorded. It is the trend that is important. It is the accumulation of the basic figures that one needs to refer to continually before he can make decisions.

Mr. DADDARIO. You have referred to water as a resource. We talk about monitoring and the way criteria are established. Do you consider that we should also include air as a resource? Would you put that separately?

Dr. PECORA. I would claim air as one of our most valuable resources for man and other living things on earth. Our organization does not work in that environment. We are in the soldid earth sciences area.

Speaking of water in the solid earth science area, we normally think of water in the visible state—that which we can see and measure at the surface and remeasure and analyze and reanalyze.

There is a second area of water called the invisible water which we refer to in our profession as the ground water. I think this is much more important than perhaps is realized by most people. There is a constant interaction of the water locked up in the porous and permeable rocks of the earth, a constant interaction of this water supply with the streams. Streamflow basically depends on this continuing ground water supply. Constant loss of this water in the coastal areas through underground flow also occurs. We are very much concerned in not only the quantity of water that is available to man but in the quality of water needed for many purposes. As a third party information sources for all users, managers, and planners, we have developed a system of evaluating the resource in its entirety both quality and quantity, in its various environments.

Mr. DADDARIO. Have we identified or are we capable of identifying these ground water streams, as you put it, so that we can come to some judgment about them?

Dr. PECORA. We are far behind in the knowledge that we need for future best management of this invisible ground water—far behind in the knowledge we need in order to add another reliable resource for use of man. Many countries of the world have no real concept of the great potential of ground water.

In the Eastern States, for example, the Congress has just authorized an interstate study of ground water in Delmarva, involving the three States of Delaware, Maryland, and Virginia.

In the gulf coast region there are 13 States greatly concerned with future supplies of ground water. In the High Plains region there are many States east of the Rocky Mountains that require additional knowledge of ground water. These are parts of the whole problem.

To do anything that would pollute this potential supply of water is a grevious fault on the part of man. In this direction we need to acquire many kinds of information, you see, that can go into the decision-making processes of planners, users, and managers.

Mr. DADDARIO. Dr. Pecora, we are beginning to establish criteria based on the importance of this ground water resource without having a good idea what we in fact have. My question gets back to how do we really know what we are dealing with?

Dr. PECORA. We know on the basis of decades of work that there is an hydrodynamic pattern of water flow from rain and seepage to the underground. We would need to develop knowledge of ground water in greater detail so it can be a continuing factor in management.

In direct response to your question, Mr. Chairman, we know much. We don't know enough. We are moving in the direction of learning more.

Mr. DADDARIO. You are talking about vast amounts of water which in fact amount to a very valuable resource, which we know very little about?

Dr. PECORA. Yes. I think the point that I should make is that we have the potential now of making an overall survey of the value of this invisible supply of water.

Mr. DADDARIO. You have the potential which means the capability. Do you have enough money to do it?

Dr. PECORA. Talent, I think, is more important than money at this time in this subject area. This may surprise some Members of Congress to hear this kind of a statement.

Mr. DADDARIO. No; it does not. We find the manpower situation is the reason we sometimes have a problem. We were not able to anticipate the need or deal with it in advance.

Dr. PECORA. Yes.

A few decades ago our group in the Geological Survey developed what we call the science of underground hydrology. We have been working with the universities to help develop new talent in the subject area as well as with our international associates.

We feel this is an area of great possibility and potential for the people on this earth. We intend to push in the direction of acquisition of more and better information about the ground water supply so that this resource can be integrated properly with the surface water supply in all management decisions.

Mr. DADDARIO. I had assumed when you said you had the potential to do this that you had the manpower to do it. Your statement then is that we have the potential and the background knowledge, but we need to develop manpower and support in order to get this job done. You believe it valuable enough so that we do this?

Dr. PECORA. That is exactly it; we need to develop more talent in order to do more of this kind of work, and we are capable of doing this.

Mr. FULTON. Mr. Chairman.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON. Do you look into the question of the water table and ground-water pollution in your work?

Dr. PECORA. Yes. This is part of our general jurisdiction, the monitoring of the quality of water in all of its locations. It is a rather important part of our work.

Mr. FULTON. Why should you and Dr. Weinberger not be working in the same shop?

Dr. PECORA. We are both in the Department of Interior.

Mr. FULTON. Yes; but I said why is it divided in the Department of Interior?

Dr. PECORA. May I refer to the national water data coordination effort which was set up through the Bureau of the Budget Circular A–67, a well-known circular among water users. The acquisition of water data and its storage in a computer system for general output is a joint effort between the Federal Water Pollution Control Admin-

istration, Geological Survey, and other agencies. We have been given the obligation of developing this on a joint-use basis. There is much closer collaboration than perhaps is indicated by the inquiry.

Mr. FULTON. I was interested in the number of wells you are drilling and the progress you are making, but I wondered if you also use a divining rod in your agency or a forked peach branch.

Dr. PECORA. I can say for the record that we do not.

Mr. FULTON. Might I assist you on your word "creation" because I am interested in it. Where you had changed suburbia to "rurbia" I think all you have to do is put an extra "r" in and have "subrurbia."

That is all.

Dr. PECORA. I merely wanted to introduce these comments into the record. I know we are short of time.

Mr. DADDARIO. Dr. Pecora, I appreciate that. I assume you are available if we have any additional questions.

Dr. PECORA. At all times, sir.

(Dr. Pecora's complete statement follows:)

PREPARED STATEMENT BY W. T. PECORA, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR, ON THE BUREAU'S RESEARCH AND DATA-COLLECTION PROGRAM

The Geological Survey has a long-standing responsibility for studies of the earth's physical features and resources. The object of this work is to provide reliable information on existing conditions and to generate sufficient knowledge of chemical, physical, and biological processes that one can determine changes likely to occur under a variety of environmental stresses, including those imposed by man. This in turn is aimed at providing reliable information for use by others in wise management of natural resources. In studies of this kind one must consider the earth's topography, geologic structure, and mineral components because they undergo a variety of interactions which are sensitive to, and have a bearing upon the behavior of living things.

Collection of basic data on water resources and research for improvement of ability to collect and interpret these data constitute a major part of the Survey's scientific program. This is an important aspect of the Nation's pollution-control program because it documents present conditions (for example, temperature patterns) and indicates the direction and extent of change. At the present time there are more than 3,000 Survey people engaged in the study of water resources. Measurements of quality and equally important quantitative measurements are made at 8,000 surface-water sampling sites on schedules ranging from monthly checks to continuous monitoring. Similar qualitative and quantitative measurements are made on 15,000 observation wells scattered over the 50 states. Seventeen district and regional Survey laboratories perform water analyses on a continuing basis. Plans already have been completed for increasing the number of basic network sampling points by 50% within 5 years and for adding 150 new multiparameter, automatic monitors to the 160 in operation for better sensing of points particularly important to water managers. A plan has been developed jointly with the Federal Water Pollution Control Administration for combining the Survey's general purpose water data and the Administration's special purpose data in a single master data bank and computer readout system. This will make all information immediately available in uniform style to those who need it for control of pollution problems and other water management operations. During the past year great emphasis has been placed on faster and better collection transmission and readout of water data. With the help of teletransmission and master computer facilities recently installed we expect that most of the Survey's data will be available to local users and from master data centers on weekly or more frequent bases before the end of another fiscal year.

The Survey's Water Resources Division aims much of its research effort at improvement of water data. Well-staffed analytical research laboratories in Washington, D.C., Denver, Colorado, and Menlo Park, California concentrate

on developing analytical methods and related equipment. Together with district and cooperating laboratories they conduct continuing analytical reference and methods standardization studies to insure maximum practicable reliability and uniformity of results. Similar research is underway on improving data network design, methods of data transmission, and data processing. Both inhouse and extramural research is done on data sensitivity to determine what kinds of data must be collected, how often, and at what points to serve the greatest need at the lowest cost. This program also includes research on improved methods of extrapolation and interpolation from point samples to ungaged points in space and time. A new and highly important research project has been started to develop better methods for collecting water data in urban environments, and a significant start has been made on identification of ecological indicators of stream health.

Remote sensing techniques are being perfected for faster coverage of water resources of larger areas. Airborne radiometers and infrared scanners already are providing useful data on thermal patterns in surface waters, and considerable progress is being made in detecting other pollutants by selective band photography. Lesser equipment offers considerable promise as a quantitative and perhaps a semiquantitative tool for analyzing polluted waters from an aircraft or space platform. Plans already are under way for data satellites with land-based computers capable of reading out synoptic information on a global, time-lapse basis for many factors which bear upon pollution problems. These include effects of changing land use and urbanization on flow and quality of rivers, cyclic quality patterns in lakes and ponds, and evidence of progressive degradation in surface waters.

In addition to the comprehensive programs of basic data collection and data improvement research, the Survey has a sizeable effort in fundamental and applied hydrological research aimed at better understanding of the origin, movement and fates of pollutants. Hydrodynamic research on rivers and estuaries already has produced a two-dimensional mathematical model capable of predicting flow patterns at any point on a water body using data collected from any other point. Similar three-dimensional models are being developed. Hydrodynamic work on lakes started during last fiscal year is expected to produce very useful information on dispersion patterns and to simplify tracing of troublesome pollutants. Survey researchers have played and are continuing to play a lead role in studies of heat dissipation from lakes and ponds, including cooling ponds, and of thermal die-away patterns from point heat sources in rivers. A very significant pilot study is underway on ecological responses of a major estuary to abnormal waste heat loads from a power plant.

Other principal areas of our research closely related to the pollution problem are mechanics of sediment dispersion, transport, and deposition; movement of water and waste materials in the unsaturated soil zone and ground-water systems; practicability and effects of artificial recharge with waste water; processes and problems related to storage of liquid wastes underground, and geochemical controls of water quality in troublesome processes such as mine-acid generation, euthrophication and leaching of solid waste dumps. In recent years there has been increasing emphasis on fates of pollutants in underground systems because of the trend toward more underground waste disposal and the recognized difficulty of purging underground fresh waters once they are accidentally contaminated. Increasing attention also has been paid to the movements and fates of pesticides and other troublesome synthetics. The overall cost of Survey research related either directly or indirectly to pollution problems, is approximately $12 million per year. Each year the work generates 300 to 400 Professional Papers, Water-Supply Papers and journal articles available to many users.

Multidiscipline capability has proved to be of considerable help to the Survey in conducting research of the kinds described above. Knowledge of geology and geochemistry simplify research on behavior of pollutants in surface water and ground water. Expertise in topographic studies helps in predicting flows of surface water which have a marked bearing on the behavior of and impact of water contaminants. Knowledge of geomorphology and geography allows one to understand sediment transport phenomena and related problems. Because of this interaction of disciplines it is fair to say the Survey's entire staff of approximately 9,000 contribute significantly to the subjects discussed above and therewith to the solution of environmental pollution problems

The need for better information on water quality despite limited funding has led to increasing effort on improved programming of the Survey's water studies. The Office of Water Data Coordination, established under Bureau of the Budget Circular A–67, confers with federal and nonfederal data users annually to determine what new data and data systems deserve priority attention. Comprehensive status reports of all Survey research are studied carefully several times each year to determine what work is contributing significantly to major environmental problems and to redirect effort as appropriate. The Headquarters staff of the Water Resources Division now includes a well-staffed program office and a systems analysis laboratory which devote full time to assessment of needs in basic data and research and to development of the programs and pilot studies needed to fulfill them.

The Survey heartily endorses the thesis of this Committee that more research effort must be concentrated on pollution problems. In doing this we think that one must recognize the importance not only of corrective research, such as the highly important work on water reuse and advanced waste treatment, but be equally conscious of, and attentive to, baffling scientific questions which must be answered if there is to be proper understanding for preventive as well as corrective treatment. At present, far too little is known about phosphate chemistry in the natural environment to allow one to assess its effects in euthrophication, or to eliminate whatever undesirable contribution it is making. As the Committee already has observed, we still cannot read ecological danger signals far enough in advance to take proper inhibitive action in processes of this kind. Many aspects of mine-acid generation still are poorly understood and no one is properly prepared to recharge water or liquid wastes into complex underground systems with certainty of the results that such an operation may yield.

In addition to upgrading our knowledge of the fundamental science related to pollution problems, we believe there must be continuing emphasis on upgrading of data systems and on ability to test significance of and interpret water data. Neglecting these subjects is likely to result in our continuing to overlook the relatively simple solutions.

The Committee's interest in intensified research on water-quality problems is timely, well-oriented and of special concern to the Geological Survey. We are eager to play our proper role in collecting the data and to cooperate in the research needed to provide the best quality of our water resources. We recognize the needs highlighted by the Committee's action and we are tooling up as rapidly as possible under unavoidable restraints to get on with the job.

Mr. DADDARIO. We have Mr. Everts here, who has come from Cincinnati. We apologize for keeping you so long, and yet this is the situation we are in. We would appreciate if you could summarize your statement, Mr. Everts, and then we will see where we go from there.

Mr. FULTON. Would you, before we start with Mr. Everts, Dr. Pecora, give us a statement for the record on the water table and ground water pollution?

Dr. PECORA. We certainly will.

(The information requested is as follows:)

In most of the Nation, there still is neither serious depletion nor serious pollution of ground water. However, certain local and regional problems warn that substantially more effort must be made to identify and quantify ground water.

In areas not yet affected by heavy ground-water pumping, any temporary change in the water table resulting from man's early development of the land has reached a state of dynamic balance and is not cause for concern. In other words, there is no progressive depletion of ground water in lightly pumped regions. The water table fluctuates normally with climate, season, and years as in the recent Northeastern drought. Naturally induced trends may persist for years before recovery, and sufficient knowledge of such cycling must be available to avert undesirable consequences.

In some pumped area, ground-water levels have been lowered substantially without developing serious problems. For example, ground-water levels near Memphis, Tennessee, have declined persistently for years as withdrawals for municipal, industrial, and agricultural uses have increased. This still is not

considered to be an area of troublesome depletion, but, of course, pumping costs have increased because of greater pumping depth.

Depletion in the sense of withdrawal from storage greatly in excess of anticipated natural replenishment has occurred in many small areas scattered over the country, but in only a few large areas and regions. Outstanding examples are the southern High Plains of Texas and New Mexico, north-central Arizona (the Cental Arizona Project area), large areas of the San Joaquin Valley of California's Central Valley, and a substantial number of smaller alluvial valleys in California, Arizona, New Mexico, and locally elsewhere. In all these areas, the depletion is sufficiently severe that plans and projects to ameliorate its effects are in various stages of progress.

Pollution of ground water still is primarily a local problem, but some relatively large and important areas have been affected. Several million spectic tanks and other types of industrial sewage disposal systems serve as point sources of potential pollution to nearby water wells. Relatively few examples of such pollution have occurred in the vicinity of Norfolk, Va., and Anoka, Minn., because of the peculiar character of the soil in these areas. Disposal of a variety of domestic, municipal and industrial wastes in wells and ponds also have caused significant local problems. Typical ones have occurred in limestone ground water systems of Ohio and Florida, as well as in other types of rock in Colorado and Chesapeake Bay area of Maryland. Fortunately, such situations are receiving increasing attention. Hopefully the time is approaching when large quantities of polluted material cannot be dumped into the ground without considerable thought being given to possible consequences. Data of the kind collected by the Geological Survey is essential to such thinking.

Encroachment of sea water in coastal areas is a form of pollution which has occurred in numerous parts of the country including Long Island, New York, Florida, Texas, and California. Most of these situations are under study and plans for remedies are more or less advanced. Creation of a fresh water barrier by installing artificial recharge wells along the coast near Los Angeles, and pilot recharge wells in Long Island are aimed at correcting situations of this kind.

The U.S. Geological Survey uses thousands of test wells and some hundreds of federal and nonfederal cooperators in watching for significant changes in the quantity and quality of ground waters. We conduct extensive research on movement of ground water and ground water contaminants, as well as on the effects of wastes discharged underground in order to predict what changes are likely to occur. In collecting ground water information, as in collecting surface water information, the Survey plays a long-standing third part role in producing objective data which are not influenced or restricted by any management or control responsibility. These are made available quickly and without reservation through the master data system of the Department of the Interior, operated by the Geological Survey, not only to the Water Pollution Control Administration, but to all others who have need for them.

Mr. DADDARIO. Mr. Everts.

(Mr. Everts' biography follows:)

CURTISS M. EVERTS

Position: Chief, Water Supply and Sea Resources Program, National Center for Urban and Industrial Health, Bureau of Disease Prevention and Environmental Control, Public Health Service, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio 45202.

Birthplace and date: Houston, Texas, Oct. 7, 1908.

Education: Texas A. & M. College, 1926–30, BS (Civil Engineering) 1930; Harvard University, 1938–39, MSE (Sanitary Engineering) 1939.

Experience: Public Health Service, U.S. DHEW:

Chief, Water Supply and Sea Resources Program, National Center for Urban and Industrial Health, Cincinnati, Ohio 45202, Aug. 1967 to present.

Regional Program Director, Solid Wastes Program, National Center for Urban and Industrial Health, San Francisco, California, Sept. 1966, July 1967.

Director, Pacific Northwest Water Laboratory, Corvallis, Oregon, Sept. 1963, Sept. 1966.

Oregon State Air Pollution Authority, Secretary and Chief Engineer, 1961–63.

Oregon State Sanitary Authority, Secretary and Chief Engineer, 1941–63.
Oregon State Board of Health, Principal Asst. Sanitary Engineer, 1936–41.
Texas State Board of Health, Utah State Board of Health, Asst. State Director, Oregon State Board of Health of Community Sanitation, 1934–36.
Texas State Board of Health, District Sanitary Engineer, 1931–34.
City of Colorado City, Texas, City Sanitary Engineer, 1930–31.

ASSOCIATION MEMBERSHIPS

Member, American Water Works Association
Member, American Public Health Association
Member, Western Branch, American Public Health Association (President 1953–54)
Member, Oregon Public Health Association (President 1947–48)
Member, Pacific Northwest Pollution Control Association (President 1952–53)
Member, Conference of State Sanitary Engineers 1941–63 (Chairman 1951–52)
Member, State and Interstate Water Pollution Control Administrators 1958–63 (Chairman 1958–60)
Diplomat, American Academy of Sanitary Engineering

## STATEMENT OF CURTISS EVERTS, CHIEF, WATER SUPPLY AND SEA RESOURCES PROGRAM, PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Mr. EVERTS. Mr. Chairman and members of the committee, I appreciate the opportunity of appearing before you to present some of the highlights of the Public Health Service effort in the field of water supply.

The interest of the Public Health Service in the problems of water supply and its relations to health began in 1912 with the enactment of Public Law 410. These statutes authorized the Surgeon General to conduct research investigations and studies related to the cause and prevention of diseases and impairments of man; to make and enforce certain public health regulations including those relating to the prevention of the interstate spread of communicable diseases; and accept assistance from and to assist States in obtaining compliance with regulations, as well as to control and prevent disease.

The Interstate Quarantine Regulations and the Public Health Service Drinking Water Standards were promulgated pursuant to such authorization. Under the Interstate and Foreign Quarantine Regulations, the Public Health Service is responsible for inspecting and certifying water supplies used by interstate and foreign public conveyances in the United States. Responsibility for certification of interstate water supplies involves sanitary engineering inspections and evaluations of approximately 780 public water supply systems serving some 92 million local populace and over 2 million interstate travelers daily. To assure compliance with the Public Health Service drinking water standards surveys are made by our personnel in company with personnel of State health departments and local water purveyors of the source, treatment processes, storage, distribution system, and supporting laboratory services.

While the drinking water standards were created to apply to water supplies used by interstate carriers they have also been generally used by State water supply sanitation agencies and by the American Water Works Association as the standards for other water supply systems.

With the enactment of the Water Quality Act of 1965 the Federal Water Pollution Control Act was amended to create within the De-

partment of Health, Education, and Welfare the Federal Water Pollution Control Administration. Reorganization Plan No. 2 of 1966 transferred the Federal Water Pollution Control Administration from the Department of Health, Education, and Welfare to the Department of the Interior. Under the terms of the transfer, the Department of Health, Education, and Welfare retained the responsibility for advising the Department of the Interior on the public health aspects of water pollution.

An interdepartmental agreement of September 1966 between the Department of the Interior and HEW, following the transfer, defined HEW responsibilities in the following broad areas: (1) public health aspects of water pollution related to man's drinking water; (2) man's contact with water in recreation and work; (3) contamination of food sources, particularly shellfish; and (4) to the breeding of specific vectors of disease.

Mr. DADDARIO. Is that a proper definition of responsibility?

Mr. EVERTS. Yes, sir, we think so.

Mr. DADDARIO. Why do you say that?

Mr. EVERTS. We feel in the Public Health Service we have capabilities to assess the effects of pollution on man, particularly as it relates to his drinking water, and to his contact with recreation waters. We have had long experience in esturial pollution. Since 1925, we have worked in a cooperative program in the sanitation of shellfish, with both the State agencies and industries. While we frankly admit that we do not have all of the answers, we do have our program plans made to seek solutions to those problems of communicable disease and illness which may result from contaminants in water.

Mr. DADDARIO. I will go into that in greater length, but there is some question about the way we are organized and whether or not it is the most efficient way to organize and whether necessarily these things are compatible one with the other.

Mr. EVERTS. Yes, sir.

In fulfillment of the Department of Health, Education, and Welfare responsibility for implementing this agreement between the two agencies, the Public Health Service, where requested to do so, has reviewed and commented on those State water quality standards as related to pollution control, as submitted to the Department of the Interior before June 30, 1967. Such water quality standards proposals from 36 States have been reviewed by PHS field offices and comments have been made on the adequacy of those standards to protect drinking water supplies as well as waters to be used for water contact sports or shellfish production. Twelve States are now under review and two have not yet been received.

The Public Health Service has under preparation health guidelines for water quality as related to pollution control, in the following areas: Water to be used for domestic purposes and food processing; recreation use; estuarial waters and vector control. These guidelines are under intensive review by the Public Health Service and will be furnished to the Department of the Interior as soon as they are finally approved.

While the public health drinking water standards and the proposed new health guidelines represent the best current knowledge in protect-

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ing the water and shellfish consumers from communicable diseases or illness, we know that health aspects associated with pollution of water in relation to the various users are numerous, complex, and certainly to date have not been adequately studied. Technological process continually creates new contaminants that must be evaluated. Restrictive limits for many of the new materials or for the existing low-level contaminants found in drinking water supplies are, however, difficult to establish because of the gap in knowledge regarding acute and chronic physiological effects on humans. In some cases, the analytical procedures and treatment technology need improvement.

Of equal concern is the need to determine whether or not the barriers guiding against biological contamination of drinking water supplies are being strained to the breaking point. To what degree time-tested supply safeguards and safety factors have been reduced to dangerous levels poses a vital question. Little is actually known of quantitative procedures for isolating pathogens from water, and from the infectious dose of many pathogens that reach our water intakes. Current extensive experimentation with, and the eventual need for, waste water reuse with resultant increase of biological hazards as well as buildup of chemical contaminants, imposes on the Public Health Service an inescapable responsibility for determining the health hazard potential. The Service is equally responsible for assuring that meaningful indicator indices are developed and used in assessing the impact of water renovation on human health. The urgent need for such research has been supported both by rhw Committee on Water Resources Research of the Federal Council for Science and Technology and the Federal Water Pollution Control Administration.

Our future program will involve additional research and development resources pertaining to water quality on health, including refinement of meaningful potable water standards. Investigations will include: (1) Development for improved methods for the identification and measurement of organic materials and trace elements occurring in drinking water supplies; (2) epidemiological and toxological studies to determine the significance of organic material and trace elements in relation to human health; (3) development of suitable methods for the removal of harmful trace contaminants, determination of human health effects of water that has been renovated from polluted sources; and (4) initiation of development of rapid determinable tests to assure public drinking water supplies of good quality.

Mr. DADDARIO. Now, shouldn't that be the responsibility of the Federal Water Pollution Control Administration? If it is not, and you should do it, should they be doing it, too? How do you coordinate your activities?

Mr. EVERTS. Under the terms of the interdepartmental agreement, we have been assigned these responsibilities. The Public Health Service has a long history of dealing with matters relating to human health, and we have the resources to do it.

Mr. DADDARIO. I do not disagree with that. It is just that since the Federal Water Pollution Control Administration does have certain responsibilities, we are concerned with how the governmental agencies are set up and who is doing what and why, especially regarding No. 3,

the development of suitable methods for the removal of harmful trace contaminants, et cetera. That certainly is an FWPCA responsibility. It becomes a question of how much are they doing and how much are you doing. Ought it to be done by both of you? How do you coordinate it?

Mr. EVERTS. Yes, sir. May I comment on that?

It seems to me that we have to get a little clearer definition of the treatment of waste water and the treatment of water to be used for drinking purposes. These are two separate and distinct processes.

Mr. DADDARIO. We recognize that they are distinct; they are separate. Yet, in the final analysis, someone has to put it all together and explain why, even though it may be for different purposes and it may be done in separate places.

Mr. EVERTS. We are really dealing in different quality standards. We have established our standards on the basis of those elements that should have limiting factors in relation to the use of water for drinking purposes.

Mr. DADDARIO. That is really not what I am talking about, although it is part of it. We are trying to get to the way it is being managed.

I have here a chart of proposed water resources research expenditures for fiscal 1968. Under "Water treatment" you have both Interior and HEW spending a considerable amount of money.

How have you established this relationship so that everybody knows what everybody else is doing? Since we are talking about water treatment ought it to be put under one head?

Mr. EVERTS. I do not have before me the figures which you have there, but our expenditures in direct operations research for the fiscal years 1967 in the water supply research program have only been about $328,000.

Mr. DADDARIO. Mr. Carpenter will show you the line items.

Mr. EVERTS. In 1968 our research—and this may be a misnomer when we are talking about water treatment—our expenditures authorized for the 1968 fiscal year are $520,000. For the 1969 fiscal year there is an anticipated increase of some $750,000 in research activities in the water supply program.

Mr. DADDARIO. Is that figure correct for Interior, Dr. Weinberger?

Dr. WEINBERGER. Mr. Chairman, it represents the total departmental budget. I would suspect that certainly it is very close to being correct, subject to some changes that might have been made in the 1968 estimate. It does represent a 1968 estimate but the change would not be very large from these figures.

Mr. EVERTS. A substantial part of that money will be used in disease studies, studies of chronic illness, which may be of water origin. In answer to your other question about departmental program relationships, under the interdepartmental agreement the Department of the Interior and the Department of Health, Education, and Welfare each have a liaison representative who meet to coordinate activities between the two agencies to be sure that there would be no overlap, or to reduce duplication as much as possible between the two agencies. They are Mr. Allan Hirsch from the Department of the Interior and Mr. Vernon MacKenzie from the Department of HEW.

Mr. DADDARIO. A lot of sins in management have been covered up by the idea that we establish a liaison. I ask the question because this area

is expanding, and because there are so many complications and questions about criteria. There are different standards we must apply for different purposes. Before we develop a confidence in our ability to deal with these problems, we have to make certain that our management efforts, the way we coordinate our activities, are much better than they are. This is not your direct responsibility, and perhaps I should not even be making the observation, but it is not my feeling that we do a good job simply by pointing to the fact that liaison people have been created. It often covers up more than it improves.

Mr. EVERTS. Knowing both of these gentlemen and having worked with both of them in times past, I am sure this will be a very effective liaison arrangement. I would also like to add to my earlier comments that it has been my experience over the years that in order to develop public confidence that where the health agency has had the responsibility for the development of criteria and the standards, particularly where human health is involved, that they have discharged this responsibility in admirable fashion. They are well equipped through their resources in research, medicine, and in engineering, to handle their part of the problem in good fashion.

Mr. DADDARIO. I find nothing in what you say to be in conflict with what I have been saying. The fact is you are pointing to the capability of your Department to do this. Yet, the Federal Water Pollution Control Administration is going to have the responsibility, and they are the ones upon whom we have to have the confidence. We have to know then how your competence can be translated to them. In the proliferation, you run into some difficulties.

Mr. EVERTS. I think we have to work very closely with them in an advisory capacity. However, I see no obstacles to consummating such an arrangement.

Mr. DADDARIO. If you will continue, please.

Mr. EVERTS. As part of the public health aspects of pollution in estuaries, the shellfish sanitation research program of the Public Health Service will continue providing scientific data required for maintenance of effective controls to prevent transmission of disease agents through marine foods, notably shellfish. Emphasis will parallel problems associated with natural and manmade contaminants, both chemical and microbiological, of estuaries. Attention will be given to controlled laboratory studies on the uptake, retention, and elimination of potentially toxic agents in order to establish or validate safe limits for estuarial water and shellfish. Laboratory, pilot plant, and field studies will be directed toward survival of human disease-causing viruses in estuaries and their uptake, retention and depuration by shellfish; development of accurate laboratory methods for assay of industrial wastes, naturally occurring marine toxins, pesticides, viruses, bacteria, and other similar disease-causing microorganisms in shellfish; ecology, biogenesis and detoxification of marine toxins; and refinement of methods for the depuration and/or detoxification of shellfish.

In recognition of the expanding demands for water throughout the Nation, Congress established through the 1965 Water Resources Planning Act a national policy for conservation, utilization and development of water and related land resources. As one of the five principal members of the Water Resources Council established under the act the

Secretary of Health, Education, and Welfare is also represented by Public Health Service staff members on the various river basin commissions, interagency planning groups and field committees.

HEW responsibilities in water resources planning include:

A. Assessment of the potential of disease outbreaks and the means for their prevention and control.

B. Assessment of the availability, protection, and safety of community water supplies.

C. Assessment of the health significance of specific contaminants with regard to:

1. Recreational water use.
2. Community water supplies.
3. Shellfish or marine food production.

D. Assessment of other conditions of health significance affected by water resource development:

1. Vector-borne disease hazards.
2. Air pollution.
3. Solid wastes disposal operations.
4. Planning and environmental control for recreational developments.
5. Radiological health.

The Public Health Service has provided initial implementation of its responsibilities in the area of water resources planning. Some review and consultation have been offered to Federal and State agencies on the health aspects of water resources projects. Public health consultation has been provided to five national technical committees on water quality criteria, and comments have been developed on public health aspects for two water resources planning projects. We hope to strengthen technical staff in our regional offices for project reviews and other program functions to insure adequate consideration of public health aspects of water resources planning. The development of public health guidelines for the use of water pollution control and water resources development agencies is urgently needed as well as the development of public health comments in the form of comprehensive health aspects appendixes for inclusion in the reports of the national planning studies; and the development of technical assistance capabilities utilizing research and surveillance data on water pollution and disease.

If there are any further questions, Mr. Chairman, I will be glad to try to answer them or to furnish additional material for the committee.

Mr. DADDARIO. Mr. Everts, we will have more questions for you for the record. The few that I would ask now would not necessarily improve those, so I will leave them to be submitted to you in written form.

I just have an observation, Dr. Weinberger: Last year when we were having our pollution hearings we were asking where we were and what was going on. The day after our hearing Secretary Udall announced a breakthrough in phosphate removal from municipal sewage. We were somewhat surprised that that breakthrough was developed immediately after our hearings had ended. We would hope that if you do have a breakthrough tomorrow that you will tell us today.

Dr. WEINBERGER. Mr. Chairman, I am going to Chicago this evening and I will be appearing there. I hope it will not be characterized as a

breakthrough, that is, my presentation there tomorrow. It will be a factual reporting of where we stand in terms of removal of one impurity.

Mr. DADDARIO. It is little things like that, Mr. Everts, that sometimes show the gaps that exist in our liaison capabilities.

## QUESTIONS SUBMITTED TO CURTISS M. EVERTS BY THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

*Question 1. Does the Public Health Service or the Federal Water Pollution Control Administration feel that adequate information on human health criteria is available to allow total reuse of municipal waste water? If not, what is missing, who is responsible for getting the facts, and when will we know whether this alternative water supply is available?*

Answer. It is believed that we have only enough information at the present time to proceed with pilot plant tests of processes for the use of reclaimed waste waters for all purposes. Processes now exist for renovating waste waters for use as water supplies, but the questions that have not been answered involve economics, the reliability of these processes, and the development of suitable standards by which their performance may be evaluated.

Although standards applicable to public drinking water supplies have been in use for more than 50 years, little, if any, work has been done to establish a basis for the development of criteria that could be applied to the use of reclaimed municipal waste water for all purposes. Drinking water standards always have included provisions for sanitary surveys of the water source to ensure that the water treatment plant used a raw water that was relatively unpolluted. Morbidity and mortality data have supported these finished water standards, for acute health effects in humans have not been attributed to waters that have met the standards. All possible toxic elements and compounds that could occur in water are not included in the standards for the reason that they have not been present in amounts considered significant, or they may have appeared only in trace concentrations on an erratic or periodic basis. If the raw water souurce is sewage, where contaminants are present in more concentrated form, a much more extensive set of standards will be necessary.

During the past decade, much has been learned about treatment of waste water for removal of some organic substances and bacteria. Not enough effort, however, has been devoted to the development of methods to remove other harmful contaminants, such as trace elements, pesticides, and some unidentified viruses.

Since little, if any, control can be exercised over the disposal of chemicals and other harmful substances into waste water collection systems, the problem of establishing fail-safe operating and control criteria for reuse of waste water becomes quite a complex problem, particularly when the reclaimed water is to be used for drinking and culinary purposes.

Whether reclaimed waste water can be used for all purposes also will depend upon the development of reliable methods and techniques for waste water treatment and for identification of contaminants. In addition, meaningful indicators must be developed and used to assess the impact of renovated waste water on human health. For example, such elements as copper, at the optimum level, are beneficial, but, at concentrations higher than optimum, they may prove harmful.

Except in a research situation, a water renovation plant could not be expected to analyze for everything that could be discharged into a sewer. Analytical cost and time would make the system impracticable. Some screening or indicator test procedures must be developed.

More precisely, the new information and techniques required are:

1. Improved and more rapid methods for the identification and measurement of pathogenic bacteria, viruses, and indicator organisms.
2. Improved techniques for the identification and measurement of trace elements and of natural and synthetic organic materials.
3. The determination of human health effects related to consumption of waters containing substances found in reclaimed waste waters.
4. The development of waste water treatment systems that can be depended upon to continuously operate and produce a water of safe quality for domestic use at all times.
5. Determination of the effectiveness of present advanced water treatment facilities in removing pathogenic parasites and other contaminants from waste water.

6. The development of monitoring equipment capable of operating fail-safe devices if purification equipment fails to operate or treatment facilities fail to produce a water of satisfactory quality.

The Public Health Service, on the basis of its long experience in matters related to human health and water supply, is the agency best equipped to undertake the investigations in the first three studies outlined. State health agencies that are charged with local water supply responsibility have traditionally looked to the Public Health Service to provide the leadership and guidance in matters related to the protection and purification of public water supplies. The Water Supply and Sea Resources Program of the National Center for Urban and Industrial Health and the Division of Environmental Health Sciences of the National Institutes of Health would require from 3 to 4 years, after adequate funds are made available, to complete the work necessary to establish initial criteria.

The Federal Water Pollution Control Administration, on the basis of its work and experience in advanced waste water treatment systems and in the development of monitoring equipment, is best qualified to undertake the investigations in the next two areas outlined. The Administration is best qualified to indicate the time required to develop the equipment and devices outlined.

The development of suitable monitoring equipment seems to be an area where there will be some overlapping of research interest. Research undoubtedly will be undertaken by the Federal Water Pollution Control Administration to develop devices to ensure the continuous operation of waste treatment plants so that poor operation or bypassing will not endanger aquatic life in receiving waters. We also must upgrade the operation of water treatment plants to ensure that disease outbreaks do not continue to occur. Equipment design for both of these purposes would be usable for waste water renovation plants. The research might differ as to the degree of precision required or as to the parameters measured. It is anticipated that the liaison developed under the interdepartmental agreement would ensure that research is not duplicated, but that each study complements other research.

The use of reclaimed waste water for drinking purposes should be planned only if no other suitable fresh water source is available. It should be pointed out that waste water for purposes other than drinking and culinary use could be reclaimed more quickly, particularly where separate systems for irrigation, fire protection, cooling water, and street flushing are appropriate.

Since drinking water is only a small portion of our total water need, possibly it can be provided more economically if it is separated from the total supply and delivered to the consumer in a special distribution system. When more is known about cost of water renovation and the cost of monitoring the operation, an economic analysis of alternative methods of supply may indicate the best solution. There also will be an interest, however, in treating the water only to the degree necessary. Standards can not be overly conservative and must be justified. But, on the other hand, surveillance for health protection must be included, as there always will be the urge to economize too much.

*Question 2. The health effects of nitrates in air, food and water have been considered recently. What do we know about the sources, persistence, mobility and effects of nitrate nitrogen? What would abatement entail? What priority should this contaminant receive? Since nitrate nitrogen moves in both air and water, which Federal agency is responsible for obtaining the facts?*

Answer. We do not feel that nitrate problem is interrelated with all aspects of environmental pollution. The problem is to determine the contribution, if any, from each source. We have checked with epidemiologists of the National Center for Air Pollution, and their similar-sounding problem is one of oxides of nitrogen produced during combustion. These gases, nitrogen dioxide and nitrogen tetroxide, in high concentrations are toxic to humans; the effects of trace concentrations are under investigation. High concentrations of these gases in air overlying water would result in some nitrates and nitrites being absorbed by the water. Trace concentrations, however, that are involved with air pollution would result in an insignificant uptake by water.

A 1966 Monograph by the National Academy of Sciences—National Research Council, *Toxicants Occurring Naturally in Foods*, reviews the nitrates and nitrites problem. Addition of these chemicals to a limited number of meat and fish products is permitted. Their use must continue to be controlled, however, inasmuch as poisonings from misuse have occurred.

Problems with cattle feeds containing nitrates have also been reported. Adult humans are not affected by nitrates occurring in vegetables, but reportedly they have caused illness in infants.

Methemoglobinemia has occurred in infants given water or formula made from water with a nitrate concentration greater than 45 ppm as nitrate. The Drinking Water Standards use this concentration as a recommended limit. These cases of methemoglobinemia have apparently been adequately explained by the nitrate concentration of the water, and the further complication of food intake has not been involved. The unresolved problem is why methemoglobinemia does not always occur from use of water high in nitrate. As only a select segment of the population is involved (infants less than 6 months), and then not always, there is agitation to raise the allowable concentration. Bottled or other water could be supplied for the bottle-fed infants. Cow's or mother's milk is reputed not to contain nitrates. In the foreign literature, studies of subclinical effects in older children have been reported, and we plan to conduct similar investigations.

Nitrate from natural causes is a problem in some groundwater, and the problem is increased where polluted water is used to recharge groundwater. Nitrate is a difficult contaminant to remove from waste water. It is possible that the nitrate concentration will be the controlling factor in some applications of waste water reuse. Any recommended limits in the Drinking Water Standards must, therefore, be justified on the basis of sound research because of the far reaching economic consequences of meeting this standard. In some cases, the most economical solution may be to supply special water to families with infants, unless research shows that a large portion of the population is effected.

Although the presence of nitrate in drinking water presents a problem, so many other contaminants, such as lead and arsenic, have a much more pronounced effect on human health that we lack sufficient knowledge of relative toxicities to establish a priority at this time.

*Question 3. Dr. Bernard B. Berger, Director of the Water Resources Research Center at the University of Massachusetts, has recently stated "While we must admit that health statistics do not support a claim that the polluted urban environment constitutes a clear and present public hazard, it must be emphasized that we have not looked hard and long enough to be absolutely certain of this claim." Do you agree with both parts of this statement?*

*He goes on to say: "The epidemiologist is not attracted by a challenge of this kind. He prefers to work with overt disease outbreaks." What is the portent of this statement for bringing greater confidence to decisions in pollution control that will be costly and disruptive to industry and to our mode of living?*

Answer. We agreed with both parts of Dr. Berger's statement. Health statistics are developed on the basis of the number of cases of deaths from reportable communicable disease in a community, as well as the number of deaths resulting from chronic diseases, accidents, and natural causes.

Geographic differences in mortality have long been noted. Infant mortality has been noted. Infant mortality has been a sensitive measure of sanitation, and rural death rates for a long time were higher than urban rates. A shift has occurred, however, that may be attributed to a deterioration of the quality of the urban environment as well as to improvements in rural living. The rural-urban differences are also noted for other disease death rates. The higher mortality in the central cities, as compared with the noncentral city counties, has been attributed to air pollution. Many causes of death are correlated with the population size of the metropolitan environment.

Some environmental contaminants may have such subtle long-term effects on human health that they would not be noticed as readily as the explosive epidemic of a communicable disease or the acute toxic effects of a poison.

Seldom is mild gastroenteritis or "stomach flu" from a water or food supply severe enough to require medical care; generally it goes unreported. The identification of many organic materials in drinking water has not been accomplished, and the correlation with any health effects of those that have been identified has been undertaken in only a modest and cursory fashion.

Morbidity may prove to be more sensitive to environmental differences, but the illness data necessary to make very detailed geographic comparisons are not available. Current sampling procedures only allow comparison of larger areas, such as regions of the country or, at best, the largest metropolitan areas. On a few occasions, special epidemiological studies have been conducted to evaluate the effect of the environment on morbidity. But these studies are costly.

Besides the problem of obtaining data on health parameters, data on environmental conditions are needed to relate to these health data. To what level of contamination is the public exposed? We do not have water quality data on the drinking water actually consumed by the public. The data we have are on the quality of water leaving the unpolluted source or the treatment plant. This is changed by contact with the distribution system and with household plumbing.

Many epidemiologists trained in communicable disease control are not attracted by the challenge of studying the effects on human health resulting from more subtle materials. Such tedious and time-consuming work requires that a number of different scientific disciplines be brought together in a planned stack on such "environmental contaminant-disease" related problems.

Disease outbreak investigation is, of course, a classical role for the epidemiologist. In this situation, many cases are compared for common exposure, and the cause is determined. Another investigative technique, the retrospective study, compares the past experience of a group of ill persons with a control group of well persons to investigate chronic disease causes. Probably the chronic diseases do not have a single sufficient cause, but many conditions influence their cause. The retrospective study, which finds the most dominant cause first, would not be able to determine the more subtle effects of, say, water quality until the more dominant causes were controlled. This might be illustrated with the example of cancer of the lung; it is difficult to show the effect of air pollution when the most dominant cause is cigarette smoking.

Prospective studies are used by epidemiologists, but they are costly. Here, one with population, and another without, the environmental contaminant are followed to see how many cases of disease develop. The study populations must be large and can differ in only a few environmental conditions.

Although the Public Health Service Drinking Water Standards represent the best current knowledge on the protection of water and shellfish consumers from communicable disease and illness, the health aspects associated with the pollution of water are numerous and complex and certainly have not been adequately studied. As we have pointed out before, technological progress constantly creates new contaminants that must be evaluated in relation to their effect in human health.

Frankly, we do not know enough about the acute and chronic effects on human health of some contaminants found in water, and until we do, the development of meaningful standards will be delayed. The best that can be done at present is to use current knowledge until adequate funding becomes available for the required research, studies, and investigations that will provide answers to these problems.

In those instances where there appears to be a relationship between environmental contaminants such as organics or trace elements in water supplies and chronic disease, the Public Health Service has now organized its resources both at the National Center for Urban and Industrial Health in Cincinnati and at the Division of Environmental Health Sciences of the National Institutes of Health in North Carolina to undertake careful and precise studies, investigations, and assessments of these relationships in an effort to unearth some of the facts on which future water quality criteria can be developed.

We do not believe that calculated risks can be assumed where human health is involved; where harmful contaminants are present in drinking water supplies, they must be removed.

PREPARED STATEMENT OF CURTISS M. EVERTS, CHIEF, WATER SUPPLY AND SEA RESOURCES PROGRAM, NATIONAL CENTER FOR URBAN AND INDUSTRIAL HEALTH, PUBLIC HEALTH SERVICE, U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, CINCINNATI, OHIO

The interest of the Public Health Service in problems of water supply and its relations to health began in 1912 with the enactment of Public Law 410. These statutes authorized the Surgeon General to conduct research investigations and studies related to the cause, and prevention of diseases and impairments of man; to make and enforce certain public health regulations including those relating to the prevention of the interstate spread of communicable diseases; and accept assistance from and to assist States in obtaining compliance with regulations, as well as to control and prevent disease.

The Interstate Quarantine Regulations and the Public Health Service Drinking Water Standards wore promulgated pursuant to such authorization. Under the Interstate and Foreign Quarantine Regulations, the Public Health Service is responsible for inspecting and certifying water supplies used by interstate and foreign public conveyances in the United States. Responsibility for certification of interstate water supplies involves sanitary engineering inspections and evaluations of approximately 780 public water supply systems serving some 92,000,000 local populace and over 2,000,000 interstate travelers daily. To assure compliance with the Public Health Service Drinking Water Standards surveys are made by our personnel in company with personnel of State health departments and local water purveyors of the source, treatment processes, storage, distribution system, and supporting laboratory services.

While the Drinking Water Standards were created to apply to water supplies used by interstate carriers they have also been generally used by State water supply sanitation agencies and by the American Water Works Association as the standards for other water supply systems.

With the enactment of the Water Quality Act of 1965 the Federal Water Pollution Control Act was amended to create within the Department of Health, Education, and Welfare the Federal Water Pollution Control Administration. Reorganization Plan No. 2 of 1966 transferred the Federal Water Pollution. Control Administration from the Department of Health, Education, and Welfare to the Department of the Interior. Under the terms of the transfer, the Department of Health, Education, and Welfare retained the responsibility for advising the Department of the Interior on the public health aspects of water pollution.

An interdepartment agreement of September 1966 between the Department of the Interior and HEW, following the transfer, defined HEW responsibilities in the following broad areas: 1) public health aspects of water pollution related to man's drinking water; 2) man's contact with water in recreation and work; 3) contamination of food sources, particularly shellfish; and 4) to the breeding of specific vectors of disease.

In fulfillment of the Department of Health, Education, and Welfare responsibility for implementing this agreement between the two agencies, the Public Health Service where requested to do so has reviewed and commented on those State water quality standards as related to pollution control, submitted to the Department of the Interior before June 30, 1967. Such water quality standards proposals from 36 States have been reviewed by PHS field offices and comments have been made on the adequacy of these standards to protect drinking water supplies as well as waters to be used for water contact sports or shellfish production. Twelve States are now under review and two have not yet been received.

The Public Health Service has under preparation Health Guidelines for Water Quality as related to pollution control, in the following areas: Water to be used for Domestic Purposes and Food Processing; Recreation Use; Estuarial Waters and Vector Control. These guidelines are under intensive review by the Public Health Service and will be furnished to the Department of the Interior as soon as they are finally approved.

While the Public Health Service Drinking Water Standards and the proposed new Health Guidelines represent the best current knowledge in protecting the water and shellfish consumers from communicable disease or illness, we know that health aspects associated with pollution of water in relation to the various users are numerous, complex, and certainly to date have not been adequately studied. Technological progress continually creates new contaminants that must be evaluated. Restrictive limits for many of the new materials or for the existing low-level chemical contaminants found in drinking water supplies are, however, difficult to establish because of the gap in knowledge regarding acute and chronic physiological effects on humans. In some cases the analytical procedures and treatment technology need improvement.

Of equal concern is the need to determine whether or not the barriers guarding against biological contamination of drinking water supplies are being strained to the breaking point. To what degree time-tested supply safeguards and safety factors have been reduced to dangerous levels poses a vital question. Little is actually known of quantitative procedures for isolating pathogens from water, and of the infectious dose of many pathogens that reach our water intakes. Current extensive experimentation with, and the eventual need for, waste water re-use with resultant increase of biological hazards as well as build-up of chemi-

cal contaminants, imposes on the Public Health Service an inescapable responsibility for determining the health hazard potential. The Service is equally responsible for assuring that meaningful indicator indices are developed and used in assessing the impact of water renovation on human health. The urgent need for such research has been supported both by the Committee on Water Resources Research of the Federal Council for Science and Technology and the Federal Water Pollution Control Administration.

Our future program will involve additional research and development resources pertaining to water quality on health, including refinement of meaningful potable water standards. Investigations will include: 1) development of improved methods for the identification and measurement of organic materials and trace elements occurring in drinking water supplies; 2) epidemiological and toxicological studies to determine the significance of organic material and trace elements in relation to human health; 3) development of suitable methods for the removal of harmful trace contaminants, determination of human health effects of water that has been renovated from polluted sources; and 4) initiation of development of rapid determinable tests to assure public drinking water supplies of good quality.

As part of the public health aspects of pollution in estuaries, the shellfish sanitation research program of the Public Health Service will continue providing scientific data required for maintenance of effective controls to prevent transmission of disease agents through marine foods, notably shellfish. Emphasis will parallel problems associated with natural and man-made contaminants, both chemical and microbiological, of estuaries. Attention will be given to controlled laboratory studies on the uptake, retention, and elimination of potentially toxic agents in order to establish or validate safe limits for estuarial water and shellfish. Laboratory, pilot plant, and field studies will be directed toward survival of human disease-causing viruses in estuaries and their uptake, retention and depuration by shellfish; development of accurate laboratory methods for assay of industrial wastes, naturally occurring marine toxins, pesticides, viruses, bacteria, aand other similar disease-causing microorganisms in shellfish; ecology, biogenesis and detoxification of marine toxins; and refinement of methods for the depuration and/or detoxification of shellfish.

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A. Assessment of the potential of disease outbreaks and the means for their prevention and control.

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C. Assessment of the health significance of specific contaminants with regard to:

1. Recreational water use
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of water resources planning. The development of public health guidelines for the use of water pollution control and water resources development agencies is urgently needed as well as the development of public health comments in the form of comprehensive health aspects appendices for inclusion in the reports of the national planning studies; and the development of technical assistance capabilities utilizing research and surveillance data on water pollution and disease.

Mr. DADDARIO. This committee will adjourn until tomorrow morning at this same place at 10 o'clock.

(Whereupon, at 12:42 p.m., the subcommittee recessed, to reconvene at 10 a.m., Thursday, February 1, 1968.)

# ENVIRONMENTAL QUALITY

THURSDAY, FEBRUARY 1, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
*Washington, D.C.*

The subcommittee met, pursuant to recess, at 10:20 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. The subcommittee will come to order.

My apologies to you all for holding up the meeting, but my plane, which was supposed to have arrived an hour ago, just got here. It is important for us to get back to our home district, even in the middle of the week.

Dr. TAPE. I understand.

Mr. DADDARIO. This subcommittee has followed the development of civilian nuclear electric power reactors with considerable interest. The Joint Committee on Atomic Energy and the Atomic Energy Commission are to be highly commended for the ambitious but thorough planning strategy which is apparent in the program.

Our study of environmental quality suggests that nuclear electric power could contribute significantly to pollution abatement. Not only would powerplant emissions be reduced compared to fossil-fuel combustion, but cheap power may lead to electrical space heating, thus eliminating small, hard-to-control combustion equipment.

But atomic energy labors under a number of doubts and constraints, some real and some based on emotion, whereas most water and air pollutants discussed in these hearings produce health effects only after substantial exposure. The release of virtually end radioactive materials into the environment is to be avoided. The reliability of nuclear waste management is thus a prime consideration, and the forecast of the growth of nuclear power means that we need confidence now that future wastes can be controlled.

If the research and development of long-term reactor waste management techniques can be shown to be proceeding at a proper pace, then atomic energy can take a major role in restoring and maintaining the quality of the environment.

Our witnesses today include Commissioner Gerald F. Tape, who is accompanied by Dr. Joseph A. Lieberman, Assistant Director for Nuclear Safety, Division of Reactor Development and Technology, AEC.

We are pleased to have both of you here. Since time is already short, we should proceed immediately.

(The biographies of Dr. Tape and Dr. Lieberman follow:)

### Dr. Gerald Frederick Tape

Dr. Gerald F. Tape was born in Ann Arbor, Michigan, on May 29, 1915. After receiving his A.B. degree at Eastern Michigan University in 1935, he entered the University of Michigan, where he received his M.S. degree in physics in 1936 and his Ph. D. in 1940.

In 1939, Dr. Tape was appointed instructor in physics at Cornell University, where he was associated with the cyclotron research group, and used cloud chamber techniques for the study of neutron interactions with hydrogen and deuterium. He joined the staff of the Radiation Laboratory, Massachusetts Institute of Technology, in 1942 to work on World War II projects that included the development of airborne radar and radar relay equipment. He also helped to develop equipment for training radar operators under simulated conditions. During 1944 and 1945, he directed the aribone radar work of the MIT Radiation Laboratory in Europe, operating primarily with the U.S. Eighth Air Force from laboratory headquarters in Malvern, England. In 1946, he became a member of the University of Illinois staff, serving first as assistant professor and later as associate professor of physics. He was in charge of the administration and teaching of engineering physics courses and also continued his work in nuclear physics and cyclotron development.

Dr. Tape became associated with Brookhaven National Laboratory, Upton, Long Island, N.Y., on July 1, 1950. He served as Deputy Director from October 1951 to May 1962, during which time he was involved in all scientific, technical and administrative aspects of the laboratory's program. On January 18, 1962, he was appointed Vice President and on October 19, 1962, President of Associated Universities, Inc., the corporation which operates the Brookhaven National Laboratory for the Atomic Energy Commission and the National Radio Astronomy Observatory for the National Science Foundation.

Dr. Tape was nominated by President Kennedy on April 3, 1963, to fill the unexpired term of Dr. Leland J. Haworth, who was appointed Director of the National Science Foundation. He took office on July 15, 1963, and his term expired on June 30, 1966. Dr. Tape was reappointed by President Johnson for a term expiring on June 30, 1971.

His chief scientific interests are nuclear physics, accelerator development, research reactors, radar development and radio astronomy. He is a Fellow of the American Physical Society and a member of the American Nuclear Society, American Astronomical Society and the American Association for Advancement of Science. He received an honorary doctor of science degree from Eastern Michigan University in June 1964.

Dr. Tape received an Army-Navy Certificate of Appreciation in 1947. He is a member of Phi Beta Kappa, Sigma Xi, Phi Kappa Phi and Kappa Delta Pi.

Dr. Tape and his wife, the former Josephine Waffen, live at 7705 Winterberry Place, Bethesda, Maryland. They have three sons, Walter Richard, James William and Thomas Gerald.

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### Dr. Joseph A. Lieberman

Dr. Lieberman attended The Johns Hopkins University where he received the Bachelor of Enginering degree in 1938 and the Doctor of Engineering degree in 1941. Following military service with the Corps of Engineers in the Pacific Area in World War II, he was engaged in hydrologic research with the U.S. Forest Service. In January 1949, he joined the Atomic Energy Commission as a Sanitary Engineer in the Division of Engineering. In December 1956, he became Chief of the Environmental & Sanitary Engineering Branch, Division of Reactor Development. He was appointed to his present position of Assistant Director for Nuclear Safety, Division of Reactor Development and Technology in August 1961. He was Secretary of the Subcommittee on Waste Disposal and Dispersal of the National Academy of Sciences, member of the Interim Committee on Nuclear Wastes of the Federation of Sewage nad Industrial Wastes Association, Chairman of the Waste Disposal Subcommittee of the American Standards Association, and is a member of the Subcommittee on Radioactive Waste Disposal by Incineration of the National Committee on Radiation Protection, the AEC member of the Federal Council for Science and Technology Committee on Water Resources Research, member of the Environmental Engineering Intersociety Board, Inc., Committee on Engineering Education. He is also a Diplomate of the American Academy of Sanitary Engineers, a Registered Professional Engineer, and a member of the Society of Sigma Xi. He was a Technical Delegate to the 1958 and 1964 Conferences on Peaceful Uses of Atomic Energy in Geneva and has participated in technical exchanges with the U.S.S.R., Australia, Japan and Latin America.

## STATEMENT OF DR. GERALD F. TAPE, COMMISSIONER, ATOMIC ENERGY COMMISSION, AND DR. JOSEPH A. LIEBERMAN, ASSISTANT DIRECTOR FOR NUCLEAR SAFETY, DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY, ATOMIC ENERGY COMMISSION

Dr. TAPE. Thank you, Mr. Chairman.

The principal testimony this morning will be given by Dr. Lieberman. He has a statement which he has prepared for you. However, I would like to say just a few things before Dr. Lieberman proceeds with his statement.

I think it important to recall that when we are talking about the presence of radioactive materials and radiation as a potential environmental contaminant, we are talking about something that we cannot see, don't feel, don't smell. Many of the things we think about in terms of contaminants can be detected with the normal senses. You realize there is something not quite right.

So, in the field of atomic energy, which deals with radiation and radioactive materials, it has been necessary from the very beginning to be alert to this difference between other materials and radioactive materials. Therefore, we have had to develop a research and development program, and an operational program, which look toward instrumentation and toward developing knowledge of the situation. Advanced analysis is used to be able to predict what may or may not happen, and then operational procedures and practices which would take all of these into account are established.

So I think it quite interesting that from the very beginning of the functioning of our agency we have had to recognize and have recognized the potential impact of this particular type of potential contaminant.

Recognition of the nature of these potential problems has very logically resulted in the development and application of a policy toward preventing possible adverse environmental effects, rather than trying to cure something that may have already taken place. So, the emphasis has been on prevention.

Another factor which I think is important to recognize is that we started from the beginning when there were no nuclear reactor plants. In other words, we developed them and developed the safety and the operational procedures connected with them from the beginning. So, again, where other areas may have the problem of trying to cure a situation which is already in being but is getting worse because of the magnitude of the problem, we started at a time when there was essentially no such contamination, and we have prevented such contamination from developing.

This has led us to a research, development, and operational program which has been directed toward obtaining basic information on the nature and behavior of the radioactive materials with respect to the environment. From the very beginning, our biomedical research program has had a very strong component looking at the interaction of radiation and the environment. We have had to develop the technology to provide for the proper management and handling of these radioactive materials. This has been done through AEC's own operational program which was involved first in the military program and later in setting the pattern for the civilian work. We have had to carry out operations in a manner that gives priority to safety, not only radiation

safety but industrial safety as well, and I am pleased to say this works back and forth, because one becomes more safety conscious.

We have had to develop standards and criteria—for example, radiation protection guides by which these operations could be measured.

We have done this throughout the years looking to our national laboratories, looking to our contractors, and we have actually developed through this procedure a very major competence in essentially all the scientific disciplines that relate to environmental questions. It has cut across the lines of chemistry, physics, biology, geophysics, engineering, medicine, and so on.

Although this has been a record of the past, I think none of us can relax in any way or can rest on our laurels. We recognize these are continuing problems. As you will hear later, the role of nuclear energy in the civilian electric power economy is growing strongly and, therefore, one needs to be looking at the potential problems for the future.

Thus, it is necessary for us to keep on top of the problem, to anticipate new developments, to look for any areas in which we may have overlooked something in the past. I think you will find from Dr. Lieberman's discussion with you this morning that we have had a tremendous amount of experience and are continuing a very strong research and development and operations program to meet these needs.

With that, Mr. Chairman, I think it might be well if we go directly to Dr. Lieberman. We will both be here for whatever questioning you would like.

Mr. DADDARIO. Fine.

Will you proceed.

Dr. LIEBERMAN. Mr. Chairman, I am pleased to appear with Dr. Tape before your committee.

I might indicate some of our associates who are here. Walter Belter, Chief of the Environmental and Sanitary Engineering Branch, Division of Reactor Development and Technology; Dr. David Ballantine, who is in our Isotopes Development Division; and Dr. Nathaniel Barr, technical adviser to our Assistant General Manager for Research and Development. We might call on them to ampilfy or clarify certain points that might come up during the discussion.

Mr. DADDARIO. You may do so at any time you wish.

Dr. LIEBERMAN. Thank you, sir.

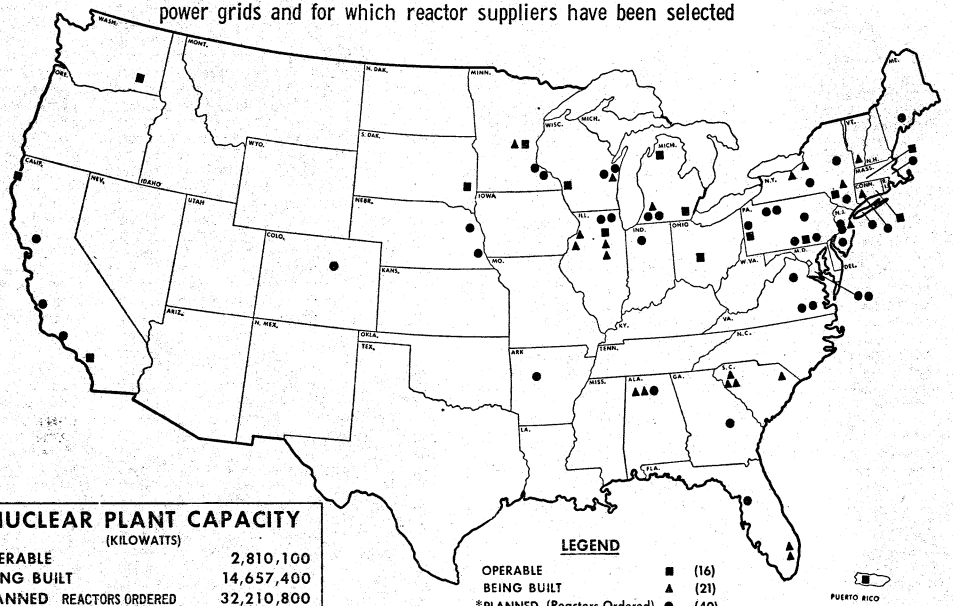
With the committee's permission, rather than reading the statement which has been prepared, which I hope can be put into the record, I would propose to try to summarize this statement rather quickly; and then, following that, I believe it might be useful to the committee to elaborate on some of the things that Dr. Tape has already indicated in the way of observations that occur to me as a result of some 19 years' association with the environmental aspects of this industry. If I have your permission to do that, Mr. Chairman, I will proceed.

Mr. DADDARIO. You may. Your full statement will be entered in the record.

Dr. LIEBERMAN. First I will point out that 1967 has marked a year of great expansion in the nuclear power industry. You have been given a map which indicates the nature of the geographic distribution of this expansion. By the end of the year 1967, there were something like 50,000 megawatts of electrical capacity committed.

# NUCLEAR POWER PLANTS IN THE UNITED STATES

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected




## NUCLEAR PLANT CAPACITY

(KILOWATTS)

| | | |
|---|---|---|
| OPERABLE | | 2,810,100 |
| BEING BUILT | | 14,657,400 |
| PLANNED | REACTORS ORDERED | 32,210,800 |
| | REACTORS NOT ORDERED | 10,100,000 |
| | TOTAL | 59,778,300 |

ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF OCT. 30, 1967: 263,292,537 KILOWATTS

**LEGEND**

| | |
|---|---|
| OPERABLE | ■ (16) |
| BEING BUILT | ▲ (21) |
| *PLANNED (Reactors Ordered) | ● (40) |

*12 more reactors with over 10,100,000 kilowatts have been announced for which reactors have not yet been ordered.

U.S. Atomic Energy Commission
December 31, 1967

(over)

90-064—68——15

| | SITE | CAPACITY (Kilowatts) | UTILITY | STARTUP |
|---|---|---|---|---|
| ALABAMA | Browns Ferry | 1,064,500 | Tennessee Valley Authority | 1970 |
| | Browns Ferry | 1,064,500 | Tennessee Valley Authority | 1971 |
| | Browns Ferry | 1,064,500 | Tennessee Valley Authority | 1972 |
| ARKANSAS | Dardanelle Lake | 825,000 | Arkansas Power & Light Co. | 1972 |
| CALIFORNIA | Humboldt Bay | 68,500 | Pacific Gas & Electric Co. | 1963 |
| | San Clemente | 430,000 | Southern Calif. Edison and San Diego Gas & Electric Co. | 1967 |
| | Corral Canyon | 462,000 | L.A. Dept. of Water & Power | 1971 |
| | Diablo Canyon | 1,060,000 | Pacific Gas & Electric Co. | 1971 |
| | Sacramento County | 800,000 | Sacramento Municipal District | 1973 |
| COLORADO | Platteville | 330,000 | Public Service Co. of Colorado | 1971 |
| CONNECTICUT | Haddam Neck | 462,000 | Conn. Yankee Atomic Power Co. | 1967 |
| | Waterford No. 1 | 549,200 | Northeast Utilities | 1969 |
| | Waterford No. 2 | 800,000 | Northeast Utilities | 1974 |
| FLORIDA | Turkey Point No. 3 | 651,500 | Florida Power & Light Co. | 1970 |
| | Turkey Point No. 4 | 651,500 | Florida Power & Light Co. | 1971 |
| | Red Level | 825,000 | Florida Power Corp. | 1972 |
| GEORGIA | Baxley | 800,000 | Georgia Power Co. | 1973 |
| ILLINOIS | Morris No. 1 | 200,000 | Commonwealth Edison Co. | 1959 |
| | Morris No. 2 | 809,000 | Commonwealth Edison Co. | 1968 |
| | Morris No. 3 | 809,000 | Commonwealth Edison Co. | 1969 |
| | Zion No. 1 | 1,050,000 | Commonwealth Edison Co. | 1972 |
| | Zion No. 2 | 1,050,000 | Commonwealth Edison Co. | 1973 |
| | Quad Cities No. 1 | 715,000 | Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co. | 1970 |
| | Quad Cities No. 2 | 715,000 | Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co. | 1971 |
| INDIANA | Burns Harbor | 515,000 | Northern Indiana Public Service Co. | 1970's |
| MAINE | Wiscasset | 790,000 | Maine Yankee Atomic Power Co. | 1972 |
| MARYLAND | Lusby | 766,000 | Baltimore Gas and Electric Co. | 1973 |
| | Lusby | 766,000 | Baltimore Gas and Electric Co. | 1974 |
| MASSACHUSETTS | Rowe | 175,000 | Yankee Atomic Electric Co. | 1960 |
| | Plymouth | 625,000 | Boston Edison Co. | 1971 |
| MICHIGAN | Big Rock Point | 70,400 | Consumers Power Co. | 1962 |
| | South Haven | 700,000 | Consumers Power Co. | 1970 |
| | Lagoona Beach | 60,900 | Power Reactor Development Co. | 1963 |
| | Bridgman | 1,054,000 | Indiana & Michigan Electric Co. | 1972 |
| | Bridgman | 1,054,000 | Indiana & Michigan Electric Co. | 1973 |
| MINNESOTA | Elk River | 22,000 | Rural Cooperative Power Assoc. | 1962 |
| | Monticello | 471,700 | Northern States Power Co. | 1970 |
| | Red Wing No. 1 | 550,000 | Northern States Power Co. | 1972 |
| | Red Wing No. 2 | 550,000 | Northern States Power Co. | 1974 |
| NEBRASKA | Fort Calhoun | 457,400 | Omaha Public Power District | 1971 |
| | Brownville | 778,000 | Consumers Public Power District and Iowa Power and Light Co. | 1972 |
| NEW JERSEY | Toms River | 515,000 | Jersey Central Power & Light Co. | 1968 |
| | Keyport | 800,000 | Jersey Central Power & Light Co. | 1973 |
| | * | 1,050,000 | Delaware Valley Group | 1971 |
| | * | 1,050,000 | Delaware Valley Group | 1973 |
| NEW YORK | Indian Point No. 1 | 265,000 | Consolidated Edison Co. | 1962 |
| | Indian Point No. 2 | 873,000 | Consolidated Edison Co. | 1969 |
| | Indian Point No. 3 | 965,300 | Consolidated Edison Co. | 1971 |
| | Scriba | 500,000 | Niagara Mohawk Power Co. | 1968 |
| | Easton | 765,800 | Niagara Mohawk Power Co. | 1971 |
| | Rochester | 420,000 | Rochester Gas & Electric Co. | 1969 |
| | Shoreham | 540,000 | Long Island Lighting Co. | 1973 |
| | Lansing | 829,200 | New York State Electric & Gas Co. | 1973 |
| OHIO | Piqua | 11,400 | City of Piqua | 1963 |
| PENNSYLVANIA | Peach Bottom No. 1 | 40,000 | Philadelphia Electric Co. | 1966 |
| | Peach Bottom No. 2 | 1,065,000 | Delaware Valley Group | 1971 |
| | Peach Bottom No. 3 | 1,065,000 | Philadelphia Electric Co. | 1973 |
| | * | 1,065,000 | Philadelphia Electric Co. | 1975 |
| | * | 1,065,000 | Philadelphia Electric Co. | 1977 |
| | Shippingport No. 1 | 90,000 | Duquesne Light Co. | 1957 |
| | Shippingport No. 2 | 800,000 | Duquesne Light Co.–Ohio Edison Co. | 1973 |
| | Three Mile Island | 831,000 | Metropolitan Edison Co. | 1971 |
| PUERTO RICO | Punta Higuera | 16,500 | Puerto Rico Water Resources Authority | 1964 |
| SOUTH CAROLINA | Hartsville | 663,000 | Carolina Power & Light Co. | 1970 |
| | Lake Keowee No. 1 | 839,000 | Duke Power Co. | 1971 |
| | Lake Keowee No. 2 | 839,000 | Duke Power Co. | 1972 |
| | Lake Keowee No. 3 | 839,000 | Duke Power Co. | 1973 |
| SOUTH DAKOTA | Sioux Falls | 58,500 | Northern States Power Co. | 1964 |
| VERMONT | Vernon | 513,900 | Vermont Yankee Nuclear Power Corp.–Green Mt. Power Corp. | 1970 |
| VIRGINIA | Hog Island | 783,000 | Virginia Electric & Power Co. | 1971 |
| | Hog Island | 783,000 | Virginia Electric & Power Co. | 1972 |
| | * | 800,000 | Virginia Electric & Power Co. | 1974 |
| WASHINGTON | Richland | 790,000 | Washington Public Power Supply System | 1966 |
| WISCONSIN | Genoa | 50,000 | Dairyland Power Cooperative | 1967 |
| | Two Creeks No. 1 | 454,600 | Wisconsin Michigan Power Co. | 1970 |
| | Two Creeks No. 2 | 454,600 | Wisconsin Michigan Power Co. | 1971 |
| | Carlton | 527,000 | Wisconsin Public Service Co. | 1972 |

*Site not selected.

The distribution of this is of some interest. The map, which does not indicate Federal Power Commission regions, indicates that New England, the Southeastern United States, the area around the Great Lakes, and the west coast are the areas of the country in which the growth of nuclear power will be the greatest. The estimates for the years 1980, 1990, and 2000 indicate the major expansions and concentrations of nuclear power in Federal Power Commission regions, regions 1, 2, 3, and 8—1 being the New England-New York-New Jersey area; 2 being the area around the Great Lakes; 3 being the southeastern quadrant of the United States; and 8 being the west coast.

I will get, a little bit later on, into the way in which this growth of nuclear power relates to the magnitude of the nuclear waste problem.

This nuclear growth is quite remarkable when one considers that it has really been only 10 years ago that the first plant; namely, the Shippingport plant now being operated by Duquesne Light & Power in Pittsburgh, went on the line. So, there is little question that the nuclear power industry is a viable and rapidly expanding industry.

The nuclear plants have been developed to the point where they are safe and reliable. The research and development program carried out by the Atomic Energy Commission, the test program which has been associated with this, the work by the industry which is involved in producing these plants, have all provided the technology to accomplish the basis for this rapid expansion.

I might also point out that a very vital factor with respect to both safety and reliability is the essential requirement for careful, high-grade engineering and a well developed regulatory program. These are also, obviously, very major factors in assuring that these plants are operated both safely and reliably.

Economics is, obviously, a factor in the growth. I do not think the utilities would be going through the expansion they are going through now if it were not clear that these plants provided some economic incentive to them.

However, as you indicated in your remarks at the outset, Mr. Chairman, there is an increasing awareness of the cleanliness of this method of producing electric power, particularly with respect to air pollution. It has been indicated to me by utility executives in the past that this, indeed, has been a consideration in their "going nuclear."

Mr. MOSHER. Does that involve an economic consideration, too?

Dr. LIEBERMAN. Yes.

Mr. MOSHER. In other words, what they would have to do to clear up their conventional practices would be so costly that it is an incentive to go nuclear?

Dr. LIEBERMAN. Not only the cost, Mr. Congressman, but the capabilities in some cases to do this. The existing technologies for certain aspects of air pollution control, at least in these cases, led these executives to the conclusion that for a variety of reasons their decision should be to go nuclear.

Dr. TAPE. I think, Congressman Mosher, when decisions are made by utility executives, frequently two competing elements will come in and it may be a little difficult to tip the scale one way or the other. I think in many of these instances the uncertainties related to what they

may get into in handling other pollutants may tip it in favor of knowing what they are faced with on the nuclear side.

Mr. MOSHER. Even the uncertainties of what Congress might do?

Dr. TAPE. That is right. To be sure, it is economics; but I think it is the uncertainty of the economics more than it is actually pricing out these differences.

Mr. DADDARIO. This is, however, a choice. You talk about New England. As I understand the New England situation, as we go ahead into nuclear development for the creation of electricity, there is simultaneous growth in the use of fossil fuel development. They go side by side.

Dr. LIEBERMAN. This is quite right.

Mr. DADDARIO. The increase of one is not actually at the expense of the other.

Dr. LIEBERMAN. That is quite right, Mr. Chairman.

Mr. DADDARIO. Therefore, the pollution problem which presently exists is still a problem, on the one hand, and the fact that you are running along in tandem is for other reasons.

Dr. TAPE. One of the major reasons for the rapid growth of nuclear power, I think, is that there has been rapid growth in the whole electrical power demand. So, what we are doing is entering a market at a time when the whole market is growing significantly.

Mr. DADDARIO. Yes. That is the overriding factor——

Dr. TAPE. It is the overriding factor.

Mr. DADDARIO. Having made a determination to go nuclear only because it was a clean way.

Dr. LIEBERMAN. In certain situations this has been the case. I think all the estimates indicate that in the future the use of fossil fuels for the production of electrical power also will increase. So, I think the point you make is certainly a valid one, that the electrical demand will require the utilization of essentially all the resources we have, both nuclear and fossil fuels. So, I think it an important, and I believe, necessary conclusion, to note that the advent of increasing nuclear power, while we think it can make a significant contribution to the alleviation of these problems, will not by itself completely eliminate the problem.

Mr. DADDARIO. I would say that is a very important statement. It ought to be taken into consideration with what the Commissioner has said. To meet the demand will require the use of all of our resources, and we have come to the point in a short period of time where we have looked to the nuclear production of electricity as a resource.

Dr. LIEBERMAN. The safety and waste management record of commercial plants has been and continues to be excellent. I think the record will show, for example, in the area of affluent control, the quantities and concentrations of radioactive materials that have been released into the environment have been well within, that is, less than 10 percent of, established radiation protection limits.

Mr. DADDARIO. How do you establish the 10-percent limit? Are you absolutely sure of this, or is this a guess?

Dr. LIEBERMAN. No. This is not a guess.

Mr. DADDARIO. Has there been the research necessary to be absolutely sure that dosages of less than 10 percent will not be harmful?

Dr. LIEBERMAN. Let me state it this way, Mr. Chairman: The development and establishment of these radiation protection guides and limits are based on very extensive biomedical research. The establishment of these standards has included and involved groups that are outside the AEC—the National Commission on Radiation Protection, the International Commission on Radiological Protection and Measurement—and are based on the best medical evidence available.

I might also say—this is a statement which has been made by others—that there is perhaps as much or more known about the biomedical effects of radiation than almost any other potential contaminant that we are dealing with because of the extensive amount of work which has been done. So, these radiation protection guides and the maximum permissible concentrations which are utilized in regulating and controlling the industry are based on rather extensive background information and experimental work.

Having had those protection limits or guides established, the capability for measuring these concentrations of radioactive materials in the environment has very high resolution limits so that we can measure down to very low levels. The number I quoted is really the result of the detailed monitoring which has taken place in the vicinity of operating plants. So, I think we can say, and there is data to support the conclusion, that the discharge or release of radioactive materials to the environment has not come very close—the number I used was less than 10 percent—to these radiation protection limits.

Mr. DADDARIO. Recognizing all you say, that the experience you have accumulated and the best information you have allows you to come to this conclusion, you would not, however, stop any research in this area to come to exact determinations upon which you could then say this is what the situation in fact is. We have not, as yet, reached that point.

Dr. LIEBERMAN. No, sir. I think there are still questions to be answered with respect to whether there is a triggering mechanism or whether there is a threshold below which there is no effect or whether really the effect does start from any amount of radioactive materials. There is a very significant amount of work still going on at various laboratories on both the somatic and genetic long-term effects of radiation.

Mr. DADDARIO. I think it does help if we could understand at this moment the best information we have allows you to come to this conclusion, and that we feel it is reliable, but that we are continuing research. We are not just taking these figures as they stand. It is our ultimate objective to have this refined to the point where we can be positive because of research that this is, in fact, a safe level?

Dr. LIEBERMAN. Yes, there is continuing extensive research in these areas.

The growth of the industry, obviously, has precipitated questions on our capability for managing the wastes that would be associated with this growth. The major considerations in this whole area of waste from the growing atomic energy industry is related to wastes that are associated with the reprocessing of the irradiated fuels. Back as far as 1959 and before that, as you indicated, Mr. Chairman, the Joint Committee on Atomic Energy had extensive hearings on this

subject, and specifically to try to get a handle on what we would have to contend with in the future.

I might point out that estimates were made at the time of those hearings with respect to waste volumes that we would have to contend with in the future, and by 1980, for example, there were expected to be something like 40 million gallons of these highly radioactive wastes that would have to be handled.

In the past 8 years, as a result of improvements in the technology for reprocessing these irradiated fuels, there have been significant reductions in the unit volume of waste produced. Whereas, for example, in 1959 and 1960 for every ton of irradiated fuel that was processed we were producing something like 1,500 gallons of highly radioactive waste that had to be managed, at this point in time we are producing only about 100 or 200 gallons of highly radioactive wastes per ton of fuel processed. So, even though the estimates for power growth have gone up, the estimates of the actual volume of wastes that we would have to handle have gone down to the point that now—this now includes the introduction of breeder reactors into the nuclear power economy—it is estimated that in the year 2000, we would have to handle something like 80 million gallons of highly radioactive wastes. This is quite comparable to what is now being handled as a result of the Atomic Energy Commission's production operations via tank storage at this point in time.

I think this is simply one indication that in assessing the technology that we used in the past and we are now developing in relation to the future problem, we are quite confident that, indeed, we do have in hand or will have very shortly as a result of the development work being done, the capability adequately to manage these wastes in a safe manner.

Dr. TAPE. I think this is an important point, Mr. Daddario, in developing the confidence you are talking about, because what Dr. Lieberman is saying is that with all of these projections, growth, and so on, the technology which is in hand today will give us a volume which we have already handled in operations to date. So, we are not looking at anything which is drastically different from the experience we have already had.

Mr. DADDARIO. You can expect comparable improvement in your ability.

Dr. TAPE. This does not mean you give up trying to make even better technological improvements.

There is another point which we have glossed over, that is at the heart of the whole waste management problem with respect to nuclear power. In the nuclear power system, the waste is created within the core of the nuclear reactors where proper management is really keeping that waste under control at all times.

The big waste problem is not the dissipation into the environment; we are not using the environment to get rid of it. It is quite a different approach to those followed in the past with other processes. We didn't start out to use the environment to get rid of the waste. The philosophy was to control it. It is controlled right through the entire process.

Mr. DADDARIO. The problem comes as you bring it from place to place, how long you have to keep it there, and how dangerous it becomes.

Dr. TAPE. Those are problems at each stage in the process, from the plant to chem processing plant, to intermediate storage, to permanent storage. But it is important to note that the way in which you handle this is through control, and because it is concentrated and packaged it can be controlled.

Mr. DADDARIO. The problem that has bothered me is that "permanent" sounds fierce enough from a problem point of view but when you go from "permanent" to "perpetual" that is really a little frightening.

Dr. TAPE. Perpetual burial doesn't frighten me when you consider how small a quantity you are talking about in the perpetual burial phase.

Dr. LIEBERMAN. I would like to comment on that point.

Mr. DADDARIO. Won't you come to that?

Dr. LIEBERMAN. Yes, I will.

I am taking more time in summary than I had proposed. I might skip some specific topics but if there are questions we can certainly discuss them.

Let me get to the long-term aspects since you have alluded to this point, Mr. Chairman, in handling and managing these high-activity wastes.

Up to this point these wastes have been evolved primarily at the Government-owned fuel reprocessing plants located at Hanford, Savannah River, and in Idaho. There is now commercially operating a relatively small reprocessing plant in New York and there is one proposed for construction by the General Electric Co. in the State of Illinois.

At these major AEC installations over the past 20 or 25 years the storage of these wastes in specially designed and located underground tanks has been satisfactory. There have been instances where wastes have had to be transferred from one tank to a standby tank, but I think in general one can fairly state that this operating experience has shown that the tank storage at these locations is a satisfactory way of handling these wastes.

However, because of the long-term implications involved, the nature of the radioactive materials included in these wastes, strontium, et cetera, which means that you have to be concerned about these materials for literally hundreds of years, it would lead us to at least an indication that there might well be some limitations to tank storage, even though from a practical engineering standpoint one can come up with a system that would include transfer from one tank to another.

This concept of having to do something "permanent" with these materials is not something that is new to us. I recall one of our early sessions in 1955 carried out under the sponsorship of the National Academy of Sciences under Dr. Harry Hess of Princeton in which we considered this problem of long-term handling of these wastes.

Out of this meeting, and in further subsequent discussions, the concept of solidifying these high-activity wastes, converting them into a form whose mobility was minimized, and then taking these materials and putting them into an environment that was essentially separated from the biosphere, if you will, seemed to be a reasonable and adequate long-term—and I might even say perpetual if you will allow me to define it in terms of geologic time——

Mr. DADDARIO. What is geologic time?

Dr. LIEBERMAN. I will do it this way, Mr. Chairman. The salt formations in which we conducted field tests out in Kansas have been there for a long period of time, for geologic periods of time, and I think we have every reasonable reason to believe they will continue to be there for roughly equivalent periods of time. Therefore one can conceive, as I think we have and are demonstrating in an engineering way, of techniques for solidifying these highly radioactive materials, minimizing the volumes so that by the year 2000 we would have something less than 1 million cubic feet produced of these solidified wastes, taking them, then, and putting them into the salt formations for long-term or "permanent" storage. These salt formations, which by their geologic nature are not associated with sources of water supply because if they were the salt wouldn't be there, have other very useful properties. The material behaves something like a self-sealing gas tank. If one puts this radioactive material in solid form in that kind of environment he can be reasonably sure that for the lengths of time we have to be concerned with this material it is adequately managed. The development and demonstration of this technique represents a major undertaking of our research and development program.

We are now demonstrating in an engineering scale plant out at Hanford three processes for solidifying these wastes. We are just completing field tests in the salt mine in Kansas where we have used irradiated fuel elements to simulate these waste pots, to corroborate our laboratory work with regard to the behavior of salt under temperature and radiation conditions, and I think it is reasonable to state that this technology indeed is in hand and it is being demonstrated. The final engineering reports on this work will be available within a matter of the next year or two.

Mr. MOSHER. When you say 1 million cubic feet, over what period of time?

Dr. LIEBERMAN. As of the year 2000, with the installed capacity of nuclear power that would be included by that time, we would be producing in this solidified form something like 90,000 cubic feet per year, but by the year 2000 we would have accumulated, as a result of everything that has gone on, all the nuclear power which has been produced up to that point, with all the waste processing, something like 960,000 cubic feet.

That 960,000 cubic feet would be the amount we would have accumulated by the year 2000, based on the estimates of the growth of nuclear power.

Mr. MOSHER. Then there would be continual production?

Dr. LIEBERMAN. By the year 2000, this would be roughly 90,000 cubic feet per year.

Mr. MOSHER. That would not appreciably increase after that?

Dr. LIEBERMAN. No. It would increase as the nuclear power growth went up. Our crystal ball looking stops at the year 2000, but if the nuclear power installed were to double over the course of the following 10 years, then there would be a proportional increase in the volume of solids we would have to handle.

Let me indicate it in terms of how much salt mine space you would need for this operation. The estimates we have made would indicate that by the year 2000, and Mr. Belter can check me on this, something less than 3 acres of salt mine space per year would be required.

As you are probably aware, there are substantial areas of the country in which these salt beds do occur, and this is a relatively small percentage of the space that is mined out just in salt production per year, so we do not see any bottleneck in that respect.

Mr. DADDARIO. You talk about 3 acres. Even though you say you do not see any bottleneck in that regard, it may be significant to ask why you changed your figure? You and Mr. Belter wrote an article, "Waste Management and Environmental Aspects of Nuclear Power," where you say that the amount of space required would be 1.2 acres.

Your statement here at page 2 states 2.8 acres. You now speak of 3 acres.

Dr. LIEBERMAN. Yes.

Mr. DADDARIO. Even though the bottleneck may not occur at 3 acres, the figure needs explanation.

Dr. LIEBERMAN. The estimates of the volumes of waste at the time that that article was prepared did not include the introduction of the breeder reactors into the economy.

With the introduction of breeder reactors, because of the greater extent to which the fuel is utilized, what we call higher burnup of the fuel, the unit activity in the volume of waste would be higher and perhaps would have to be diluted to take care of some of the temperature problem, so the estimates of the volume of wastes have gone up because by the year 2000 we anticipate indeed there will be a significant introduction of the breeder reactors. This increase, then, is reflected in a proportionate increase in the space required to handle it.

Mr. BELTER. The time that article was written was before the revised nuclear power estimates which have just come out during the past 6 months. By the year 1980 there has been substantial, about 25 to 40 percent, increase in these power estimates.

What this means is that the rate of nuclear power growth really will be increasing that much more rapidly, so we will have on the line by the year 1980, say, approximately between two and three times as much power, nuclear power, which would be carried over to the year 2000. Because of having that much more power we will be turning out that many more megawatts and we will have that much more fuel load which has to be reprocessed.

Dr. LIEBERMAN. In essence, at the time of that paper our estimate of the growth of nuclear power was faulty.

Mr. DADDARIO. You were talking about a different set of statistics?

Dr. LIEBERMAN. That is right.

Dr. TAPE. I might point out that sometimes we are pretty brash making forecasts this far in advance. Given the nature of the problem we have to do our best job at the time, looking toward the year 1980, 1990, 2000, and so on. This is true for this aspect of the problem and true for the developmental side of the problem. Modern-day technology takes a long period for development and a long period to introduce it into the civilian economy, and so on. We have to make estimates like this and do the best job we can.

Mr. DADDARIO. No one can find fault with it. I think it is important that as we see the situation differently we ought to talk about it a little bit so people can understand why there has been an adjustment.

Dr. TAPE. We need to recognize changes when they occur and update accordingly.

Mr. LUKENS. Is there an advantage to be gained in radioactive dissipation with the solid storage as opposed to liquid storage?

Dr. LIEBERMAN. Yes; I think there is an advantage to be gained, but not in terms of the dissipation of the radioactive materials.

Mr. LUKENS. We are talking about hundreds of years.

Dr. LIEBERMAN. The radio-nuclide doesn't care whether it is in a solid matrix, liquid, or whatnot. It has its own clock and nothing can change it. It will take the same length of time to decay whether it is down in a salt mine, in a tank, or no matter where you put it.

Mr. DADDARIO. You referred to the word "manage", that you could manage it under these circumstances. Are you talking about managing it without people? Can you put it there and you do not need people constantly to keep tabs on this?

Dr. LIEBERMAN. I suppose scientifically one could mount an argument for saying once it is put in this environment you can walk away and forget it. I would venture to say for practical purposes that there would have to be some measure of continuing surveillance over this material. If I have a facility out in Kansas I would not want it arranged so people would just walk in and out of it.

The kind of manpower and the amount of manpower that would be required to do this would be minimal. I do not think I can visualize a situation where we put it in a salt formation and literally walk away from it.

Mr. MOSHER. I am familiar with a plant that is shown here on the map in the Lower Peninsula of Michigan, but in the northern part of the Lower Peninsula. How are the wastes transported from there to wherever you take them? In what form do they leave that plant and how often?

Dr. LIEBERMAN. As Dr. Tape indicated, the high activity wastes we talked about here are not evolved in the plant to which you refer, which is what we call a water reactor. The fuel elements which produce the energy leave the plant in a solid form which is identical to the way they came in with one obviously very significant difference. When they came in you could handle them directly with gloves. When they go out they have to be in substantial shielded casks because they are highly radioactive.

The fission products, which really constitute the wastes and are really the things we have to control, are contained in these solid metallic fuel elements that are transported either by rail or by truck in specially designed casks to go to a fuel reprocessing plant which may be located in New York, Illinois, or some other place, and it is at that fuel reprocessing plant location that these wastes are evolved, so the transport is a significant function involved in this whole fuel cycle management business.

In addition to this high activity waste, within the plant there are components and facilities for handling low activity wastes. There are evaporators for certain types of liquid effluents, or, for example, if you have a laundry associated with the plant and things of that sort. We end up with what we call low activity or intermediate level activity wastes. You may have an ion exchange system or some other process to purify these wastes. Eventually you have to get rid of the ion exchange resins. These are packaged and also transported to a commercially available burying ground. There are five of these.

I have the location of these somewhere in my notes. They are specially located installations which are regulated either by the State or the Atomic Energy Commission. They can receive this kind of radioactive waste.

In general I would indicate that there is essentially no radioactive material disposed of onsite at a power reactor except for those effluents which have gone through processing and are deemed safe to release to the environment.

These latter categories include both liquids—no solids because in every case I am aware of they are shipped off site—both liquids and gases.

The statement I made at the outset of my remarks, that these releases are well within acceptable limits for continuous exposure, would be the thing that would apply here.

I might also say one other thing which I think is important. The AEC regulatory people, and I am sure this also applies to the industry, do not look at those radiation protection guides and limits as something you should build up to. From a policy standpoint, if you will, the effort is made to keep the quantity of radioactive materials that are released to the lowest practicable minimum. Certainly from a safety standpoint they have to be within these prescribed limits.

Mr. MOSHER. In this transportation by rail and highway I assume you are confident that you have adequately guarded against accidents and all that sort of thing when you refer to these casks. Have you had adequate experience which demonstrates that?

Dr. LIEBERMAN. We have. Rather than going into detail if you would like I am sure we can provide this information for the record.

I would simply say in summary fashion that our transportation experience has been quite excellent.

There have been accidents but in all of our experience there has been no individual in the public adversely affected.

There have been situations where, for example, in the worst situation I can recall, to close a truck terminal for a period of time and clean it up.

In connection with this question of transportation again this goes back to identifying the problem and assuring that you have the technology to cope with it.

We carried out a very interesting and very useful operations research study of trucking radioactive materials. This was done for us by the Johns Hopkins University. We utilized the accident records we got from the ICC for large truck movements and related these accidents to the season, the day of the week, hour of the day, geographical area, road type, and so forth. We identified out of that what kind of accident rate we might expect. What are the technological factors we should be looking at? This goes back, in addition to the requirements for a cask for shielding and protection against radiation, to carrying out a program to drop test casks to see whether we can model the behavior of casks under impact and fire, and this work has been going on.

Another example is the project we carried out in cooperation with the Transportation Corps of the Department of Defense in which

a loaded vehicle was crashed to measure what happens and see how these containers behave.

Transportation is an important factor and in general I would indicate that I think our cognizance or recognition of it as a factor has been quite extensive. What has been done, and the experience record, logically leads to the conclusion that we have this factor in hand.

Mr. MOSHER. Mr. Daddario, this is a practical example of the advance assessment of technology you have been talking about.

Mr. DADDARIO. It does fall into that area.

You have not had necessarily to simulate accidents. We have a chart here which shows there have been 171 incidents during transportation on road, rail, air, sea, et cetera. You have actually had practical ways to learn about the problems.

Dr. LIEBERMAN. Except most of these have been relatively minor. Dr. Tape also pointed out to me, and I failed to say this, that the Interstate Commerce Commission, Bureau of Explosives, has had a vital role to play in this whole transport business. This should be stated for the record.

Yes, we have had that experience but in these accidents there was not the kind of instrumentation to enable us to understand what kinds of forces were involved, how the energy distributed through the whole transport system, and things of that sort. As part of our safety program we think it is essential that we get a good clear understanding of the phenomena which are associated with these accidents even though the likelihood of their ever occurring might be extremely small. This is part of the philosophy, if you will, which in large measure has contributed to the success I think our record indicates we have achieved.

Dr. TAPE. The point is that one takes advantage when there are accidents to learn as much as one can.

On the other hand you do not wait for the accidents to provide the information needed for the future. You take advantage when you are in the unfortunate situation of an accident. You do not wait for it in order to get on top of the problem, however.

Mr. DADDARIO. I understand that. I brought out the 171 accidents just to show you have been able to handle it, and the fact that these have been relatively minor.

At the same time the possibility exists, and it is important for us to develop the best techniques possible.

We could probably keep you at the beginning of your statement for the rest of the morning, but I do think we had better move along.

Any points we miss we can come back to you later.

Dr. TAPE. We will be happy to supplement in any way you would like, Mr. Chairman.

Mr. DADDARIO. Proceed.

Dr. LIEBERMAN. Let me, then, just wrap up what I think might be useful for the committee and perhaps will provide basis for further discussion.

First I would like to emphasize the point that Dr. Tape has made, regarding the preventive rather than curative approach. This has been a vital factor in our setup.

While I recognize that the industry and its development is unique, and it has been under Federal control, the fact remains that the prob-

lems in this area were identified, the phenomena associated with them and they were explored, and there were adequate resources made available to do this. The definition of the problems and the understanding of the phenomena was not done on a unilateral basis. We worked with expert groups, and this goes back to when we first anticipated stack effluent problems and the establishment of a stack gas problem working group to be sure we had the kind of definition of the problem that was required in order to say what kind of technology we needed to take care of it.

As an example, out of this kind of approach came the development of a high efficiency filter to specifically cope with the problem of removal of small particles from air and gas streams.

Incidentally, this filter now is used in hospitals, telephone exchanges, breweries, and so on.

The fact remains, having defined the problem, understood the phenomena associated with it, behavior of the material involved, we could do something about it.

The other observation I would make would relate to the utilization of related existing competencies in other organizations. I think this is a tribute to the outlook which my employers had when they said "Let us not build up a competency in meteorology, geology, fish and wildlife, but go to these agencies and get them to help us." I think this has stood us in good stead. We have had assigned to us on a full-time basis an employee of ESSA, a meteorologist, a geologist, and so on. At Los Alamos and at Hanford and Oak Ridge in the early days we had Public Health Service employees assigned to work there, not only benefiting us but they got trained in the business, too. I think this was extremely important and has contributed to the advantageous posture I think we are in now.

On our relationship to other agencies of Government—at one time there were discussions of jurisdictional problems. Who controls here? Was it the Federal Government or the States?

In setting up groups like the Mohawk River advisory group, an advisory group on the Savannah River, and others, we didn't worry about jurisdictional questions. We went to the State organizations, State health departments, conservation departments and worked with them to get them to understand what we were trying to do and to take advanage of the competencies and information which they had because they lived at the place. I think this was extremely important in helping to develop our programs and approaches to these problems.

The next observation I would make is in connection with our work with the universities. By assigning to universities, under contract, specific research and development, we not only had the advantage of slave labor, if you will excuse the expression, but we trained people who are now in our program and are contributing significantly to our continuing work in this area.

The development of technology that Dr. Tape mentioned I think is extremely important. This high efficiency filter is one example. The development of unit operations, borrowing from the oil industry and applying hydrofracturing techniques, solidification and the salt business, represents the kind of work that can develop a technology to cope with the problems. I think this is tremendously important.

Lastly, I think it is important to note the fact that we have had the continued observation and cognizance, and the support, of an informed congressional committee, the Joint Committee on Atomic Energy.

The National Academy of Sciences, and its constituent organizations such as their Earth Sciences Division (we were one of the agencies instrumental in establishing this group, their Committee on Oceanography, their Committee on Sanitary Engineering and Environment have been consulted and involved. By utilizing these competencies we obtained significant additional ability to cope with our problems.

With that, Mr. Chairman—I am sorry the summaries took as long as they did—I hope we have given you a reasonably good idea of our participation in and contribution to this environmental pollution control situation.

Mr. DADDARIO. First of all I would like to say that in that part of your statement which refers to thermal effects of steam electric generating plants, Senator Muskie also will have hearings on that in the near future. We will look to them for the development of that particular aspect.

Dr. LIEBERMAN. It was for that reason that I skipped this.

Mr. DADDARIO. We think it is important for congressional committees to coordinate their activities and not run one over the other, and we can be helpful in that regard.

We are talking about the preventive techniques you developed. How do you go about obtaining the independent assessments and reviews of these procedures when most of the knowledgeable people involved are working within the AEC program? Who arbitrates? How do you handle that part of it?

Dr. LIEBERMAN. I think there are at least two things that might be said here, Mr. Chairman. First of all, as you know, there is a regulatory side of the Atomic Energy Commission which is physically separated from us. They are in another building in Bethesda and we are out at Germantown. Indeed they are independent. I can speak from direct experience in working with them.

However, we do work with them as they discharge their responsibilities in controlling the industry and granting licenses for nuclear powerplants and fuel reprocessing plants. We get from them the kinds of questions that they feel need answers in order for them to carry out their responsibilities. I think this is one way in which we get this independent input and assessment.

Another very important way is one I alluded to very quickly. When we have gone over to other agencies like the Public Health Service or the Geological Survey or the Bureau of Mines we have essentially asked them to tell us what are the problems we will have to contend with here? We are not in the business of telling them how to do their geology or meteorology.

By doing this we have also been provided an independent assessment of our activities.

The third one would be in dealing with organizations like the National Academy of Sciences, an authoritative group to which we have looked to review our research and development program and to help us identify requirements in an independent manner.

I think that these three are simply examples of how we accomplish that very important matter.

Mr. DADDARIO. Have you in fact used the Academy of Science for this purpose? Do you mean by what you have just said that in the event it did come about you would use them?

Dr. LIEBERMAN. We have in fact used them over the years.

Mr. DADDARIO. Could you provide for the record an example or two?

Dr. LIEBERMAN. We can provide for the record copies of some reports that the National Academy of Sciences have produced at our behest. These go all the way from assessment of disposal of radioactive wastes in the oceans to disposal in salt, or deep underground formations.

Dr. TAPE. In that connection, the Commission has been looking at what might be called the continuing relationship between the Academy and ourselves in this area of radioactive waste management.

What we are doing now is discussing with them the creation of a new group in the Academy which has a somewhat broader scope than we have used in the past. This has not been completely defined as yet but I could probably provide you a draft which might be useful in this connection.

Here is a case in which we indeed would like to see the independent input that you were talking about having the broadest possible representation of disciplines which would be brought to bear on this kind of problem. I think it will be useful to the Academy and useful to us to have someone who has this focus on a continuing basis.

Mr. DADDARIO. Commissioner Tape, it is a very interesting proposal you have just talked about. From it I understand that this group when put together, as you intend it to be, will be able to independently come to a judgment about something that ought to be done rather than have you ask them.

Dr. TAPE. What we are starting out with in the NAS proposal is that this committee of the Academy become fully familiar with: our own operational plans; the way the AEC itself has been doing business; what our operational practices have been; the plans for waste management; surveillance activities we have had; and the research and development programs.

I think you can see that in our bringing them into the picture we hope to expose them to the broad gamut of operations and research.

There are some restrictions. For example, we cannot have the committee involve itself in specific licensing operations because that is a specific function of the Commission's regulatory role. Although they can use those cases for examples in terms of the way things develop we want to be sure we do not involve them in the regulatory sense. Research and development and planning for the future is involved and we look to this as a continuing relationship where we will have the option of their looking at both general and specific aspects.

Mr. DADDARIO. We certainly would be interested in getting your views on that.

Dr. TAPE. These are preliminary. Discussions are underway with the Academy.

The group has not been appointed. The point here is that the older committees which have been involved, as Dr. Lieberman was saying, have at times addressed themselves to certain specific questions. Here we want a little broader consideration.

(The proposal referred to is as follows:)

NATIONAL ACADEMY OF SCIENCES—NAS–NAE ENVIRONMENTAL STUDIES BOARD

*Proposal for Advisory Services to the Atomic Energy Commission Concerning Long-Range Radioactive Waste Management Plans and Programs for an Expanding Nuclear Energy Industry*

Program Administration:

C. K. REED,
*Executive Secretary, NAS–NAE Environmental Studies Board.*
Phone: 961–1706.
Contract Administration:

B. L. KROPP,
*Deputy Business Manager, NAS–NAE–NRC.*
Phone: 961-1213.

PROPOSAL FOR COMMITTEE ON RADIOACTIVE WASTE DISPOSAL ADVISORY TO THE ATOMIC ENERGY COMMISSION

This proposal is submitted in response to discussions between representatives of the Atomic Energy Commission and the National Academy of Sciences concerning utilization of the services of the Academy in connection with the disposal of radioactive wastes.

If this proposal meets with AEC approval, the Academy would proceed with the appointment of an appropriate committee to review and advise the AEC concerning long-range radioactive waste management plans and programs for an expanding nuclear energy industry. This primary task would include the general assessment of the adequacy of the present and projected technology in relation to meeting long-range health, safety and other environmental requirements, and the identification of new research needs.

The general scope of the Committee, as stated above, may be modified or extended as needed by mutual consent of the Commission and the Academy. Specific studies would be undertaken on the initiative of either the Commission or the Committee following agreement of representatives of the Academy and of the AEC on the objectives of such studies. It is understood that the Committee would not be requested to provide advice on specific cases which normally come within the purview of the AEC Advisory Committee on Reactor Safeguards.

The NAS–NAE Environmental Studies Board would periodically review and guide the work of the new Committee. The general concept for organization and operation of the Committee would be as follows: The Committee membership, which shall be discussed with the AEC, would include professional competence from essential areas such as health physics, chemical engineering, environmental engineering, meteorology, geology, hydrology, industrial hygiene, oceanography, and geological sciences. Where necessary *ad hoc* panels would be established to develop specific areas essential to the Committee effort. AEC will be given adequate prior notice of each Committee meeting and invited to be represented by one or two liaison representatives.

Throughout the conduct of its work the Committee would depend upon the cooperation of the Commission, its staff, and its contractors to furnish available information and data as these may be required. The initial orientation task of the Committee would be to become familiar with both AEC and industrial waste operational practices; plans for waste management and associated surveillance activities; and research and development programs. A series of briefings would be required, and it is contemplated that the Committee, or particular members thereof, would spend sufficient time at disposal sites reviewing the work already completed or underway on the various waste management approaches. The next task of the Committee would be to compile a comprehensive listing of various topics within the scope of the Committee's charter, that could be considered by NAS and AEC as additional topics for study by the Committee.

The Committee's report(s) would be furnished to the Commission for its consideration and any distribution beyond the AEC. The time schedule for reporting would be worked out with the Commission and the Committee in the course of the initial meetings.

Funds are requested to cover general operating costs of the Committee for a two-year period from March 1, 1968, to February 1970, at a level of about $50,000 per year. It is expected that special studies or tasks will be identified as the Committee proceeds with its work, which may require separate, additional support.

Mr. DADDARIO. Could you go into your relationship with other agencies a little bit? You have talked about ESSA and others such as HEW. Is this a relationship where you call them in when you feel you need them, or do you have a committee structure where there are regular meetings and regular opportunities for people to come to judgment about these things?

Dr. LIEBERMAN. As I indicated, and this goes back in history, in certain instances we have something even better than that. There is an employee of ESSA paid by ESSA who has a desk right across the hall from me who then becomes familiar with our programs and problems, but then he has access on a continuing basis to all the competencies and facilities which exist in that organization.

As a result of that very close working relationship, and I use this only as an example, at the National Reactor Testing Station in Idaho we have had, ever since it has been in operation, an ESSA group which is doing research and development in meteorological diffusion at that testing station for our purposes, but it is also useful to the industry in general.

I might also point out, again in this specific area, the working relationships have been intimate and extensive. When we first asked them to put out a document called Meteorology and Atomic Energy, back in 1955 or 1956, that document—and this might be a self-serving declaration but it is a fair one—I think represented a major contribution to air pollution meteorology, not only for the Atomic Energy Commission and the nuclear industry but industry in general. They are now completing a revision of that document.

The working relationship, therefore, is far from haphazard. There is AEC money which goes to these agencies when it is required to support research and development by those agencies. I could list the agencies with whom we work in this regard. They cover almost every agency which has anything to do with the environment—Fish and Wildlife, Public Health Service, Geological Survey, Weather Bureau, and many others.

At this point in time only ESSA and the Geological Survey are represented by actual employees assigned to us, but at one time this also included the Public Health Service.

I can hardly overemphasize the importance we attach to this kind of relationship and the value that has accrued from it.

Mr. DADDARIO. Let us take the Fish and Wildlife reference, which I think is at the bottom of page. You say:

The Commission takes into account reconcentration aspects in setting release limits to the environment from operating facilities. U.S. Fish and Wildlife Service is regularly consulted on questions in this area.

Who has the veto if there are disagreements? How do you come to a judgment about what you can or cannot do?

Dr. LIEBERMAN. Let me say one thing by way of introduction to this point, Mr. Chairman.

First of all, the Fish and Wildlife Service at its laboratory, the one I am generally familiar with being in North Carolina, has done an extensive amount of work on the behavior and uptake of radioactive materials by various marine organisms. This has provided the basic information which is required to do the kind of thing indicated in the statement.

From the standpoint of the regulatory function of the Commission, when they get an application for a license for a commercial plant they routinely send these applications over to the Fish and Wildlife Service and ask for their comments. As far as I know there has been no instance where the Fish and Wildlife Service has come in with a comment which indicates that something more has to be done where this has been overriden by the regulatory people.

I think the answer to your question is, therefore, that if indeed there were an argument that developed in a particular situation, while the Fish and Wildlife Service as a result of this relationship would not have a veto power, their comments would be considered and would be made available to the public in accordance with regulatory procedures. Insofar as this comments relates to radioactivity and radiological safety, the AEC regulatory function would be such that what the Fish and Wildlife Service means would be incorporated in whatever requirements the regulatory people came up with and which a licensee would have to meet.

Mr. DADDARIO. The Fish and Wildlife people probably would have to depend pretty much on information you give them as to the effects of this.

Dr. LIEBERMAN. No, because they have done work in this area themselves with their own people. They have carried out in their laboratories uptake studies and reconcentration studies of various radioactive materials. They have done it in the past and so far as I know they are continuing this work.

This is another example of not building up a tremendous duplicating competency within our own in-house organization in a specialized aspect of the business.

If radioactive materials might get to where fish will get to them we ought to know how they interact and we ought to go to the people who have the experience and competence in these areas. This is what was done. This does not mean the Fish and Wildlife Service are the only ones who have been working in this area. The comments and views that the Fish and Wildlife Service would come up with in this connection would be based on their own knowledge, experience, and competence.

Mr. DADDARIO. We can take that as a somewhat typical example of a Government agency with which you have worked over the course of time and which has developed an ability to look into radioactive problems and to come to a judgment as to how they can accomplish their own missions. Then you work with them in both providing the answers and coming to solutions.

Dr. LIEBERMAN. That is quite right, Mr. Chairman.

Mr. DADDARIO. Dr. Lieberman, it probably comes as no surprise to you that we might on occasion have some national coal policy newsletters come to this committee. There is in here a statement about a

General Electric permit which I would like to read to you and would like your comment.

It says:

The Atomic Energy Commission this week granted to General Electric a provisional permit to construct an irradiated nuclear reactor fuel reprocessing plant in Grundy County, Illinois, adjacent to the three Dresden nuclear power stations of Commonwealth Edison Company. One condition attached to the construction permit was that General Electric show proof that the land on which nuclear waste, created in the plant operation, will be stored has been transferred to the State of Illinois, which will exercise permanent control.

The plant, to be known as the Midwest Fuel Recovery Plant, will have a capacity for processing compacted uranium dioxide at an annual rate of 300 metric tons of uranium. It is designed to recover plutonium, neptunium and uranium from fuels which have been used in nuclear power plants.

Highly radioactive wastes which will be produced are to be reduced to solids, canned and placed in storage basins below ground level and under cooling water. Gaseous effluents from the plant operation which will be released into the atmosphere will be kept within safe levels, AEC said. In addition, AEC says the plant is so designed that the gases will be trapped inside the structure in case of uncontrolled release due to an accident of some sort.

In view of everything that we have said, we get the feeling that there is a certain amount of instability, it is more than just storing of this if you have to store it under cooling water.

Dr. LIEBERMAN. Mr. Chairman, we did not go into all the process details. We mentioned solidification and storage in salt.

Mr. DADDARIO. I understand that. I just add one further point. If you would like to just answer this for the record, you may.

Dr. LIEBERMAN. Fine. What you read there is, I believe, consistent with our approach and the comments that I have made this morning. The wastes are stored in water for an interim period because of the heat involved from the radioactive decay. It is being stored in a way that later the General Electric Co. would be able to remove it and transport it to a salt mine if that was going to be its permanent disposal place.

Mr. DADDARIO. It is not inconsistent with what you have said.

Dr. LIEBERMAN. That is correct.

Mr. DADDARIO. During this period of time there is the need for much closer surveillance than after 30 years.

Dr. LIEBERMAN. Yes.

Dr. TAPE. The point of the State control of land, for example, is indicative of public authority that has long-term cognizance of the land on which this is to be placed and you do not have to worry about a question of a private company that might move out, and so on. It is a question of looking at the permanent commitments.

Mr. DADDARIO. Once this is transferred to the State, such as Illinois, how do you stay on top of it for this period? Who checks and gives advice? What controls do you have?

Dr. TAPE. This depends on the particular State, Mr. Daddario. One of the features of the Atomic Energy Act is recognition that public health and safety matters have long been under the cognizance of the States. The Atomic Energy Act authorizes the Commission to transfer to a State certain of the Commission's regulatory authority over radioactive materials when the Governor certifies that the State has a regulatory program which is adequate to protect health and safety, and the Commission makes a finding that the State's program is adequate

as certified by the Governor and is compatible with the AEC's regulatory program. The authority transferred to the State includes licensing and inspection of low level radioactive wastes. AEC, under its regulations, retains authority over wastes resulting from the processing of irradiated nuclear fuel. Thus, a State which has entered into an agreement with the AEC for the transfer of regulatory authority would supply, through its public health-radiological safety authority, licensing and inspection for low level wastes. For high level wastes, the AEC regulatory side would continue to license and inspect to see to it that such wastes are controlled in accordance with the AEC regulations. As I recall it, Illinois has not yet exercised this option; so this would be an AEC responsibility even for low level wastes.

Mr. DADDARIO. If you were to transfer this responsibility to a State, would you watch it, and if there occurred a period of political instability in that State, maybe some budgetary problems where they could not continue the maintenance control, could you then step in again?

Dr. TAPE. Part of the agreement with a State is to maintain compatibility with the Federal program of regulation in this area. We do meet with them and go over their plans and operations at regular intervals to assure ourselves that they are continuing as they indicated at the time of signing the agreement. The Commission is authorized to terminate or suspend the agreement with a State and reassert its own licensing and regulatory authority upon request of the Governor, or upon a finding that such termination or suspension is required to protect the public health and safety. I think we would prefer to help correct their deficiencies rather than to take away authority in any sense of reverting to Federal control. As noted earlier, however, the Commission's authority over wastes from plants which process irradiated fuel is not transferred by the agreement but is retained by AEC.

Mr. DADDARIO. But one way or the other, you do have a way to pull the thing back?

Dr. TAPE. We do have sufficient influence and control that this can be done.

Mr. DADDARIO. Dr. Lieberman, Mr. Carpenter was attracted by a magazine concerning the amount of radiation which may be harmful. Now, there are statements here about dosage levels. I am concerned about the problem. If there is an agreed-upon lifetime exposure, how do you take into consideration different parts of the country or the world where the natural radiation problem may be greater than in other parts? What happens when you need to be X-rayed, dental or otherwise, and how does this fit into this picture? How does the ordinary person, as he goes about his daily life, as he gets involved with radiation, natural and otherwise, medical, or what have you; how is he protected under this 10-percent emission or less?

Dr. LIEBERMAN. As an individual, I do not think anybody that goes for a dental X-ray or a chest X-ray has any more idea than a rabbit how much dosage he is getting.

Mr. DADDARIO. Does that include the fellow who is X raying him?

Dr. TAPE. Some.

Dr. LIEBERMAN. In some, I guess that is true. Although I have the impression, as a layman in this area, that that situation is improving markedly, that the dental associations and medical associations are indeed doing a substantial job in trying to keep to a minimum the amount of exposure that is required for medical reasons.

Dr. TAPE. One of the byproducts of our business has been increasing cognizance on the part of the medical and dental raidologists, X-ray technicians, the people in the field, both on the user side and on the equipment supplier side. I think the question of X-ray exposure has received much attention and, as such, is being looked at in a very concerted way.

Mr. DADDARIO. Because the patient does not know, as Dr. Lieberman says. It is important for those who are handling the equipment involved to understand the situation to the highest degree. The indication is not just from you, of course, but from others that this is not the case.

Dr. TAPE. Actually, Mr. Chairman, I think the situation here is that levels which have been established for what you might call the manmade radiations have tried to take into consideration that the general public does receive X-rays in a medical diagnostic, or therapeutic way, and the standards do take into account some average value that might be concerned there. So that on the average these levels have tried to reflect that.

Now, what this does not do is address itself to the individual who is undergoing some rather drastic radiation therapy. This is a matter of judgment on the part of the doctor and his patient as to what is right for the patient under the circumstances.

The philosophy behind all radiation exposure is that there be some kind of a risk-benefit evaluation. The levels have been set as low as they have for the general public because it is felt that the risk at that level is far less than the benefits that are being achieved by the presence of, say, nuclear reactor plants or other applications.

On the other hand, an individual may be given a very high exposure to radiation for medical reasons if his doctors believe that such treatment is required to cure a serious malady. In this case the benefit is the possible cure of the malady and this may be much larger than the risk from exposure to radiation. This is the kind of evaluation that one makes. I think you and I mentally do this every time we may be asked "Do you want another set of dental X-rays?" And you think back as to when you had the last set and maybe you say "Yes," and maybe you say "No." So it is in that context that I think we are all much more conscious of the situation.

Mr. DADDARIO. I remember when I had the last one. But as I listen to you, I wonder when I am going to get the next one.

Dr. TAPE. Improvements are being made. Here we know those X-rays can help us, they can find things that need to be cured, so we make our decision as to how frequently this needs to be done.

Mr. DADDARIO. Commissioner Tape, I think that is all well and good. Yet, it does not take into consideration the millions of Americans who do not go into this process of whether to cure or not, but who just go from day to day doing what they have to do and are X-rayed when the doctor says they ought to be, for teeth or anything else. They take whatever dosages are imposed upon them. Somehow, I would think that to be the general case and I would suspect that that would be the kind of research that you would feed into your own requirements. It would seem to me to be dangerous for you to do otherwise.

Dr. TAPE. As I said, the initial reference levels have tried to take into account that for medical purposes one does have this somewhat average value that you would expect him to be receiving.

Mr. DADDARIO. Dr. Lieberman, doesn't this get us back to our earlier discussion. Because we are operating on information that we are confident about but which is not absolutely precise, that we ought to in all of these areas, including radiation, do the amount of research necessary to be able to come to determinations as quickly as possible.

Dr. LIEBERMAN. I certainly think it is important that we do this research, Mr. Chairman. As I indicated, extensive work is going on. However, and this is a personal belief, I think we know a lot more about radiation and its potential effects and what to do about them than a lot of other things that we do not know very much about.

My wife, for example, is an avid coffee drinker and, if I were to ask the question "Well, is all the caffein you are taking in—does it have any carcinogenic possibilities?" I don't know whether it is known. I recall a statement made, I think it was by Dr. George Beadle, the geneticist, who is presently in Chicago, I believe, and was chairman of a group that the National Academy of Sciences had—Dr. Wolman can remember this—on the biological effects of atomic radiation. Dr. Beadle—I think he is the one—said that we are in beter shape in terms of assessing the potential effects and how to control them in connection with radiation than many other things that we accept on a daily basis. Now, once again, this does not mean that we should rest on our laurels. I think more work has to be done because of the unique aspects of this particular possible insult to use as human beings. So while I agree completely with your comment that this research has to be done to pin this down better, I am simply indicating that I think there does exist the basis for the rational development of this industry and its control.

Mr. DADDARIO. I find no disagreement with that. I think we are doing marvelously well. I think it is quite obvious that this is the situation. We are involved with a program which just a short while ago people could not even believe. It is now in a sense becoming a way of life. There is a tendency when this happens for us to accept things and to do less than we ought to. We do have regulatory controls which are imposed in this particular area and we, therefore, have an extra responsibility. We know it happens in any place where some heated water goes into a river, such as the Connecticut River. Everybody gets up in arms because they think of all the problems, not just those attendant to that emission, but they begin imagining everything else. This has a great effect on the whole psychological structure of an area.

I recognize your problems, and I do not in any way mean to be critical about what you are not doing. You are doing a great deal, but I do think it is important for us to understand that at a time when activities in this field become more and more commonplace and become accepted as a way of life, that is the time when it could be more dangerous.

Dr. LIEBERMAN. This is quite right, I fully agree with that. I think this in itself is justification for carrying out the kind of research and development program that is being done.

Dr. TAPE. I also think that in all of these areas, not just the radiation area but in all of them, we are operating with what I call moving targets.

We may have a certain evaluation today but additional research, development, additional experience may change our views in 10 years. That is what I consider to be a moving target.

Mr. DADDARIO. Commissioner Tape, that is exactly how I feel about it. We must recognize that these are moving targets and that there is so much to be done and we ought not to take a ho-hum attitude about this. In a sense, we are beginning to. The great part of your work is still ahead of you from the standpoint of how you will be able to come to judgments about certain things. If we can recognize that and give a continued sense of urgency to what you are doing we may all do a better job. This is partially our responsibility in the Congress. It is of vital urgency to us to accomplish more while, at the same time, making certain we are doing all these things at the highest level of competence that we can. You give every indication in your testimony today that that is what you are doing.

Mr. Brown?

Mr. BROWN. Let me ask just a question or two on this moving target theme.

There has been a very major growth in nuclear power capacity over the last 10 years, as your chart and presentation show. You have made projections going to the next 20 to 50 years. Roughly, what kind of an annual growth rate in nuclear power capacity have you been projecting to get these figures? Or do you do it on that basis when you are estimating the amount of waste that will be produced in 1990 or 2020, for example?

Dr. LIEBERMAN. Mr. Brown, one comment I would make there is that the estimate we made at the time of the paper that the chairman referred to earlier, and what happened in 1967 did not check out. The industry grew at a much more rapid rate than was estimated. I think that the estimates that are made go something like this: By the year 2000, half the installed capacity will be nuclear and by 1980 its percentage is something like maybe 25 or 30 percent.

Mr. BROWN. The amount of total installed capacity?

Dr. LIEBERMAN. The total installed capacity from nuclear sources.

Dr. TAPE. Mr. Brown, one has to realize that we work closely with the Federal Power Commission in trying to look to the future as to what the total requirement may be. Then with some feeling for the total requirement, our people can look at various areas of the country and see to what extent we feel that the utilities may be moving in a nuclear direction or in a fossil direction. We have to make some judgments as to what this may be like at that time. Earlier when Dr. Lieberman was talking about electricity for a certain region, it was the Federal Power Commission that provided that kind of background information.

So it is a judgment, then, of two kinds: One, what the total is apt to be and, then given the total, what is the break between the two, fossil and nuclear, apt to be. That is the way we develop our estimates. You can see that some of these are pretty fuzzy. When we came out about a year ago with our 1980 estimate we said 120,000 to 170,000 megawatts. You may say to me that is a pretty wide range; but the point is that the actual nuclear power growth pattern is determined by the selections by the utilities and is not in our hands. It is the public and the utilities who make these selections.

So it has to be pretty broad. But having made the estimates, then Dr. Lieberman's group can go ahead and try to say "All right, if that is the situation then these are the quantities of wastes we might anticipate."

Mr. BROWN. But we are talking here about a growth rate in which installed capacity is probably doubling every 10 years or something of that magnitude.

Dr. TAPE. That is right.

Mr. BROWN. This kind of a logarithmic curve produces tremendous changes. For example, that figure of 3 acres of salt mine, if you are doubling every 10 years you are going to need 6 acres in 10 years, and 12 acres in another 10 years.

Dr. LIEBERMAN. That is the figure of 2000. You are quite right, if indeed beyond 2000 the demands for energy increase at the rate of doubling every 10 years, then that is what we are going to have to contend with.

Dr. TAPE. There are some other problems that are going to enter into this, if you start looking that far in the future and assume a doubling every 10 years. The water that is available for cooling may be a limitation on how rapidly this expansion transpires. There may be a number of other limitations that come in. We may not be able to double every 10 years. So there are many other factors that come into this, not all related to nuclear power in any way.

Mr. BROWN. Your projections haven't gotten to the point where you see any leveling off of this process? You have not projected a steady state situation.

Dr. TAPE. Well, we have cut off at the year 2000 because we realize that to continue that kind of a projection is hard to rationalize right now. I think most of us—there are many utility people too—have considerable difficulty just imagining what these systems are going to be like 30 years from now.

Mr. BROWN. Unfortunately, there are a lot of curves in our society today which have this same characteristic. What about the growth in other areas of the world, other than the United States? Do you project similar patterns of growth in installed nuclear capacity?

Dr. TAPE. We do the same thing on an international basis, not in the Soviet bloc sphere but in the rest of the world. These percentages vary depending on the country, the locale, and so on.

One can be misled a little bit because there are areas in which the present electrical generating capacity now is very small. So they are in a catch-up role and may be doubling every 5 years. Others that are somewhat more like ourselves, then their growth rates are something like ours.

On the other hand, in certain areas of Europe where they have, for example, been importing coal from us, the economic pressures on them to go to the nuclear route are higher than they would be, let's say, in our country. So one has to make a region-by-region evaluation. One finds lower growth rates, higher growth rates, one finds some areas where nuclear is moving more rapidly than we are. England, for example, had more megawatts on the grid than we did. These are matters of time and how they develop.

Mr. BROWN. It bothers me a little to see these projections made for a period of time which it appears as if we can handle the results, yet in a very short period of time after that for reasons which are uncontrolable, we could not handle the results. For example, the total water supply of the United States. I am becoming more and more concerned about the need to do planning for what you might call a stable state society, a condition of society in which these problems are solved rather than just saying, "Well, we cannot project what will happen in another 50 years."

Dr. TAPE. You are suggesting consideration of a very broad problem. My memory, for example, of the population that is figured into the year 2000 projection of ours is 300 million people—for the United States.

Mr. BROWN. And about 7 billion for the whole world.

Dr. TAPE. We have based these evaluations on 300 million people for the year 2000. Actually, I am afraid we are going to have have many, many other problems with 300 million people that just the electrical power problem.

Mr. BROWN. We are going to have many others. Well, I do not want to pursue this any further, Mr. Chairman, but I think it is a significant problem.

Mr. DADDARIO. Commissioner Tape and Dr. Lieberman, we still have a number of other questions which we will submit for the record. We do have two other witnesses who I hope we might hear before the day is out.

Dr. TAPE. We would be pleased to supplement in any way that you like.

Mr. DADDARIO. Thank you. We will be in touch with you. We do appreciate everything you have said. It has been a very interesting morning for the subcommittee.

Dr. TAPE. Thank you very much.

Dr. LIEBERMAN. Thank you.

## QUESTIONS SUBMITTED TO DR. JOSEPH A. LIEBERMAN BY THE SUBCOMMITTEE OF SCIENCE, RESEARCH, AND DEVELOPMENT

*Question 1. The central question is whether we are proceeding to count on nuclear energy to fill our power requirements* before *all the dangers have been identified, techniques for eliminating them have been devised, and a complete cost-benefit analysis performed. The pressure of economics, the momentum of a commercial power reactor program, and tendency for the short term gain at the expense of long term environmental effects makes this question very important now. What research strategy is being followed to gain confidence that nuclear power will be a tolerable factor in the world of tomorrow?*

Answer. The nature of radioactivity as a potential hazard to man and his environment and the importance of satisfactory radioactive effluent control were recognized when the atomic energy program was conceived under the auspices of the Manhattan Engineer District in 1942. As a consequence, careful attention has been given by the Atomic Energy Commission from the outset to the measurement, evaluation, and control of potential hazards to the environment from all Commission production and developmental activities.

In the planning and development of nuclear and reactor technology over the past 20 years, it has been a continuing research policy of the Commission to

thoroughly study all nuclear safety and radioactive effluent control aspects of each project as an integral and essential part of the program. Similarly, in the planning and conduct of its waste management research and development program, the Commission has always considered the satisfactory treatment and permanent disposition of all waste materials as a prime requisite for all program activities. To assure the safe and successful development of advanced reactor and fuel reprocessing technology for the expanding nuclear power industry and in order to maintain the industry's safety record of the past 20 years, the AEC waste management program will continue to emphasize a "preventive" approach in these activities rather than a "curative" one.

Briefly stated, the "strategy" is to:

(*a*) Identify, define and characterize potential problems,

(*b*) Investigate the phenomenology associated with the possible problems,

(*c*) Develop technology as required to properly cope with the problems, and

(*d*) Apply the technology as engineered systems or processes, procedures, or other control mechanisms.

*Question 2. "If" there is an agreed upon life time exposure limit to ionizing radiation, how much is consumed by natural background, x-rays for health purposes, fallout, etc.? In other words, how much leeway do we have for additional radiation from nuclear power plant effluents, bomb testing, "plowshare" type emissions, etc.? How does this leeway decrease with the predicted future growth of nuclear power?*

Answer. No limit has ever been established for the maximum ionizing radiation dose a person should be allowed to receive in his life time. The Federal Radiation Council (FRC) in its first report, dated May 13, 1960, recommended radiation protection guides for the use of Federal agencies. These guides, which are generally consistent with the recommendations of the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), have been adopted by the Atomic Energy Commission in the development of its radiation protection standards.

The FRC guides are applicable only to man-made sources of radiation and are exclusive of the deliberate exposure of patients by medical doctors. The basic recommendation for general population exposure is that the yearly radiation exposure to the whole body of individuals in the general population should not exceed 0.5 rem. It was recognized that under certain conditions, such as widespread radioactive contamination of the environment, the only data available may be related to average contamination or exposure levels. Under these circumstances, it is necessary to make assumptions concerning the relationship between average and maximum doses. The FRC suggested the use of the arbitrary assumption that the majority of individuals do not vary from the average by a factor greater than three. Thus, it was recommended that a guide value of 0.17 rem be used for yearly whole body exposure of average population groups.

When the size of the population group under consideration is sufficiently large, consideration must be given to the genetically significant dose. The FRC endorses in principle the recommendations of the NCRP and ICRP conecrning population genetic dose, and recommends the use of the Radiation Protection Guide of 5 rem in 30 years (exclusive of natural background and the purposeful exposure of patients by practitioners of the healing arts) for limiting the average genetically significant exposure of the total U.S. population. The use of 0.17 rem per year as a means for assuring that the individual whole body dose is not exceeded, is likely to assure that the gonadal exposure guide is not exceeded in the foreseeable future.

The following table is taken from FRC Report No. 1. Though this report is almost 8 years old, the dose estimates are substantially unchanged. The estimated per capital 30-year dose resulting from all weapons tests conducted through 1962 was 110 millirem. Atmospheric tests conducted since 1962 have not significantly increased this estimate.

*Estimated annual exposure of U.S. population from all sources of ionizing radiations—Average annual genetically significant dose to the population (millirem)*

| | *Irradiation* |
|---|---|
| Natural sources: | |
| External | |
| Cosmic rays | 32–73 |
| Terrestrial gamma rays | 25–75 |
| Internal: | |
| Potassium–40 | 19 |
| Carbon–14 | 1.6 |
| Radium–226 | 2 |
| Medical (exposure of patients): | |
| Diagnostic X-rays | 40–240 |
| Therapy | 12 |
| Internal (radionuclides) | 1 |
| Occupational | 20 |
| Environs (including waste disposal) | 5 |
| Other (luminous dials, TV, etc.) | 2 |
| Total | 160–450 |

It should be noted that of the 160–450 millirem estimated average annual population dose, less than 30 millirem is attributed to the atomic energy industry. This is less than 20% of the recommended guide for the average annual population exposure.

With regard to the question concerning the predicted future growth of nuclear power, no difficulty is anticipated in maintaining the environmental exposure level well within accepted health and safety standards.

*Question 3. In your testimony you discussed how the AEC obtains outside assessments and reviews. What built-in assessment mechanisms exist within the AEC? Who arbitrates disputes between the regulatory or licensing functions and the reactor development people?*

Answer. There are three organizational units within the Atomic Energy Commission which have responsibilities in the licensing and regulation of nuclear power plants. These are the AEC's regulatory staff, the Advisory Committee on Reactor Safeguards, and the atomic safety and licensing boards. Each of these groups is organizationally separated from the Commission's operating organization. While they have the benefit of information which flows from the Commission's operating and development activities, none of them has any operating responsibilities. Their sole responsibility is in the field of nuclear safety and related regulatory matters. Each group is independent of the others.

Technical reviews and judgments have to be made on licensing applications by each of these groups, then the Commission, in the following order:

(*a*) Review by the regulatory staff. This is performed principally by the AEC's Division of Reactor Licensing, which calls upon many technical disciplines.

(*b*) Review by the Advisory Committee on Reactor Safeguards, as required by law. The ACRS is a 15-man committee appointed by the Commission, and is composed of scientists and engineers with extensive experience in various fields related to reactor technology.

(*c*) Review by a three-man atomic safety and licensing board after a mandatory public hearing. The board is drawn from the Atomic Safety and Licensing Board Panel appointed by the Commission. The Panel is made up of technically qualified experts and persons experienced in administrative procedures.

(*d*) Review by the Commissioners themselves—formally if an appeal is taken from the initial decision of an atomic safety and licensing board, or informally if no appeal is filed.

These reviews occur at both the construction permit stage and the operating license stage, except that a public hearing is usually not held and an atomic safety and licensing board is usually not appointed for the operating license stage. Commission-owned power reactors located at non-AEC sites and operated as part of conventional utility systems are not licensed. However, procedures which are parallel to those described above are used in the issuance of authorizations for construction and operation of these reactors.

In addition to the regulation of licensed facilities and AEC-owned power reactors operated by utilities, the regulatory staff and the ACRS review the safety of reactors owned by the AEC and the Department of Defense. On an internal basis within the AEC, any disagreement between regulatory and reactor development program personnel is normally resolved on the staff level, with the benefit of consultation with technical staff at Commission field sites. In infrequent cases, it may be necessary to refer certain technical issues to the Director of Regulations and the General Manager for resolution. Finally, any continuing disagreement could be referred to the Commission itself for disposition, taking into account the views of the independent ACRS.

*Question 4: In your testimony you indicated that the AEC routinely sends licensing applications to the Fish and Wildlife Service for comments, and that their recommendations are "incorporated in whatever requirements the regulatory people came up with and which a license would have to meet".*

*(a) What other agencies does the AEC routinely send applications to?*

*(b) Have there been disagreements, and, if so, who makes the final decision?*

Answer. (*a*) In conducting its safety reviews of applications for permits to construct nuclear power plants, the AEC seeks the advice of expert consultants as well as of persons of specialized competence within the regulatory organization. The regulatory staff calls upon the expertise of other Federal agencies in such fields as meteorology, hydrology, geology, and seismology.

In addition to the U.S. Fish and Wildlife Service, whose recommendations are requested with respect to potential radiological effects on fish, other marine life and wildlife, the AEC routinely uses the technical capabilities of the U.S. Geological Survey with respect to the geological aspects of the site; the U.S. Weather Bureau with respect to meteorology; and the U.S. Coast and Geodetic Survey with respect to seismology.

Where the need is indicated, advice also is obtained from other Federal agencies as may be appropriate. For example, the U.S. Army Coastal Engineering Research Center has furnished hurricane data on coastal areas for the purpose of establishing whether special protective construction should be required, and the Naval Ordnance Laboratory has furnished advice concerning the effects of explosives and missiles on structures.

In addition to consultation with experts from these Government agencies, the AEC consults with experts from its National Laboratories, the universities, and private organizations on special problems.

A copy of each nuclear facility licensing application also is furnished to the U.S. Public Health Service for its information in maintaining its state relations activities.

(*b*) The advice of other agencies in their particular areas of expertise is used in the same manner as information developed by the AEC staff to form a basis for decisions as to the adequacy of the facility's design and location from the standpoint of public health and safety. There have been no substantive areas of disagreement pertaining to the radiological safety matters over which the AEC has jurisdiction. The recommendations of the agencies which routinely submit formal reports on those projects referred to them are incorporated in the regulatory staff's Safety Evaluations, and become a part of the public record.

*Question 5. Regarding the doubling of installed capacity from nuclear power sources every ten years, Dr. Tape indicated that water available for cooling may be a limitation on how rapidly this transpires. Would you expand for the record how this may be a limitation, and what alternatives are involved?*

*(a) What are the other limitations referred to regarding doubling every ten years?*

Answer. Before responding to the importance of cooling water and the effect of its availability, on the growth of nuclear energy the growth estimates referred to in the question should be clarified. The *entire* electric generating capacity is expected to double every ten years. According to the Federal Power Commission's National Power Survey published in 1964, electric energy requirements were .85 x $10^{12}$ KW-hr in 1960, will be 1.6 x $10^{12}$ KW-hr in 1970 and 2.8 x $10^{12}$ KW-hr in 1980. In other words, the demand for electric power generated from all types of fuel is expected to approximately double each decade through 1980. Nuclear power is expected to have a much faster rate of growth during that period with a doubling time of roughly three years. This short doubling time for nuclear power growth is possible only because the total nuclear power

generating capacity is extremely small relative to the total national generating capacity. At the present time nuclear plants produce approximately 1/1500 of the total power generated by the steam-electric plants in this country. Thus, the growth rate when expressed as a percentage increase of previously installed capacity gives a large rate increase at this time. These percentages are of little or no meaning by themselves, in analyzing cooling water requirements. Such an analysis requires estimates of the amount of heat that must be "dumped". In this regard it is essential to note that the steam cycle requires heat removal regardless of the fuel used to produce the steam. Thus, approximately until the year 1995, based on current estimates, the combined cooling water requirements of all nuclear power plants will be less than the combined requirements of all fossil fuel plants.

A quantitative answer to the question is not possible at this time, although the AEC is supporting a demonstration of a technique for estimating cooling water availability. A computer program developed at Hanford for calculating temperature increases in the Columbia River downstream of the production reactor coolant discharge is being applied to the Upper Mississippi River basin. The program, if successful, should provide the capability for computing the generating capacity the river basin can support, without the use of cooling towers, in accord with established water quality control criteria. If the demonstration is successful, the technique may be applied to other river basins in the U.S. By using this technique, coupled with estimates of energy requirements by area of the U.S., it should be possible to estimate when alternate cooling methods, such as cooling towers, are required in each area.

As an alternative to the use of cooling towers for reducing the quantity of heat released to the environment, during recent months there have been reports of using heated effluents for beneficial purposes. For example, in western New York a utility company in cooperation with the State Conservation Department has announced plans to use condenser discharge water to hatch Coho salmon eggs in Lake Cayuga, New York. Also, the use of large cooling ponds for heated condenser waters followed by use of this water for agricultural irrigation purposes is receiving consideration in the planning of a thermal electric plant in the Pacific Northwest.

*Question 6. Please summarize for the record, as requested by Mr. Mosher, your experience in transporting radioactive materials. What is normally involved; what happened in the truck terminal incident; have casks containing the materials broken; what is the worst situation one might expect, and what is being done to guard against it?*

Answer. Regarding the question of what is normally involved in the shipment of significant quantities of radioactive materials, care must be taken to assure that in the event of an accident, the structural integrity of the cask is maintained such that its radioactive contents are not released to the environment thereby presenting a possible public hazard, and to ensure that there is adequate shielding to prevent a direct radiation hazard to personnel in the immediate vicinity of the cask.

Both the Atomic Energy Commission and the Department of Transportation have responsibilities for regulation of the transportation of radioactive materials. Over the past several years, these agencies have cooperated with each other and with the International Atomic Energy Agency, to develop improved packaging standards and requirements for the transportation of radioactive material. Substantial progress has been made, as reflected in the AEC's regulation 10 CFR Part 71, "Packaging of Radioactive Material for Transportation", effective August 22, 1966, and Notice of Proposed Rule Making, published by DOT on January 20, 1968, which would update DOT regulations in the area of safe transportation of radioactive materials and make them compatible with IAEA and AEC regulations.

As noted in our earlier statement, the shipping experience of AEC contractors and licensees has been exceptionally good. During the shipment of about a half million packages from 1957 through 1966, there were 99 transportation accidents involving AEC radioactive materials. Of these, 70 accidents caused damage to the vehicle or package but without releasing any radioactive material from the package. In the remaining 29 accidents the package was breached; however, in 18 of these cases the released radioactive material was confined to the vehicle. No accidents have occurred involving irradiated fuel shipments in which the shipping cask was breached. With one exception, the 11 times in which radioactive materials escaped beyond the confines of the vehicle, only very minor

levels of contamination occurred. The most serious accident, which occurred in January 1963, resulted from the leakage of radioactive material which had been improperly packaged. The leakage caused part of a truck terminal to be closed for several days for decontamination. This incident involved the shipment of a 13 gallon glass carboy containing 8.4 gms of plutonium and 498 gms of gold chloride in 6 gallons of acidified solution. During transit, plutonium-contaminated liquid leaked from the glass carboy (with a loosely-fitting ceramic stopper) and contaminated several trailers, truck terminals, a number of packages of other materials, and several persons handling the materials. The leakage was detected during routine monitoring of the unloading platform after the shipment was unloaded at its destination. The glass carboy was packed in a wooden box which was marked "this end up". The box also had pallets on its sides, however, and when placed on its side, the material slowly leaked out of the container. The carboy was not surrounded on all sides by an absorbent material sufficient to absorb the entire liquid contents, and therefore, was not in compliance with regulations pertaining to radioactive liquids. Neither was it in compliance with regulations pertaining to the shipment of acids. No personnel injuries resulted from this incident. The cost of decontamination was estimated to be $27,500.

The worst accident situation one might expect is generally considered to be a high speed collision of a vehicle transporting irradiated fuel with another vehicle transporting a highly flammable liquid, subjecting the shipping cask to an intense fire. To prevent the escape of significant quantities of radioactive material under these conditions, primary reliance is being placed on adequate cask design and fabrication specifications as established in regulatory safety standards. It must be demonstrated that the casks will withstand a set of hypothetical accident conditions which includes a free drop through a distance of 30 feet onto an unyielding horizontal surface, followed by a puncture test consisting of a 40-inch drop onto a 6-inch diameter steel bar, followed by exposure for 30 minutes to a fire having a temperature of 1,475° F., followed by a 24-hour water immersion test.

*Question 7. Please provide more detail on other agency employees who have worked or are working within the AEC. Why was this type of arrangement started; how many people are involved; what do they do within the AEC? How is coordination maintained with the parent agency after the people have left the AEC?*

Answer. One of the important and unique features of the Commission's operational and research and development activities in the radioactive waste management field has been, and continues to be, the utilization of specialized technical competencies of other federal agencies on a day-to-day direct working assignment basis. From the beginning, it was clearly recognized that the overall problem of safe handling of radioactive waste materials required the competencies of a broad spectrum of scientific and technical disciplines including the various engineering fields, the earth sciences, and the physical, chemical, and biological sciences. Accordingly, AEC funds have been allocated to a number of federal agencies to carry out specific programs in the disposal of radioactive wastes, and the associated environmental studies. Examples of this cooperative effort through the years include:

(1) U.S. Geological Survey (USGS), in connection with disposal in land and stream environments.

(2) U.S. Weather Bureau, now Environmental Science Services Administration (ESSA), in relation to gaseous and particulate effluent control.

(3) U.S. Public Health Service (USPHS), in relation to the disposal in surface streams and sea disposal.

(4) U.S. Coast and Geodetic Survey, in connection with sea disposal activities and seismologic factors.

(5) U.S. Fish and Wildlife Service, in connection with sea disposal operations.

(6) U.S. Bureau of Mines, in relation to R&D on disposal into the lithosphere.

Included in these arrangements is the assignment of technical personnel from these agencies to the AEC installations and offices on a full-time basis to assist in solving waste management problems, and to participate in R&D activities in this area. Examples include the ESSA group at NRTS; USGS group at ORNL and NRTS; the USPHS group at ORNL; and USGS and ESSA technical personnel in AEC Headquarters. Approximately 20 to 25 outside agency personnel have been involved at one time at AEC field installations and Headquarters. While

technical staff change in these programs, a continuing coordination is maintained by the AEC with the U.S. Geological Survey through the Office of Radiohydrology of its Water Resources Division, and with ESSA through its Air Resources Environmental Laboratory.

The experience obtained by personnel assigned to AEC from other federal agencies has also been reflected in increased awareness by these agencies of matters relating to atomic energy, and has resulted in increased capability to be responsive to AEC needs.

*Question 8. The Committee has heard testimony to the effect that a nuclear power plant under construction near Oswego, New York, (Nine Mile Point) will release to the environment each day an amount of radioactive material equivalent to 130 grams of radium. Is this a correct statement and what is the significance of this radioactivity discharge rate?*

Answer. We assume that this statement is intended to mean that radioactive materials which might be discharged from the Nine Mile Point Reactor would have an impact on public health equivalent to the daily discharge of 130 grams of radium. If this is the intent, the statement is not correct. From the point of view of possible effects on health, radioactive materials released into environmental air or water are sometimes compared in terms of their maximum permissible concentrations in these media. Although this basis of comparison is generally more valid than any other that can be conveniently made, its validity may be severely limited as indicated below.

If one were to use this basis to compare with radium the various radioisotopes discharged from nuclear power reactors similar to that under construction at Nine Mile Point, the comparison would, with perhaps one exception, lead to estimates that the daily discharge of radioactivity would be equivalent to a very small fraction of one gram of radium. The exception is the discharge of very short-lived isotopes of krypton which, on this basis, might be considered equivalent to several grams of radium per day. The comparison, however, is not meaningful from a public health consideration since these isotopes of krypton undergo radioactive decay so rapidly that essentially none of the radioactivity remains after a few hours. Radium, on the other hand, persists for thousands of years

Most of the radioactive materials released to the environment by reactors of the type in question are in gaseous form and are released through tall stacks. In this manner, the radioactivity concentration is reduced by at least a factor of 1000 before the stack effluent returns to ground level. The principal radioactive constituents of the stack gas are isotopes of the noble gases, xenon and krypton. Since these gases are chemically inert, they are not taken up by the human body to any significant degree, and hence present only an external radiation hazard. Approximately 95% of the gaseous radioactivity released from reactors of this type is attributable to radionuclides having half-lives of less than 10 hours. Krypton-85, whose half-life is 10.4 years, comprises 0.007% of the total gaseous radioactivity. All other radionuclides present have half-lives less than 12 days. The discharge limit for all noble gases is generally about 1 curie per second. Experience indicates that the actual stack radioactivity discharge rate will be only a small fraction of this value. More restrictive limits are placed on the discharge of halogens, such as iodine-131, and particulates which might be present in trace quantities.

As discussed earlier, in order to determine a radium discharge rate equivalent to the above radioactivity release rates, the established maximum permissible concentrations must be considered. The MPC is listed below for each of the radionuclides of primary interest here.

*Maximum permissible concentrations*

| | |
|---|---|
| Radium-226 | $2\times10^{-12}$ Micro curies/ml |
| Iodine-131 | $100\times10^{-12}$ Micro curies/ml |
| Krypton-85 | $300{,}000\times10^{-12}$ Micro curies/ml |

As indicated above $Ra^{226}$ is 150,000 times more radiotoxic than $Kr^{85}$.

A comparison of the MPC for each of the above radionuclides indicates that the release of one curie of radium-226 (approximately one gram), in the form of an aerosol, would result in a radiological hazard roughly equivalent to the hazard one would expect from the release of 50 curies of iodine-131 or 150,000 curies of krypton-85. Some krypton radionuclides ($^{87-88}Kr$) have an MPC as low

as $20{,}000 \times 10^{-12}$ micro curies/ml; however, their half-lives are only 1.3 and 2,8 hours. Thus, they do not present the long-term hazard presented by radium-226 with its 1620 year half-life.

Based on a previously noted stack release limit of 1 curie per second for noble gases, 86,400 curies of these noble gases could be discharged to the atmosphere daily. If this were all krypton-87 and 88, it could be considered equivalent to 8.6 grams of radium. This is not a valid comparison, however, because of the difference in half-lives. A more meaningful comparison is possible with krypton-85 (10.4 yr. half-life). Of the total daily discharge, 0.007% or about 6 curies would be krypton-85. This would present a radiological hazard equivalent to the release of 6/150,000 or 40 millionths of a gram of radium-226.

Considering the discharge limit for halogens and particulates, one can conservatively estimate a daily discharge rates of 0.0864 curies of iodine-131. This might be considered the equivalent of 0.0017 grams of radium.

(Dr. Lieberman's prepared statement follows:)

PREPARED STATEMENT OF DR. JOSEPH A. LIEBERMAN, ATOMIC ENERGY COMMISSION

1967 has been an eventful year in the growth of the nuclear power industry. The rate at which electric utilities have ordered nuclear power units has been remarkable, even to those who are close to the industry. By the end of 1967, approximately 50,000 megawatts of nuclear electric power hand been firmly commited, with about 2000 megawatts of plant capacity now in operation. This rate of growth is even more remarkable when one considers that it was only ten years ago (December 1957) that the first commercial plant—the Shippingport Atomic Power Station operated by the Duquesne Light Co.—went on the line to supply 60 megawatts of electricity to the city of Pittsburgh.

The most significant aspect of this nuclear power growth is that the safety and reliability of light water reactors have been established and nuclear plants now being planned or under construction are being built on the basis of their economics. While economics have played a major role in this surge of nuclear power, another advantage of nuclear power plants in that there has been a growing awareness of their advantage as clean sources of power which do not contribute to the current burden of air pollution. In fact, some utilities have chosen nuclear power and have indicated that in so doing, they wished to reduce air pollution.

The management of radioactive waste effluents from commercial nuclear power plants continues to be carried out on a highly satisfactory basis; operational records for the past 7–10 years indicate effluent discharges of less than 10 per cent of internationally accepted radiation protection limits. The following material presents summary information as requested on specific aspects of radioactive effluent control.

FUTURE WASTE MANAGEMENT PROBLEMS

With the recent surge of the nuclear power industry, some people have expressed concern that a serious environmental pollution problem would result from this growth; similarly, others have been concerned that the development of safe and economical nuclear power might be deterred because of the waste disposal problem. In this connection, the management of radioactive wastes resulting from the processing of spent fuel elements from nuclear electric power plants is a major consideration. The highly radioactive waste materials which are separated in this operation must be contained and isolated from man and his environment for literally hundreds of years. Long-term high activity waste management requirements are continually being evaluated, in order to guide the development and planning of the Commission's effluent control R&D program. This potential future problem was discussed at length, during hearings of the Joint Committee on Atomic Energy in 1959 when it was estimated that, using the then current processing technology, the volume of high and intermediate level wastes accumulated by 1980 would reach 36 million gallons.

Since the time of these hearings, extensive improvements in fuels technology and fuel reprocessing methods have markedly reduced the volume of high-activity reprocessing wastes which are generated per unit of nuclear power produced. Also, during this period of nine years, estimates of installed nuclear power in 1980 have risen by a factor of 5–7—from 25,000 $MW_e$ in 1959 to the present 120,000–170,000 $MW_e$ forecast. However, the estimated accumulated high-activity

waste to be handled by 1980 has dropped by a factor of about 7—from 36 million gallons to approximately 5 million gallons. Even with the currently projected nuclear power growth rate, the accumulated waste volumes by the year 2000 are estimated at about 80 million gallons, which is comparable to the high activity waste volumes which have been satisfactorily managed by the Commission in its operations to date.

These estimates are based on an assumption that the wastes would be stored as liquids for long terms in underground tanks. However, with the satisfactory development of processes for conversion of high-level liquid wastes to stable solids (now in the engineering demonstration phase), with subsequent long-term storage or disposal ina dry geologic formation such as salt (now in the field testing stage), technology for an alternative waste management system will become available. With adoption of a conversion-to-solids waste management concept, approximately 1 cubic foot of solid waste would be produced per hundred gallons of high-activity waste (per 10,000 $MW_e$ of fuel exposure). Preliminary engineering and economic evaluations indicate a 30-year interim storage of waste solids would be desirable before final disposal; by the year 2000, the rate of production of waste solids for final disposal or long term storage would require about 2.8 acres of salt mine floor space per year. (Additional information on salt disposal is provided under the Section "Long-term Safety of High-Activity Waste Storage".)

During the past year, various task force groups have been involved in an extensive cooperative effort to update the 1962 Report to the President on Civilian Nuclear Power. Included in this effort is a study of nuclear power growth patterns in the U.S. to the year 2020 in order to determine the size and location of fuel reprocessing plants and associated waste management requirements. An up-to-date comprehensive long-range waste management plan is also being developed, taking into account the latest power projections and fuel reprocessing plant size and locations, in order to determine the number and size of permanent high-activity waste storage sites which may be required. It is planned that reports of these studies will become available to industry and the public upon their completion.

In a related question, some concern has been expressed on the decommissioning of power reactors and the associated disposition of the reactor site, if this should be required. Nuclear power plants are currently being built using a design life basis of forty years. If, for some reason, it is decided to retire the plant, procedures for dismantling the plant would be subject to Commission approval and would be required to meet the Commission's standards for protection of the worker and the general public. Decommissioning alternatives, which require evaluation, include varying degrees of "moth-balling" the plant, i.e., decontaminating, dismantling and removing the facility (in whole or in part) and burial in place or at an approved disposal facility. Procedures for these operations must be submitted to the Commission in accord with its regulations, to assure that adequate safety measures will be taken in the course of decommissioning the reactor, and with respect to any sources of radiation that may thereafter remain at the site. Experience is being gained in moth-balling plants, such as the Hallam Nuclear Power Facility in Nebraska and the Carolinas-Virginia Tube Reactor in South Carolina, which indicates that power reactors can be decommissioned safely.

## TRANSPORTATION OF RADIOACTIVE MATERIALS

The principal hazards which must be guarded against during the transport of radioactive or fissile material are accidental criticality (nuclear chain reaction) and release of radioactive material or radiation because of loss of containment or shielding as a result of impact or exposure to a severe fire. These hazards are avoided by specifying the shipping conditions, carefully controlling the quantity of fissile material which may be shipped in a single container, and by designing and fabricating the shipping containers to withstand a series of hypothetical accident conditions, including severe impact and fire. Each shipment, including container design, must meet the requirements of various regulatory agencies, including the AEC and the Department of Transportation.

The shipping experience of AEC contractors and licensees has been exceptionally good. During the transportation of this material there has been no death or injury due to the radioactive nature of this material.

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A continuing research and development program is being supported by the AEC to assure that the engineering technology is adequate to satisfy the needs of the cask designer. A shipping cask design code is presently being developed for the use of the industry at the Oak Ridge National Laboratory (ORNL) in Tennessee. Other research is underway to develop a substitute for lead as the primary shielding material in large shipping casks because of its relatively low melting point. Future R&D is anticipated in the area of fast breeder reactor fuel shipping, as an integral part of the Commission's Fast Breeder Reactor Development program.

### LONG-TERM SAFETY OF HIGH ACTIVITY WASTE STORAGE

More than 20 years' experience with the storage of liquid high-activity wastes in specially designed underground tanks have shown it to be a safe practical means of interim handling, but the long-term usefulness of this method may be limited. Assessments have been made which indicate that large releases of radioactivity due to geologic and hydrologic events are only remotely possible in the areas where high-activity wastes are stored. These studies have included an evaluation of the historic record of seismicity and the longer-ranging geologic record, including investigation of geologic structure; physical and hydrologic properties of sediments and rocks; and analysis of terrains in the vicinity of high level waste management operations. Studies of extremely unlikely hydrologic events are being continued in a further effort to specify their probability of occurrence and potential effects on nuclear facilities and associated waste management systems.

Due to the inherent restrictions of tank storage, such as potential leakage and the necessity of liquid waste transfer for periods of hundreds of years, the Commission has supported an extensive research and development program directed at engineering practical systems for conversion of high activity liquid waste to a solid form. Concurrently, extensive studies have been carried out to determine the most suitable geologic formations for the long term storage of highly radioactive waste material. Salt is an advantageous disposal media because of its unique geologic characteristics. Salt formations are dry and impervious to water. They are not associated with usable ground water sources and, therefore, have no connection or contact with the biosphere. Because of its plasticity, fractures in salt seal or close rapidly. Deposits of rock salt underly some 400,000 square miles of the United States and represent some of the few naturally occurring dry environments in the eastern part of the country where the most extensive development of the nuclear industry is taking place. Extensive laboratory investigations at ORNL and field studies in the Carey Salt Mine, Lyons, Kansas, are providing field data and design information required for the engineering design of a long term disposal facility for high activity waste solids.

A field experiment called Project Salt Vault, has been carried out in which Engineering Test Reactor fuel elements of high-radioactivity were used to simulate the thermal and radiation characteristics of full-scale power reactor fuel reprocessing wastes, such as would exist in a pot containing calcined solids. The field demonstration began in November 1965—four successful changes of fuel elements were completed in June 1967. The experimental results from Project Salt Vault are now being evaluated and appear most encouraging. The feasibility and safety of handling highly radioactive materials in an underground environment has been demonstrated, and the stability of salt under the effects of heat and radiation has been shown. Engineering reports of this work will be available to industry during this year and the various factors involved in establishing a prototype salt disposal facility for the storage of high activity waste solids is now under study at ORNL. The use of other geologic materials for long term storage, such as crystalline bedrock, thick anhydrite, or limestone beds is also under study.

### WASTE MANAGEMENT RESEARCH

The management of radioactive waste materials in a growing atomic energy industry can be classified under two general categories. These are the treatment and disposal of large volumes of low activity gaseous, liquid, or solid wastes which are evolved during the course of operating reactors and other nuclear facilities; and the treatment and ultimate disposal of much smaller volumes of high activity wastes generated during the reprocessing of irradiated nuclear fuels. Significant progress and accomplishments have been achieved during the

past ten years in developing satisfactory waste management systems for both categories of waste. The success, over the years, of the Commission's waste management program is illustrated by the excellent effluent control record which has been achieved by the industry and AEC contractors. AEC production and research facilities and large commercial nuclear power plants limit releases of radioactive materials to the environment to concentrations which are only a small fraction of internationally accepted radiation protection standards. Highlights of the R&D program are briefly summarized:

1. Advanced low-level waste treatment and disposal technology involving the use of evaporation, ion exchange, foam separation, electrodialysis, water recycle, and asphalt solidification has been developed. This technology is now being used in the design of commercial power reactor and fuel reprocessing waste management facilities.

2. The disposal of actual intermediate level waste by hydraulic fracturing of shale has been demonstrated with an engineering-scale pilot plant at ORNL. This technique which was obtained from the petroleum industry, consists of injecting a waste-cement-clay mixture under high pressure through a slotted well casing into an impermeable formation at depths of, in the case of ORNL, 700–1000 feet. A hydrofracturing plant was placed in operation at Oak Ridge during 1966 for the disposal of evaporator slurries; the use of this disposal method at other sites is now under study.

3. The Waste Calcining Facility at the National Reactor Testing Station in Idaho became the world's first plant-scale facility for converting actual high-level radioactive wastes to a safer, solid form in December 1963. This plant has continued to operate satisfactorily over the past four years, during which time about 1.3 million gallons of high-activity aluminum type waste from the reprocessing of test reactor fuel have been solidified with a volume reduction to about 1/10 the original, and then stored in stainless steel bins in underground vaults.

4. The technology for solidification of power reactor fuel reprocessing high-level waste has reached the engineering-scale demonstration phase with a "hot"-pilot plant having been placed in operation at the Commission's Laboratories in Hanford, Washington, in November 1966. Operational data are now being obtained for three waste solidification processes using full-scale high activity waste; results of this program will be available for industrial use during 1969–70.

5. ORNL laboratory and field research involving the storage of high-level waste solids in a salt mine has culminated in a full-scale field test program at the Carey Salt Company Mine in Lyons, Kansas (details provided above). Results of this field study and engineering design information will be available for industrial use by 1969.

In brief, the waste management R&D program has been and is providing the technology to engineer systems for effluent control, as required by an expanding nuclear energy industry, and no "breakthroughs" are required to meet future loads. The nature and quantity of waste effluents from thermal and fast breeder reactors are being evaluated as development proceeds on these future reactor systems.

### WASTE RECONCENTRATION BY BIOLOGICAL ORGANISMS (ECOLOGICAL PROCESSES)

Certain radionuclides are known to be concentrated by biological processes in organisms. This concentration by biological processes may occur in the food chain leading to man. Four notable examples are the reconcentration of (1) cesium–137 from fallout in Caribou meat which is eaten by Eskimos; (2) phosphorous–32 by fish in the Columbia River from cooling water which passes through the Hanford production reactors and is then discharged to the river; (3) zinc–65 by shellfish, particularly oysters, that live in locations near the mouth of the Columbia River, and (4) iodine–131 in animal and human thyroid glands. The reconcentration of radionuclides in man's food chains must always be considered whenever radionuclides are released to the environment. The Commission takes into account reconcentration aspects in setting release limits to the environment from operating facilities. The U.S. Fish and Wildlife Service is regularly consulted on questions in this area.

In the case of waste released by power reactors and fuel reprocessing plants the radionuclides most likely to be reconcentrated are the iodine-131 released to the atmosphere and zinc-65 released to a water system. Evidence available from

the Clinch River Study (a comprehensive stream study carried out during 1960–64 by the AEC, ORNL, USGS, USPHS, TVA, the Tennessee Dept. of Public Health, the Tennessee Stream Pollution Control Board and the Tennessee Game and Fish Commission) indicates that the maximum accumulation of radionuclides entering the Clinch River from Oak Ridge National Laboratory operations which might concentrate in the biomass constitutes only an insignificant part of the radioactivity in the river. Thus the river system can be likened to a pipeline with little retention or concentration of radionuclides in either the bottom sediments or the biota.

If zinc-65 is to be released into or can be transported to a marine environment, special consideration must be given to its reconcentration. Zinc is concentrated by shellfish (1000–10,000 times); as an activation product, zinc-65 is present in the waste discharged by several light water reactor power plants and, where required, special limits can be applied to its release.

The gaseous wastes discharged by nuclear fuel reprocessing plants may contain small amounts (below permissible limits) of tritium, krypton-85 and iodine-131. Only iodine is capable of being concentrated by biological processes; however, the other radionuclides may be cycled by ecological processes. Iodine-131 appears principally in the food chain which leads through milk to man and the procedures for monitoring this food chain are well developed. Environmental monitoring data again indicate radioactivity concentrations well below those of public health significance.

### THERMAL EFFECTS OF STEAM ELECTRIC GENERATING PLANTS

The generation of electrical power produces waste heat which must be discharged to surface water or to the atmosphere via cooling towers. The average thermal efficiencies of different types of steam electric plants vary approximately as follows:

| | *Net thermal efficiency (in percent)* |
|---|---|
| Modern coal fueled plant | 38 |
| Modern light water reactor | 32 |
| Future fast breeder (calculated) | 40 |

Therefore, at the present time, a nuclear plant of current design discharges more waste heat to surface streams than a conventionally fueled plant of the same size because of a lower thermal efficiency. Of course, about ten per cent of the waste heat from a coal-fired plant is discharged to the atmosphere with the combustion gases, whereas essentially all of the heat discharged by a nuclear plant is through the water cooling system. When fast breeder reactors become operational, this disparity will be reduced.

Generally speaking, the problem of "thermal pollution" is one of degree. An increase in water temperatures can be harmful, or in some cases, beneficial to certain fish and aquatic life. The questions that must be answered are—what are the effects of small increases of temperature in various situations, and if harmful, how can these effects be avoided? The world's electric power demand will continue to grow at an ever increasing rate. Increasing quantities of waste heat will have to be dissipated, regardless of the proportion of coal-fueled to nuclear-fueled plants that are built. Large quantities of condenser cooling water (several hundred thousands gallons per minute for a 1,000 NWe plant of either type) will be required. As a result, the availability of adequate condenser cooling water is becoming a major consideration in selecting sites for these plants. Proper site selection requires information on the physical dispersion of heat in the environment and the effects of small temperature increases on the biota.

Research in this area has been underway for some time—for example, the AEC has sponsored research on the physical and biological effects of temperature on Columbia River for more than fifteen years. As a result, mathematical models are now being developed for predicting the increase in temperature of the receiving water from heated effluents which are discharged into rivers, lakes, and tidal systems. The reliability of these models is being determined against known conditions. A model has been used to predict temperatures of the Deerfield River downstream from the Yankee Atomic Reactor, Rowe, Mass., for example, and the predicted temperatures have agreed very closely with temperatures actually measured. This mathematical model development is being followed with an application of the model to the prediction of temperature increases throughout an entire river basin. The upper Mississippi River basin has been selected for the pilot effort.

In brief, the magnitude and severity of thermal effects problems from both nuclear- and fossil-fueled electric power plants depend on local environmental conditions. Proper site selection is becoming more important as the availability of adequate surface water supplies for condenser cooling becomes more critical. However, it should be noted that technology for solving potential thermal pollution problems is available. Auxiliary cooling systems (reservoirs, ponds, or cooling towers) can be a solution, but increased initial plant costs, in the range of 5–10%, may be required over a conventional river water cooling system. However, these costs may be offset by increased flexibility in site selection, which could result in lower costs for fuel, power transmission, and land, plus a lower heat rejection to the river.

EXTENT OF AEC POLLUTION RESEARCH PROGRAM

Extensive radioactive waste management and pollution related research and development have been carried out as an integral part of the Atomic Energy Commission's overall R&D program in order to assure an orderly growth and safe development of the nuclear energy industry. Approximately $30 million was spent during FY 1967 and about $31 million is budgeted for FY 1968 in the Commission's biology and medicine, reactor development, weapons, raw materials, production and isotopes development programs for this purpose.

Resources at AEC multiprogram laboratories are also being utilized in a number of pollution and environmental health studies being conducted in direct support of the objectives of other agencies. Now underway are two joint efforts with HEW's National Center for Air Pollution Control. One, conducted at AEC's Brookhaven National Laboratory on Long Island, is examining the economic and technical feasibility of using stable isotopes of sulfur to trace the migration and chemical reactions of oxides of sulfur emitted with stack effluents. The other is a joint program involving AEC's Argonne National Laboratory near Chicago, with the Department of Air Pollution Control of the city of Chicago and the National Center for Air Pollution Control. The objective of this tripartite effort is to develop an air dispersion model which will aid in the establishment of pollution control measures for the Chicago Metropolitan area.

At Brookhaven National Laboratory a study of the oxidation, by radiation, of iron in acid mine drainage has been conducted in order to assess the potential of this method in relation to other mine drainage treatment methods being developed by the Department of the Interior and the Department of Mines and Mineral Industry of the State of Pennsylvania.

During the past year Commission staff and representatives of the Departments of Commerce, Interior and HEW have discussed how resources available at AEC's multiprogram laboratories might be applied to pressing pollution control and abatement problems. The aforementioned programs and a number of proposed programs now being discussed have, in large part, resulted from this series of interagency meetings. The Commission is continuing its efforts along this line and is hopeful that other areas can be identified in which the experience and facilities available at its multiprogram laboratories can be used to make substantial contributions to solving pollution and environmental health problems.

Very recently, last year, Sec. 33 of the Atomic Energy Act was amended to authorize AEC to assist others on health or safety research and development problems unconnected with AEC's nuclear missions. This added authority will serve to provide AEC with more flexibility in utilizing its laboratories, facilities and talent to help others solve important national problems such as environmental pollution.

SUMMARY AND CONCLUSIONS

In summary, AEC strongly supports the efforts which are directed toward restoring and/or maintaining the quality of our environment—a goal which has become an important national objective. The Commission's program of radioactive waste control is consistent with this objective. Independent evaluations of the program that have been made over the years by various technical committees in the National Academy of Sciences, and an advisory group to the President's Federal Council for Science and Technology have shown that radioactive waste management operations are being carried out in a safe and economical manner. without effect on the public and its environment. Also, the Joint Committee on Atomic Energy maintains a continuing review and surveillance over the Commission's waste management program to assure that development of the nuclear energy industry can be carried out with full protection of the public health and safety. Waste processing technology and environmental science have been,

and are being developed, which will continue to provide satisfactory pollution control systems for the expanding nuclear power industry. We believe this source of energy will make an increasingly significant contribution to the nation's energy needs and, in so doing, will lead to a major reduction of the country's overall environmental pollution problem.

Mr. DADDARIO. Our next witnesses are Mr. Kenneth Grant, Associate Administrator of the Soil Conservation Service, Department of Agriculture and Dr. Cecil Wadleigh, Director, Soil and Water Conservation Division, Agricultural Research Service. Will you gentlemen come forward, please. We regret having held you so long this morning.

Mr. GRANT. It is perfectly all right, Mr. Chairman. We have enjoyed listening.

Mr. DADDARIO. We do have a bill on the floor that comes from this subcommittee this afternoon. So we really do not have much time. We would appreciate it if you could just go into your statement as quickly as possible, Mr. Grant.

(The biographies of Mr. Grant and Dr. Wadleigh follow:)

KENNETH E. GRANT

Kenneth E. Grant was born in 1920 at Rollinsford, New Hampshire. He was graduated from Dover High School, New Hampshire in 1937 and received a B.S. degree in Agriculture from the University of New Hampshire in 1941. Following this he served as a collaborator in soil survey with the Bureau of Plant Industry and did graduate work in Agronomy. He received the degree of Master of Public Administration from Harvard University in June 1964.

Mr. Grant served in the United States Army from December 1941 to October 1945, and joined the Soil Conservation Service as a Soil Scientist at Keene, New Hampshire in March 1946. He served successively in SCS as Soil Conservationist, Work Unit Conservationist and Area Conservationist at several New Hampshire locations before joining the State Office program staff at Durham, New Hampshire in August 1955. He was appointed Deputy State Conservationist in February 1956, and became State Conservationist in January 1959. He was selected for advanced training under the Government Training Act and entered Harvard University in September 1963. In June 1964 he was transferred to Indiana as State Conservationist.

In Indiana Mr. Grant served as Department Representative on the Interagency Wabash River Basin, the Ohio River Basin Studies, and the Technical Advisory Committee on the Wabash Valley Interstate Commission. He provided leadership in developing the first Resource Conservation and Development Project in the Nation and in stimulating accelerated cooperative efforts of local, State, and Federal agencies in multiple-purpose watershed projects in Indiana. In May 1967 Mr. Grant was appointed Associate Administrator of the Soil Conservation Service.

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DR. CECIL H. WADLEIGH

Born at Gilbertsville, Massachusetts, B.S. from the University of Massachusetts, M.S. from Ohio State University, and Ph. D. from Rutgers University.

Assistant Professor at University of Arkansas, studying physiology of cotton, 1936–41; joined the U.S. Salinity Laboratory, Riverside, California, in 1941 as Senior Chemist; in 1951 became head of the Division of Sugar Plant Investigations, Agricultural Research Service, USDA; in 1954 was appointed head of the Section of Soil and Plant Relationships, Soils Division, ARS, USDA; and in 1955 assumed present post of Director, Soil and Water Conservation Research Division, ARS, USDA.

Recipient of USDA Distinguished Service Award, May 1967.

Past Secretary, Past Vice President, and Past President of the American Society of Plant Physiologists; Fellow of the American Association for the Advancement of Science, and Fellow of the American Society of Agronomy.

Member of the White House Panel on Waterlogging and Salinity Problems in Pakistan, 1961 and 1962.

Currently, member of Committee on Water Resources Research and USDA representative on Committee on Environmental Quality, Federal Council for Science and Technology Executive Office of the President.

## STATEMENT OF KENNETH E. GRANT, ASSOCIATE ADMINISTRATOR, SOIL CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE; ACCOMPANIED BY DR. CECIL WADLEIGH, DIRECTOR, SOIL AND WATER CONSERVATION DIVISION, AGRICULTURAL RESEARCH SERVICE, DEPARTMENT OF AGRICULTURE

Mr. GRANT. Thank you very much, Mr. Chairman.

The Department of Agriculture is happy to have the opportunity to appear before you today to provide you with a brief report on the concern and the commitment of the U.S. Department of Agriculture, in the area of environmental pollution. We commend the valuable service your subcommittee is performing by holding these hearings. Secretary of Agriculture Orville L. Freeman calls this subject a conservation crisis that is a matter of urgent public concern.

I am Kenneth E. Grant, Associate Administrator of the Soil Conservation Service, and I will present the statement for the Department of Agriculture. I have with me Dr. Cecil H. Wadleigh, Director of Soil and Water Conservation Division, of the Agricultural Research Service of USDA.

Enhancing the quality of the rural environment is of direct concern to and is a major objective of the U.S. Department of Agriculture.

The Department is also concerned with, and in cooperation with other agencies shares important responsibilities for, the quality of the urban environment.

Agriculture and forestry have a big stake in environmental pollution. This is indicated by four major points: (*a*) They are being hurt by contamination in the environment; (*b*) agriculture and forestry contribute some of the pollutants that are of concern; (*c*) work in the U.S. Department of Agriculture over the past 100 years has developed a vast array of new technology toward improving the quality of our environment, and has fostered its application on farms, ranches, forests, and in food and fiber processing; and (*d*) improved practices to further reduce pollution related to agriculture and forestry must be developed by those who are knowledgeable of the urgent needs for efficient systems of mechanized operations on these farms, ranches, and forests.

### ADVERSE EFFECTS ON AGRICULTURE AND FORESTRY

Mr. Chairman, you have received ample testimony on the ample tonnage (142 million tons) of pollutants entering the atmosphere over the United States during this past year. We in Agriculture are deeply concerned over the extensive damage these airborne chemicals inflict on the trees of our forests, the crop of our fields, our ornamental plantings, and even our farm animals. Smog in the Los Angeles area is damaging pine and other trees 50 miles from the city. Years ago, stack gas emissions completely denuded forest lands around smelters. Although the worst cases of smelter damage have been corrected, exten-

sive chronic injury to pine trees is still serious in the Lake States, the Northwest, and the Cumberland Plateau of Tennessee.

Damage to commercial crops grown near metropolitan areas is serious. Los Angeles County is often used as Exhibit A for a horrible example. But air pollution damage to crops has been found in every county in New Jersey. Cigar-wrapper tobacco grown in the Connecticut Valley has been seriously damaged due to ozone injury. Injury has been reported on 36 different commercial crops. Crop damage has been found in every State with large industrial centers.

Sediment, the product of soil erosion, is a major pollutant and does serious damage to farmers and rural people. Conservative estimates indicate that sediment damages in the upstream watersheds alone come to about $85 million annually. Sediment fills stream channels flowing through farms and ranches. It fills irrigation canals, farm ponds, and rural reservoirs used for recreation, fishing, irrigation, and farmstead water use.

The thousands of farmers using farm ponds to sell fishing rights are much concerned with the deterioration of water quality by sediment delivery.

Every 1,000 tons of sediment eroded from our fields robs the land of 25,000 pounds of plant nutrients.

There are about 40 million acres of irrigated land in the United States, most of which is in the 17 Western States. Income from nearly a quarter of this acreage is impaired by an accumulation of salt brought in by irrigation water or collected by natural processes.

Historically, farmers have depended on manure as a prime source of soil fertility. During the past two decades tremendous progress has been made in the technical efficiency of fertilizer manufacturing. Nitrogen fertilizer is cheaper now than it was during the depression of the thirties. Consequently, numerous economic studies have shown that it is cheaper for a farmer to fertilize his fields from the fertilizer bag than to haul manure from the barnyard. But this still leaves the livestock farmer with a large mass of matter to dispose of—manure that he usually can't sell, can't give away, and can't burn. With the tight cost-price squeeze that crowds most farmers, relatively little investment can enter into manure handling.

The stuff we are talking about has a characteristic aroma that many find objectionable. Thus, when suburbanites move into farming areas they often object to certain facets of country atmosphere. Frequently, the new suburbanites get a restraining order from the courts to the effect the farmer has to quit his livestock operation or make a very costly move to another location further from suburbia.

The problem of effectively handling and disposing of manure is causing a serious financial burden on many of our farmers, poultrymen, and feedlot operators.

Plant and animal disease agents carried by the environment have caused tremendous losses in agriculture and forestry.

In the 50 years or so since chestnut blight was first discovered in this country, this disease has practically killed all of the American chestnuts, one of our finest hardwoods, in millions of acres of its native range.

In the epidemic year of 1935, stem rust caused a 60-percent loss to the wheat crop in Minnesota and some of the neighboring States, and the loss to the country as a whole was almost a quarter of the crop. Stem rust is a continuing threat to world food production.

Hog cholera was first noted in this country in the 1880's, but it spread rapidly. The virus causing the disease may be picked up from polluted water, polluted soil, or polluted feed. Over the years, the ravages of this disease have caused losses of hundreds of millions of dollars to hog farmers.

Mr. Chairman, these few examples will indicate that agriculture and forestry are indeed severely hurt by environmental pollution. It is an important part of the mission of the USDA to help in meeting these problems.

### WASTES FROM AGRICULTURE AND FORESTRY (AIR POLLUTION)

Although most air pollution arises from industrial and metropolitan areas, forest fires and the burning of field residues make a contribution.

We must face the fact that forest fires are a major concern in the United States. During a typical year, there are about 150,000 forest fires in this country, which ravage 5 to 7 million acres. In addition to heavy monetary losses from destruction of timber resources, wild forest fires in the average year produce an estimated 160 cubic miles of smoke in the convection column. Such fires generate about 34 million tons of particulate matter each year, largely as carbon and ash; and about 338,000 tons of hydrocarbons are vaporized and condensed.

Mr. Chairman, our Forest Service is doing everything possible to find ways to cut down on air pollution from wild forest fires.

In some of our Western States the burning of residues in rice fields, wheat fields, and grass-seed lands may produce local air pollution problems.

Thirty million tons of natural dusts are emitted into the atmosphere each year. Although agricultural lands are not the sole contributor of these dusts, windblown soil is a major factor. Although much progress has been made in getting needed conservation practices on the land to prevent the tremendous clouds common during the Dust Bowl days of the thirties, our conservation task is a long way from completely tying down soils susceptible to wind erosion.

### SEDIMENTATION

Committee Print No. 9 of the Senate Select Committee on National Water Resource states that:

**Rough estimates of the suspended solids loadings reaching the Nation's streams from surface runoff shows these to be at least 700 times the loadings caused by sewage discharge.**

Curbing sediment delivery to our streams and lakes by aiding farmers and ranchers to minimize soil erosion has long been a key objective of the Department of Agriculture. In the thirties sediment delivery on the Piedmont Plateau of the Atlantic Coastal Plain and the Black Belt of Alabama was enormous. One sees far less erosion on the soils of these regions now due to the establishment of sound systems of conser-

vation farming; the farms have largely been converted from continuous row crops to continuous meadow.

But we are not achieving the same results in some other parts of the country in curbing soil erosion and sediment delivery. The advent of highly mechanized farming using six- to eight-row equipment militates against the installation of terraces or other land protection measures that would interfere with planting, tilling, and harvesting equipment. The tight cost-price squeeze on the farmer leaves him little financial leeway to worry about sediment problems 100 miles downstream. Conservation farming adjusted to the needs of highly mechanized operations is urgently essential in many parts of the country.

Forest burns poses a serious problem in sediment delivery. With loss of protective cover, soil erosion on such areas may become intense.

### CHEMICAL FERTILIZERS

We Americans apply 32 million tons of chemical fertilizers on our lawns, gardens, fields, and pastures. Some folks think this is a tremendous tonnage of chemicals that may be contaminating our soils, our streams, and ground waters by runoff and deep percolation.

The average use of chemical fertilizers per cropped acre in the United States is only one-tenth the level used in the Netherlands. Even so, fertilizer use in the United States over the past 50 years has doubled about every 10 years.

Since nitrogen and phosphorus are the nutrients of primary concern that enable growth of "algal blooms" on ponds, lakes, and streams, naturally, a suspicious eye is sometimes cast at Agriculture's widespread use of these chemicals.

Some nitrogen is moving from fertilized fields with land runoff, but most of our evidence indicates this is a minor contributor to stream nitrogen at the present time.

Mr. DADDARIO. On that point, Mr. Grant, Dr. Commoner at the New York AAAS meeting said he thought that nitrates from ground water were a danger. They have appeared in milk, drinking water, and food. Now, this runs somewhat contrary to what you have just said, that it is a minor contributor. If this is so, what should we do about it and how do you feel about Dr. Commoner's remarks in that regard?

Mr. GRANT. May I ask Dr. Wadleigh to respond to this since this is in his particular area.

Dr. WADLEIGH. Dr. Commoner especially emphasized the nitrate content of spinach as a baby food. Samples have been found carrying up to 3,000 or 4,000 parts per million of nitrate. I happened to look up some data in a 1907 issue of the Journal of the American Chemical Society the other day wherein analyses of spinach and many other foods for nitrate were made. In 1907, the spinach samples collected were found to contain from 3,000 to 4,000 parts per million of nitrate. Last year a group of chemists published data on similar samples of spinach from local markets. The samples contained from 250 to 800 parts per million of nitrate. The increase in use of nitrogen fertilizer on the land over this 60-year time has not been reflected in an increase nitrate content of vegetables.

One also has to recognize that nitrate accumulates in soils as a natural process. Back at the turn of the century, in 1910 and 1911,

chemists at Colorado State University were posing this problem: Why does nitrate accumulate naturally in the rangelands at such high level? These are the nitre spots of eastern Colorado soils.

At the meetings of the American Association for Advancement of Science a year ago, Dr. Stout of the University of California presented his studies on nitrate in well water. Some well waters run from 10 to 130 parts per million of nitrate. They have been used for drinking water but no adverse effects have been noted. These waters might have adverse effects if given to ruminant animals. The bacterial population in the rumen readily reduces the nitrate to nitrate and it is the nitrite that is poisonous.

There are instances, of course, wherein "blue babies" have been associated with nitrate in well water. Recent evidence indicates that this effect of nitrate does not take place unless there is also bacteriological polluion in the well water. The bulletin provided by the Public Health Service on drinking water quality standards cites many, many cases of "blue babies" afflicted from drinking well water containing nitrate. They have never found a "blue baby" case associated with drinking surface water containing nitrate. This indicates that bacteriologic pollution entering the baby's stomach with water induces the reduction of the nitrate to poisonous nitrite causing methemoglobinemia.

Mr. DADDARIO. That is very interesting, Doctor. I just wonder if there is this accumulation in this way that you indicate to be natural.

Dr. WADLEIGH. Yes.

Mr. DADDARIO. Isn't it incumbent on us, then, to see if we can develop a nitrate fertilizer which we could contain and prevent from being as mobile as it is, and, therefore, not adding to what must be becoming a natural problem.

Dr. WADLEIGH. I think there is an urgent need to develop better fertilization technology since nitrate is so exceedingly soluble. Studies by my staff members indicate that as much as 40 percent of the nitrogen fertilizers applied to the land each year do not enter into beneficial use to the crops. The farmers are spending $1.5 billion per year for chemical fertilizers. They are applying over 6 million tons of elemental nitrogen. What happens to this 40 percent of the nitrogen fertilizer that does not enter into beneficial use? A small amount goes into land runoff. Some goes into deep percolation. These are minor. Much of our evidence indicates that much nitrogen is lost by chemical reaction in the soil and returned to the atmosphere as gaseous nitrogen. Much nitrogen is sometimes absorbed at excess levels into crop plants.

There have been quite a number of instances in the Middle West, Indiana, Illinois, and Missouri, of cases called "silo disease." When corn or any other forage high in nitrate goes into the silo and starts fermenting, the nitrogen oxides are given off. Silo workers can become very ill. A few have been killed. When high nitrate forage is fed to ruminant animals, they can become very sick. This is sometimes a serious problem when highly nitrogenous forage is used.

As we use higher and higher levels of nitrogen applications on our fields, chemical forms that would not be readily converted to nitrate would be advantageous. The nitrate step is averted. Plants may use nitrogen as ammonium. For example, a sugar beet plant does not grow effectively unless there are 5,000 parts per million of nitrate in its petiole. Ammonium nutrition could avert this buildup.

If this sugar beet foliage high in nitrate is used for cattle feed, they are in danger of nitrite poisoning.

We in agriculture feel there is a great opportunity to develop technology of providing crop plants with ammoniacal urea, or other forms of nitrogen so that the nitrogen does not go through the nitrate stage.

Mr. DADDARIO. Everything that you say is somewhat frightening because we are beginning to develop nitrogen fertilizer plants all over the world with tremendous capacities. Mr. George Woods, President of the World Bank, before our committee, cited as a particular example our ability to meet some of the food problems in India and other places. There is now developing a capability where we expect to get production to quadruple or even be better than that.

Dr. WADLEIGH. Correct.

Mr. DADDARIO. So we will be using the same kind of fertilizer in an ever increasing amount despite the dangers which might accumulate, as you have spelled them out here today, Doctor.

Dr. WADLEIGH. I think there is a lot that could be done to improve the situation.

Mr. DADDARIO. Tell us about that. What do you think ought to be done?

Dr. WADLEIGH. The main effort needed is a concentrated study into the efficiency of the use of fertilizer by different crops. There has not been any pressure for increased efficiency of use because nitrogen fertilizer is so cheap. It is much cheaper now than it was back in the twenties. I grew up on a farm in Massachusetts.

Mr. DADDARIO. I could tell you came from Massachusetts.

Mr. GRANT. Since I came from New Hampshire, we really are quite close together.

Mr. DADDARIO. Where was your farm?

Dr. WADLEIGH. Southbridge. Nitrogen would cost 20 or 25 cents a pound when we were buying sodium nitrate back in the twenties. Now farmers are able to apply it on for 8 cents or 9 cents a pound. It is the cheapest commodity they can buy for improving their yields. We need to know more about the forms that we can put into the soil, where it should be placed in the soil, and at what time in the physiological growth of the plant so that it produces the maximum yield, and yet have the soil nearly exhausted of nitrate by harvest time.

The difficulty in many areas is that the nitrate accumulates and it is in the soil at the end of the harvest. Those who are acquainted with the sugar beet industry of the Western States know processors are deeply concerned with the deterioration of the quality of beets associated with nitrogen accumulation at the end of the season. We need far better information of the forms of nitrogen fertilizer to use that will not be readily leached out; where exactly this should be placed in the soil to provide maximum benefit to the plants: the time in the physiological growth of the crop when nitrogen availibility would be most beneficial; and the development of varieties of plants which have high efficiency in using available nitrogen.

Some of you may be acquainted with the large sugarcane industry on the muck soils of Florida. When conventional sugarcane varieties were cultivated on that muck, they would not produce commercial crops of sugar. There was too much nitrogen in the soil. It runs nearly

4-percent nitrogen. Varieties of sugarcane had to be developed that had very low efficiency in using this excess nitrogen so as to enable sugar to accumulate.

This is part of the natural growth processes. If the plant is using too much nitrogen, it will not accumulate sugar or carbohydrates. This may be why there is some complaint about the poor quality of New England potatoes at the present time. Too much nitrogen?

We can develop varieties of plants that have much higher efficiency in the use of the nitrogen. As a matter of fact, this is what has been done in the last few years by the Rice Institute in the Philippine Islands. They developed varieties of rice with a very short stalk which will not fall over when given high levels of nitrogen. The varieties are not responsive to day length, so they will produce crops every 90 days regardless of time of year; and they will respond to and use very high levels of nitrogen application. As a consequence, the Rice Institute of the Philippines has been producing 200 bushels of rice per acre every 90 days on their experimental fields.

India's average yield of rice per acre is now about 25 bushels per acre. Think what it means in terms of world food needs to develop rice varieties that have high efficiency in the use of available nitrogen together with the tremendous potential for high yields.

Mr. DADDARIO. That is very interesting. I am always amazed that you people can do these things.

Dr. WADLEIGH. Thank you.

Mr. DADDARIO. We are very proud, in New England, that we do have people who have an interest in this. Some of our great seed and food crops have originated through research done in New England. We sometimes take a little more credit in Connecticut than we should, but we keep it in the New England area.

Mr. Grant, will you continue, please.

## ANIMAL WASTES

Mr. GRANT. Domestic livestock produces wastes. For example, the 125 million cattle on our farms and ranches produce over a billion tons of solid wastes and over 400 million tons of liquid wastes. About half of these wastes are produced in concentrated supplies such as in barns, barnyards, and feedlots. Offensive odors may arise from these wastes. Piles of manure may become breeding grounds for flies and other pests. This manure may be a carrier for infectious agents. If it drains into streams, it may deplete the oxygen by its biochemical oxygen demand.

A large cattle operation such as a feedlot carrying 20,000 head must dispose of 550 tons of manure a day.

Mr. DADDARIO. What are we going to do about it?

Mr. GRANT. This is a problem which is related to many of the things that are being done in the Department. We feel that the relationship between this problem and the land use practices which we are putting on farms to curb erosion and reduce the amount of runoff that gets into streams is a part of the problem. There are many other possibilities which, again, I would say Dr. Wadleigh has investigated very carefully and I am sure he would be in a much better position to indicate the extent of involvement of the Department in this important area.

Mr. DADDARIO. I know you cannot give us the solution to the problem in the time available, but will you give us an idea?

Dr. WADLEIGH. We have explored the effectiveness of putting these wastes into oxidation lagoons, but lagoons must have a tremendous capacity to serve a large feedlot. We must explore ways of economically putting manure back onto the land.

In the past, we have emphasized the idea that it is cheaper to get the nitrogen out of the fertilizer bag than to put it on the land. However, I think that the land is still the place for the disposal of manure. It can provide some benefit and may be the cheapest disposal.

We have any number of experiments over the United States where manure added to the soil produces benefits above any chemical addition that one can provide. In areas where it might not be feasible to put the manure in the land, then the lagoon system may have to be used. I feel there must be developed more efficient mechanized systems of getting this stuff back into the land; and incorporated so it does not smell, and does not occur in the runoff into our streams and reservoirs.

### MEETING PROBLEMS OF ENVIRONMENTAL QUALITY

Agriculture and forestry have a long history of developing technolgy and providing technical guidance and other forms of assistance toward improving the quality of our environment.

### AIR POLLUTION CONTROL

We have mentioned our concern with air pollution. The U.S. Forest Service is carefully studying the resistance on susceptibility of pine seedlings to airborne chemicals. They have made selections of ponderosa and eastern white pine that are nearly immune or highly tolerant to specific air pollutants such as sulfur dioxide, fluorine, ozone, and photochemical smog. These selections will be especially valuable for plantings in and around industrial and metropolitan areas.

We are continually developing improved varieties of cigar-wrapper tobacco that may be grown in the Connecticut Valley without significant damage from air-pollution fleck on the leaves.

The U.S. Forest Service began developing improved techniques for forest fire control in 1923. This technology has been applied with remarkable effectiveness toward reducing air pollution arising from burns in our Nation's forests. This is indicated by the fact that fire damage in the national forests has been reduced over a 40-year span from 602,000 acres in 1924 to 92,000 acres in 1963. At the average damage of $76.45 for each acre burned, the cumulative effect of developing and using improved forest fire control technology over the past 40 years comes to $39 million a year.

### EROSION CONTROL

Conservation practices on the land have contributed importantly in reducing the threat of future "dust bowls" in the Great Plains. One of the best testimonials to this point was the experience of farmers in Kansas during the drought of the mid-1950's, which records show was

just as bad as that of the 1930's. Soil blowing was not nearly as serious as it was 20 or 25 years earlier. At Dodge City, Kans., in 1936–37 there were 120 days of blowing dust. At the same location under comparable conditions in 1956–57 there were only 40 days of blowing dust.

Studies started by the Department of Agriculture back in the twenties showed that graded cropland terraces can reduce soil erosion and sediment delivery; and in combination with such practices as crop rotations, mulching, minimum tillage can reduce soil loss from cultivated fields to practically nothing. Converting croplands to good grasslands, pasture, or woodlands can nearly eliminate sediment delivery.

The Department of Agriculture has had a major impact on the conservation and protection of soil and water resources and the preservation and enhancement of natural beauty through its vigorous programs of research, technical help, land management, credit, and cost-sharing assistance. USDA has provided help in contour farming on 43,900,000 acres, in 29,000 miles of hedgerow and 82,000 miles of windbreak planting, in building 1,600,000 acres of grassed waterways, in planting trees on 13 million acres, in preservation and development of 18 million acres of wetland and wildlife habitat. In fiscal year 1967, fire protection was provided on 210 million acres of forest. Farmers Home Administration loans and grants of $200 million for construction of rural community water and waste disposal systems, $28 million for development of rural recreation areas, and $442 million for construction and repairs of homes and farm buildings were made. These measures aid soil stabilization, water conservation, control of runoff, and pollution control; they also improve the attractiveness of the landscape.

### FERTILIZER RESEARCH

The Department of Agriculture has been studying the behavior of phosphorus in soils, water and plants for 80 years. We know there are only traces of phosphate actually in true solution in the soil. Phosphate is held on the surface of clay particles by high energies of retention. We have studied its chemical behavior extensively by using radioactive phosphorus as a tracer. We know that only minute amounts of phosphate move from our fields in runoff water except by their attachment to eroding soil. Soil conservation measures obviously, therefore, are the first measure of defense against pollution.

Nitrogen is another matter. That which is present as nitrate is highly soluble and will readily move with water if not absorbed by plant roots. Studies in Colorado at the turn of the century show that it is part of natural processes for nitrate to accumulate in some soils. We know that more nitrate may leach out of unfertilized, uncropped soils than from those well fertilized and growing a crop. Roots are avid absorbers of nitrate.

We have developed and provided information on proper fertilizer placement, timing of application, and optimal levels of needed applications for the different agricultural soils of the United States to help the farmer gain maximum beneficial use of his purchased fertilizer, while minimizing losses to the environment.

### HANDLING OF ANIMAL WASTES

Improved efficiency in manure handling systems are being developed by agricultural engineers. These involve using disposal lagoons, lagoons with artificial stirring to improve oxidation, conversion to slurry with land application through an irrigation system, development of a plow-furrow-cover technique, as well as improved ways of following the tried and true practice of spreading manure on the land under conditions that would minimize contamination of runoff water.

Our extensive program of veterinary research inspection and regulation have brought transmissable diseases in this country to a remarkably low level. Bovine tuberculosis and hog cholera have nearly been eliminated in this country. We are free of foot-and-mouth disease of our animals, disease which is even now ravaging the cattle of England and many other parts of the world.

### THE JOB AHEAD

There is still much to be done in curtailing environmental pollution related to agriculture and forestry. In meeting this task, it is mandatory that there be a minimum of unnecessary and misdirected effort.

It would be folly of the first magnitude to think that handling manure in the barnyard and coping with runoff carrying plant nutrients and sediment could be adequately dealt with as distinct and separate problems.

These problems are best solved at their source on the land.

Agriculture in the United States today is a highly mechanized operation, operating under the pressures of complex cost-price relationships. Any technology that is developed and put to use on the land must fit into a highly integrated management system, using a minimum of labor while producing economic yields of high-quality crops of food and fiber. Environmental pollution controls must be developed in such a manner that full consideration of the impact on agricultural enterprises are fully recognized.

In developing technology with respect to environmental pollutants on the land, we must recognize that air and water are the two main transport vehicles. For example, we must be helpful to land managers and developers in preparing plans that will take into account the characteristics of their soils and topography, climate, and the kinds of enterprises that are profitable in their area.

There are many instances where costly mistakes have been made by suburban developers, industrial companies, and even large farming and forestry operations by their going ahead without having adequate information about such things as the kinds of soils prevailing in the specific area. Soils vary tremendously in the way they take water; in the way they erode under overland flow; the way they shrink and swell, depending on moisture content; their bearing strength under loads; and their susceptibility to deterioration in tilth and tractability.

Maintaining a wholesome environment calls for an entire package of practices and a special competence in relating them to one another and to the needs of the environment. This package includes those practices that will assure this country a continuing abundance of good food and fiber at low cost. At the same time, we must keep in mind the

urgency of preserving and enhancing natural beauty and of protecting health and safety of people by maintaining the quality of water, air, and soil.

This Department recognizes that we still have a big job to do. But we are committed wholly to this as a principal need of this era, and are gearing up our programs to be of maximum helpfulness in applying the improved technology needed to upgrade and maintain the quality of our environment.

Mr. Chairman, I would like to offer for the record "Resources in Action, Agriculture/2000." In this document, this Department has set in sharp outline the steps it proposes to take to assist man to live in harmony with his natural environment.

(Document referred to can be found in committee files.)

Mr. DADDARIO. Thank you, gentlemen.

I regret we do not have more time to go into certain parts of your statement. I am particularly concerned with how you relate your activities with the other agencies, what the mechanisms are, how you divide the work, and what is the relationship of overall governmental responsibilities in developing a proper pollution control program in the most efficient way possible. We will have to develop that for the record, I would suspect.

Mr. GRANT. We shall be happy to provide the information.

(The information requested is as follows)

There are several mechanisms enabling the coordination of activities in the Department of Agriculture with comparable endeavors in other executive departments. First of all, the Water Resources Council is an excellent medium for coordination of work pertaining to some aspects of water pollution. The membership of this Council is made up of the Secretaries of Agriculture; Defense; Health, Education, and Welfare; and Interior; and the Chairman and Commissioners of the Federal Power Commission. The Sedimentation Committee set up under the Council meets regularly and offers a good mechanism for interagency communication on matters pertaining to water pollution from sediment. In 1963, this Committee sponsored an interagency symposium providing for presentation and discussion of all work on sedimentation by all agencies involved. The 900-page document covering the symposium was published as U.S.D.A. Miscellaneous Publication 970.

Regularity of water flow in streams and the avoidance of low flows are also related to degree of pollution in surface waters. The Committee on Hydrology under the Water Resources Council provides a focal point for communication and integration of work related to stream flows.

In 1962, the Federal Council of Science and Technology set up a task force to look into all aspects of water resources research, including coordination and joint planning. The effort included studies on water quality as affected by pollution. The work of this task force was published under the title of "Report to the President on Water Resources Research" as a Committee Print of the Senate Committee on Interior and Insular Affairs, 88th Congress, 1st Session, February 11, 1963. This report recommended that a Committee on Water Resources Research be set up under the Federal Council for Science and Technology. Such a committee was established under FCST in September 1963. Among the assignments to the committee was to develop an integrated Federal Water Research Program that provided for inteagency communication and coordination.

One of the reports of the FCST Committee on Water Resources Research entitled, "A Ten-year Program of Federal Water Resources Research," was published in February 1966 and provides on pages 53–58 a terse statement on "Water Quality Management and Protection in Relation to Pollution."

Over the past two years the Committee on Water Resources Research has maintained a very active subcommittee on problems of water quality in relation to pollution. This subcommittee not only provides for coordination but is developing more realistic recommendations for an integrated Federal program on problems related to water pollution.

During the summer of 1967, the Federal Council of Science and Technology established a Committee on Environmental Quality. It appears certain that this new Committee will move forward in its work of coordination with the same effectiveness as observed for the Committee on Water Resources Research.

The Interdepartmental Federal Committee on Pest Control made up of representation from the Departments of Agriculture, HEW, Defense, and Interior meets monthly and provides means for communication and coordination on problems related to environmental pollution form pesticides. Furthermore, scientists concerned with problems of pest control in the Agricultural Research Service meet annually with their counterparts in the Public Health Service, the Department of Defense, and the Tennessee Valley Authority in order to provide for communication and coordination of research programs.

Research on air pollution problems conducted by the Agricultural Research Service and the Forest Service are carried out under very close cooperation and consultation with those responsible for air pollution investigations in the Department of Health, Education, and Welfare. In fact, an appreciable portion of the research in the Department of Agriculture on air pollution is supported by funds transferred from Health, Education, and Welfare.

The Department of Agriculture has many different mechanisms of developing priorities in research. Under legal authority set up under the Research and Marketing Act of 1946, the Department appoints a number of research advisory committees that are composed of people outside the Department of Agriculture. The committees are made up of scientists and lay people familiar with the problems. These committees have met annually and submitted to the Secretary of Agriculture reports in which they have evaluated ongoing research, indicated priorities, and pointed out problems needing additional attention. Three such reports having relation to environmental quality are submitted for illustrative purposes.

The Department is especially responsive to the recommendations of high level committees such as the President's Science Advisory Committee (PSAC) and pertinent ones appointed by the National Academy of Sciences—National Research Council (NAS–NRC), and the Public Advisory Committee on Soil and Water Conservation to the U.S. Department of Agriculture. The PSAC Reports on "Use of Pesticides" (1963) and "Restoring the Quality of our Environment" (1965) were especially useful as were the NAS–NRC reports on "Scientific Aspects of Pest Control" (1966) and "Waste Management and Control" (1966).

In October 1966 the Department of Agriculture completed a two-year study that involved the thinking of some 400 scientists both within the Federal Government and at the State Agricultural Experiment Stations under the title of "A National Program of Research for Agriculture." The Department of Agriculture feels that this study is monumental as a way for developing an integrated research program that is regional in scope. A copy of this report is submitted herewith.

Key researchers who are intimately involved in solving problems are frequently in an advantageous position to weigh and decide what research most urgently needs to be done. The Department of Agriculture gives important considerations to the recommendations arising from in-house work planning conferences involving its leading researchers.

Mr. DADDARIO. I have one question, which we may not be able to finish. When Dr. Buckley was here, he touched on the fact there were $75 million being spent at the present time on research related to environment.

Recognizing the interest there is in herbicides and pesticides and their long-term effect on ecology, what is the Department of Agriculture doing in this field, and what kind of risks are involved in it?

Dr. WADLEIGH. There is no question that the Department is just as much concerned with persistent pesticides, such as the chlorinated hydrocarbons, as any group of individuals you can find. The great emphasis on our pest control program is to find alternate means of control. The use of radioactive energy to sterilize the male screw-worm flies, which eliminated the populations of this insect in almost all parts of the country, was an outstanding example. It has saved the cattle

industry millions and millions of dollars. The development of sex attractants so the insects move to this odor and, while moving to it, they go through a device that electrocutes them is another example of alternate means of control. There are many alternate ways that are being developed.

Then we must develop—and we are working on this—pesticides that are nonpersistent and ones that are more specific to the insect that one wishes to control.

Mr. DADDARIO. That creates a problem right away in the market.

Dr. WADLEIGH. Yes. After all, I am sure that agriculture suffers seriously from these nonspecific pesticides. Think of the billions of honey bees that have been killed, insects that pollinate our plants. Think of the billions of beneficial insects that have been killed by these pesticides.

In California in the citrus industry, predators control quite a number of insects, but a nonspecific pesticide also kills the predator.

Mr. DADDARIO. It is too bad we did not think this way when we were first beginning to work on these control measures.

Dr. WADLEIGH. Hindsight is so much better than foresight.

Mr. DADDARIO. I think it does enhance our vision. The discussion we had in the earlier part of the day revolved on the fact that we should have professional people competent not only to develop the work but to take the great responsibility of calling attention to the ill side effects as well as the positive gains. This is not necessarily a hindsight situation. We need to develop a forecast capability so we might be able to make assessments of those programs that are important to us, to see if they will, in fact, do everything they are touted to do, and to come to some better judgment in the future. I do not think we have too much room to move around in. Lessons we can learn from the past ought to be assessed in a complete way, not that it will just kill off insect A, but how it affects our whole environment.

Dr. WADLEIGH. That is very true.

Mr. DADDARIO. I say that only because I think, Dr. Wadleigh, we we have a tendency to use the umbrella of hindsight. Actually, it is an easy way to get out of our inability from the research, science, and technology point of view to make an assessment is part of the research job. The job of looking ahead and not looking back.

Dr. WADLEIGH. You are so right.

Mr. GRANT. I think the maximum effort to do this is certainly incumbent upon anyone who is working in this field. I know we recognize this responsibility, and it weighs heavily upon us.

However, as you have pointed out, this has not always been the case. Many assessments have not been completely accurate as to future implications.

Mr. DADDARIO. In this committee we have a bill on technology assessment. I wish we could develop a national characteristic that would be part of our research effort to look at things in the whole way.

You spelled out a very interesting and frightening proposition, Dr. Wadleigh. The fact is, it does not make much sense to kill off everything to get at one. I recognize there are great economic problems, some of which you have already on, which show how it is false economy to approach it that way. The long way around and the more expensive way in the final analysis might be cheaper.

Talking about environment, plants and animals, and our place in it, it might be a lot cheaper if we did the complete job in the first instance, recognizing that it is difficult.

Mr. GRANT. Assessing the damage, of course, has to go along with a correct assessment of the benefits.

Not to prolong this, there are many things which you have so correctly pointed out that need to be considered. There is an economic analysis which must be made in terms of the urgency of the problem and the need for solution, but also, proper consideration of the effects must be considered on a long-term basis as well.

Mr. DADDARIO. We could philosophize for the rest of the afternoon, I suspect, but we do not have time. We will be in touch with both of you. The committee appreciates your coming. We regret we had to sandwich you into what we knew already would be a full day. We have your statement in the record, and we will have a chance to follow through from there.

Mr. GRANT. Thank you very much.

Mr. DADDARIO. The committee is adjourned until tomorrow morning at 10 o'clock, at the same place.

(The subcommittee adjourned at 12:35 p.m., to reconvene at 10 a.m., Friday, February 2, 1968.)

# ENVIRONMENTAL QUALITY

**FRIDAY, FEBRUARY 2, 1968**

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
*Washington, D.C.*

The subcommittee met, pursuant to recess, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Environmental quality has assumed a third dimension in addition to air and water pollution. It is the problem of solid wastes.

We realize that the gases and liquid effluents of society go directly into the air and water environments. But solid wastes are actually the precursors of pollution—if they are not managed properly. Packaging, castoff appliances, demolition debris and the like are testimony to the fact that we do not have a recycle economy but live in an era of planned obsolescence and the throwaway container.

The key to a great deal of pollution will lie in our ability to eliminate as much waste as possible and to deal ingeniously with the material which we must dispose of. Title II of the Clean Air Act of 1965 shows the intent of Congress to provide Federal leadership in solid waste disposal. Scientific and engineering activity is an important part of the authorized program. It is our hope that during these hearings we will be able to come to some judgment as to how management is going about the handling of all of this.

Our witnesses today are Mr. Richard Vaughan, director of the solid wastes program of the Public Health Service, Mr. Arsen Darnay of Midwest Research Institute, and Dr. Walter Hibbard of the Bureau of Mines. We will begin with Mr. Vaughan.

Proceed please.

(Mr. Vaughan's biography follows:)

RICHARD D. VAUGHAN

Chief, Solid Wastes Program, National Center for Urban and Industrial Health is a Commissioned Officer of the Public Health Service presently stationed in Cincinnati, Ohio. He was born in Evanston, Illinois. He is married and has three children.

*Education*

Bachelor of Science in Civil Engineering—Georgia Institute of Technology—1951
Master of Science in Engineering—University of Michigan—1961
Master's Degree in Public Health—University of Michigan—1962

*Associations and honorary groups*

American Public Works Association
American Public Health Association
Phi Kappa Phi, Delta Omega and Chi Epsilon

Mr. Vaughan has been awarded the Public Health Service Commendation Medal and he received the William Gibson Memorial Award for scholastic achievement in environmental health while studying at the University of Michigan.

*Previous experience*

A Commissioned Officer of the Public Health Service since graduation from college with assignments in Georgia, Texas, Oklahoma, Michigan, Washington, D.C. and Cincinnati, Ohio. Served in several areas with the Communicable Disease Center as a training officer in environmental sanitation; Deputy Project Director of the Arkansas-Red River Water Quality Study; Project Director Detroit River Lake Erie Water Pollution Control Enforcement Project; Director, Robert S. Kerr Water Research Center in Ada, Oklahoma; Chief, Environmental Sanitation Program, National Center for Urban and Industrial Health; and currently Chief, Solid Wastes Program, National Center for Urban and Industrial Health.

## STATEMENT OF RICHARD VAUGHAN, DIRECTOR, SOLID WASTE DIVISION, PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Mr. VAUGHAN. For the record my name is Richard Vaughan, and I am chief of the solid waste program in The National Center for Urban and Industrial Health of the Public Health Service, Department of Health, Education, and Welfare.

Mr. Chairman, I am pleased to be here today and welcome this opportunity to present a report on the adequacy of technology in the field of solid waste management and what the solid wastes program of the Public Health Service is doing to close existing gaps in this technology.

I would like to submit my entire statement for the record and discuss some of its major points.

Mr. DADDARIO. If you would, please.

Mr. VAUGHAN. Thank you.

The solid wastes program was established to carry out the directives of the Solid Wastes Disposal Act of 1965.

In enacting this legislation, Congress recognized the increasing problems of solid waste management which have been accentuated by continuing technological progress and improvement. The Congress also recognized the fact that inefficient and improper methods of solid waste disposal threaten the health and well-being of the Nation, including interference with community life and development. Following the directives in this act, the Public Health Service has established an organizational entity to address itself to these problems and find solutions for today and tomorrow and thus, assure adequate protection of the air, land, and water resources of this country from degradation through inadequate and improper management of solid waste.

Now, I would like to discuss what the Public Health Service has done to better understand the adequacy of solid wastes practices and problems in this country and develop effective technology to cope with these problems.

The improved technology we seek must satisfy other requirements in addition to being scientifically sound. These innovations must also

be economically feasible for our society and must be safe from the standpoint of public health and the protection of our precious natural resources—our land, air, and water.

Technological development alone—no matter how effective, how economical, or how safe—will not do the job that is needed to be done to improve solid waste management in this country. Once new solutions are found and proven effective by research and development, their practicability and applicability to a real situation must be demonstrated. The public's attitude toward solid waste management must be changed to allow acceptance of new concepts. Communities which are jurisdictionally autonomous but collectively make up regional or metropolitan areas, must learn to cooperate and work together for the adoption and implementation of solid waste collection and disposal techniques which economically and effectively serve the best interests of all. No matter how innovative new technology is, the facilities involved must be operated properly to achieve the benefit intended by the developer. This then is the complete job of solid waste management—the approach to which the solid wastes program of the Public Health Service is dedicated.

Mr. DADDARIO. Mr. Vaughan, would you go into the way in which you expect the public to participate? You touch on the importance of the public understanding all of this. How do you get them to understand? What do you mean by that? How do you intend to go about it?

Mr. VAUGHAN. When I mentioned public attitude must be changed, the question might be how do you change this attitude, in what respects should it be changed.

Mr. DADDARIO. I am not assuming it is good, bad, or indifferent. What made you come to that determination of what is good and bad, and where do you go?

Mr. VAUGHAN. We find many people are not willing to accept solid waste management as a part of their community function. They want their solid waste taken off. They don't want it anywhere nearby.

We also find people putting this at the low end of the totem pole. They are willing to do almost anything except spend money for improving solid waste practices.

Another thing. Cities may be part of a metropolitan complex with 10 or 15 other communities, none of which has the real financial ability to handle this alone, but they have a reluctance to work together. I don't understand sometimes why they have this reluctance, but they do.

I assume it might be that they do not desire to give up their autonomy; but somehow, for their own good or the benefit of their citizens, ways must be found to preserve their integrity and still allow them to work together for better solutions. In these areas public attitudes must be changed.

Mr. DADDARIO. How?

Mr. VAUGHAN. We are doing it by demonstrating to them good technology. This is one of the purposes of the demonstration grant technique.

Mr. DADDARIO. Don't you need to have some kind of research into why it is this way and how it can be changed?

Mr. VAUGHAN. We have a contract proposal now that tends to go into psychometric research on why people do things. Hopefully we will get some insight into this.

Mr. DADDARIO. Who is doing this?

Mr. VAUGHAN. It is being negotiated now, being discussed. I don't know who is going to get it.

Mr. DADDARIO. Tell me what it is comprised of.

Mr. VAUGHAN. It is comprised mainly of trying to assess the reasons why people do things in general, why people are reluctant to improve solid waste disposal practices, what things should we do to get this changed, whether it be research, demonstration, or whatever.

Mr. DADDARIO. You say that you have a proposal out. To whom are you appealing? Who do you expect will be the people who will perform the contracts? Are they university people?

Mr. VAUGHAN. No. They would probably be nonprofit or profit research organizations, such as Booz-Allen, Aero Jet General, or someone of this nature. They are not necessarily going to get it, but someone who specializes in this type of work. Probably not a university. Management specialists.

Mr. DADDARIO. You say it is a management rather than a social science problem?

Mr. VAUGHAN. I see it as both, management for us to do something effectively to cope with this, and social science in finding out what motivates people.

Mr. DADDARIO. Would a management firm such as Booz-Allen and the ones that you listed, have a social science research capability?

Mr. VAUGHAN. I don't know. The ones who bid on this are required to.

Mr. DADDARIO. That is one of your specifications?

Mr. VAUGHAN. Yes, sir; on this particular contract.

Mr. DADDARIO. What made you come to the determination that you needed to have this study?

Mr. VAUGHAN. Several examples. When we got involved in the solid wastes program activities, when we saw cities that would not take the steps to improve disposal practices—that to us made no sense. Why they would permit an open burning dump to just go on smoking, why they wouldn't allow sanitary landfills to be established when we have seen many satisfactory operations. There is one not too far from here, incidentally.

When the citizens of one State refused to allow, because perhaps of a prejudgment of what it would be, sanitary landfill to be placed in their community, to eliminate a dump.

Mr. DADDARIO. I wonder, is that a social science problem or is it a regulatory problem? Does it not go into the relationship of the State to the Federal Government? Which should predominate under these conditions?

Mr. VAUGHAN. I don't know how I could classify it precisely under one problem or another. I do know it is keeping the Nation from getting the kind of solid waste practices it should have, this attitude.

Mr. DADDARIO. I would offhand classify that kind of a problem as just one where the solution is obvious. It just becomes a question of how you put into effect the necessary regulations and recognizing the inhibitions which exist in allowing the Federal Government to

force action. You could stop that kind of activity without any kind of study at all, could you not?

Mr. VAUGHAN. We have no enforcement authority now.

Mr. DADDARIO. I mean recognizing that, if you had the enforcement authority you would know what to do. There is no secret to this business, if you agree that that is so.

Mr. VAUGHAN. I have not considered this because I am living in the world of our present authority.

Mr. DADDARIO. I understand that. But the present authority notwithstanding, the solution to that dump-burning problem certainly is something that we are technically capable of doing.

Mr. VAUGHAN. Yes, sir. We are technically capable, but having the technical knowledge and getting the job done, are in some cases, two entirely different things.

Mr. DADDARIO. That means that we have to develop some kind of a relationship and regulatory situation so that we can accomplish our objective. People will have to learn to put their solid wastes in a disposal basket and not throw it out in the street and clutter up the landscape.

Dr. Wolman was on television a couple of nights ago and he referred to this character of our society as the great American slob. He was not casting a reflection on the whole society, of course, but just trying, as I understood it, to call attention to the fact that we do a lot of things which add to the solid waste disposal problem because there is no incentive to do otherwise.

It is not a question of regulations. It is not a question of technical capability, but just a lack of will to do certain things. I think this is a different problem than the example you gave of the open burning dump, which short of regulation can be a hazard.

Mr. VAUGHAN. In this case, the citizens passed regulations which prohibited this from coming about. This was not a defined regulatory authority.

Mr. DADDARIO. Now you are talking about the open dump?

Mr. VAUGHAN. Yes, sir.

Mr. DADDARIO. We are probably spending too much time on this particular question, but I am trying to distinguish in my own mind your attitude about these things.

Here, certainly, a social science research program could help put it together so that these things can be done. It would appear to me to be part of the problem.

Mr. VAUGHAN. Yes, sir.

Mr. DADDARIO. I recognize that you have some problems, Mr. Vaughan, in this matter of open burning dumps. There was some serious debate during the course of the legislation on the disposal of solid wastes and Mr. Harris did say that the purpose of this program, and I am quoting from his remarks on the House floor, is "* * * research, investigation, training, surveys, studies, and demonstrations related to the operation of a solid wastes program."

Prior to that he indicated that enforcement would be an unnecessary invasion and interference by Government in a problem that should be primarily local. These are legal and constitutional problems which somehow must be overcome.

I do think, in your handling of the solid waste problem, that you have to distinguish the one from the other, and not get them mixed up.

That is difficult to do but not impossible. There are things which we find presently impossible but need not be if we do the research necessary to overcome them.

Mr. VAUGHAN. I agree with you. I pointed this out. There are many steps along the ladder to good solid waste management. Getting new technology to find answers we don't have is one of them. Getting known technology implemented is another.

Incinerator technology represents a pressing problem facing many solid waste managers and city officials today. Incineration of solid waste is a volume reduction technique to materially reduce the amount which must be ultimately disposed by some other techniques such as land disposal. Since combustion of waste is an integral process of all incinerators, air pollution can and has resulted unless effective control measures are utilized. Furthermore, inadequate or improper design and/or operation have resulted in pollution of our land and water resources. Some cities have received rather shocking news lately when construction bids have been opened on incinerators which have incorporated air pollution control devices required by regulatory officials. The increased capital investment and operation unit costs represent a one-third to one-half increase over costs previously associated with this type of disposal facility without effective air pollution controls. We believe that all incinerators must be designed and operated to assure adequate protection of our air and water resources. We, however, are appalled when these increased costs prevent effective community action to eliminate open burning in dumps, and incineration in outmoded facilities which cannot even be modified to assure efficient operation and protection of air resources. The answer to this debacle in our opinion is to either find effective substitutes for costly incineration or where this does not appear to be feasible, develop new incineration methods which are economically feasible and effective in controlling air pollution. The Public Health Service's solid wastes program is addressing itself to both approaches.

Mr. DADDARIO. Who is doing this kind of thing?

Mr. VAUGHAN. Aerospace. Combustion power section of Aerospace. This is a research firm in California.

Mr. DADDARIO. My question is, what level has this reached? Are you actually in demonstration?

Mr. VAUGHAN. No, not yet. We are in the research and early development stage of it.

Mr. DADDARIO. You are working on this. I would expect there would be other areas of incinerator development that you are working on?

Mr. VAUGHAN. Yes, sir.

Mr. DADDARIO. If that is the case, we would like you to provide that for the record.

(The information referred to follows:)

The City of Brockton, Massachusetts, supported by a Public Health Service solid waste demonstration grant is evaluating a newly developed ultra high temperature incinerator purported to have low capital and operating costs and great flexibility in the size and type of solid waste it can receive. This incinerator operates at such a high temperature that it produces an inoffensive residue which can

be used widely in many community operations in lieu of gravel. The inventors claim the high operations temperature will greatly reduce the need for air pollution control devices and thus lower the costs even more. If the evaluation proves successful, a demonstration in an appropriate community could follow and perhaps a major contribution in incinerator technology.

Through the contract mechanism the Solid Wastes Program is in the process of developing a new concept in incineration which may lead to a major breakthrough in incinerator technology. Many incinerators here and abroad have considered utilization of waste heat to lower the net cost of operation by generating steam for purposes of heating or electric power generation. Our new approach takes advantage of jet engine technology to transform waste heat from combustion directly to a gas turbine and generate electric power with far greater efficiency and thus lower net cost. If this method, which includes effective air pollution control devices, proves to be as successful as it now appears likely, the net cost of operation may be substantially lower than present incinerators operating *without* any air pollution control devices.

Mr. DADDARIO. If we can go back a little bit, you talk about inadequacy in proper design and the increase in costs, and use Brockton as an example. That could be an improvement or it could be faraway wish to accomplish what they want to. How do you give some guidance on that so that successful salesmanship does not allow a community to buy something?

This city of Brockton could accomplish everything that you indicate it might. At the same time, you are not endorsing it.

Mr. VAUGHAN. That is right.

Mr. DADDARIO. It may very well have been sold on the basis of what it could accomplish, not what it does, and found itself in the category of inadequate design and excessive cost. How do you consider the restrictions under which you must operate and bring some order to this?

Mr. VAUGHAN. The city of Brockton has put in for a demonstration grant to evaluate an existing incinerator with the prospect of demonstration. This is a prototype. It is a pretty good sized one. I think it is about 150 tons a day, which is a fair-sized incinerator. There has been no evaluation, technical evaluation of this particular piece of equipment. We are in no position to say, as you say, whether it works or not.

This evaluation and demonstration grant will be operating for a period of time in which the equipment will be tested thoroughly and then they will know and other cities will know whether this would be worth while and whether the salesman's talks are true or not. It will be evaluated by a consulting firm hired to carry out specifications which we have provided them, so that we know that the tests will be thorough enough to give us a picture—and the rest of the people that are interested in this—a picture of whether (1) it will operate at about the financial level that they indicate; (2) whether it is effective in doing all the things they say; (3) how effective it is in preventing air pollution.

Mr. DADDARIO. You have some research activity going on in the field of incinerators, as you indicated.

Mr. VAUGHAN. Yes, sir.

Mr. DADDARIO. You also have, according to what you just said, a development capability to give some guidance to communities looking to better devices in the incinerator field?

Mr. VAUGHAN. Yes, sir.

Mr. DADDARIO. With some ability to assist them in coming to a judgment as to whether or not this is good, bad, or indifferent?

Mr. VAUGHAN. That is right. This was one of the directives of the act, as I remember. I don't remember the exact section where we were to give such guidance to cities; more in the form of information.

Mr. DADDARIO. My question is, Do you have that capability?

Mr. VAUGHAN. Yes.

Mr. DADDARIO. I wonder if you could provide for the record what this involves.

Mr. VAUGHAN. Yes, I can.

(The information requested is as follows:)

At the present time the most commonly used alternative to incineration is land disposal. The sanitary landfill is currently recommended as the most desirable technique. This method prohibits burning at any time, is designed and engineered to prevent pollution of ground and surface water, and is covered daily with an adequate layer of clean earth to prevent insect and rodent infestation and eliminate other insults to our environment. Too often the sanitary landfill degenerates into an open burning dump through poor operation—giving this method a bad name. If not used instead of incineration some method of land disposal is generally used with it to dispose of residue and outsized material which cannot be handled by the incinerator. Rising land costs and shortages of suitable areas have restricted use of sanitary landfill as have such factors as lack of citizen acceptance because of bad publicity. When public opinion or lack of available land forces the location of this operation long distances from the source of the waste, the resultant transportation cost may equal or even exceed the savings one might expect from land disposal as opposed to proper incineration. Lack of reliable information concerning settlement of sanitary landfills and the effects of methane gas produced as a result of decomposition of buried and compacted solid waste have also hindered effective utilization of this technique.

Mr. DADDARIO. We would like some examples to illustrate just how this is progressing.

Mr. VAUGHAN. I would be happy to.

Mr. DADDARIO. Where?

Mr. VAUGHAN. The United States. There is lack of information but we are studying it in California.

Mr. DADDARIO. When you say the United States, where in the United States specifically?

Mr. VAUGHAN. Almost wherever sanitary landfills are used in the planning of this ultimate utilization when they are finished. Very little information is available on precisely how much settlement one could expect, or precisely the problems that would occur from methane gas and odors, or uneven settlement.

We are trying to find out two things—exactly how to better understand it, and second, how can you control these problems so that you can use the land after it is finished for other purposes. It may be nice to use it for a park but perhaps you can use it for more than this.

Mr. DADDARIO. What is the methane gas problem? What proportion of danger are you including in your remarks? When you talk about methane gas, where in the country have you found it to be a danger so that it causes you to include it in your remarks this morning?

Mr. VAUGHAN. In California. Southern California. Los Angeles.

Mr. DADDARIO. How does it show itself to be a danger?

Mr. VAUGHAN. It shows itself to be a problem in three ways: (1) in uneven settling of land over the fill; (2) from odors which emanate from cracks; and (3)—this is not too well understood—methane gas traveling laterally into housing areas.

Mr. DADDARIO. Can we assume from that that is a serious problem?

Mr. VAUGHAN. I don't know how serious it is. This is what we are trying to find out.

Mr. DADDARIO. We don't know how serious it is. Then we are in an area where there is the possibility we have a dangerous situation. Therefore, we would need to develop new techniques altogether for the storage of such solid wastes.

Mr. VAUGHAN. That is correct. That is the purpose of our work there. To more fully understand this problem and, if necessary, develop operational procedures which control or eliminate it.

Mr. DADDARIO. As of the moment we haphazardly dump waste and, as we have in the past, assume that it is going to be safe when there are indications that it is not.

Mr. VAUGHAN. There have been some intimations it might be a dangerous problem in very specific circumstances. I don't fully understand this. Most of the complaints have been from odors.

Mr. DADDARIO. It is certainly something that ought to be ascertained?

Mr. VAUGHAN. Yes, sir; it sure is. We are proceeding on this.

Mr. DADDARIO. If it is, since it is an offensive odor, it might be dangerous and there is sufficient reason for us to be concerned?

Mr. VAUGHAN. This is the reason for our undertaking this work.

Mr. DADDARIO. Again, if you could provide for the record how you are structured in order to take care of this, who is involved, and what kind of a future commitment do you need to make from the management point of view and whatever else goes with that, to overcome that problem?

Mr. VAUGHAN. All right.

The Public Health Service is approaching these problems on the basis that land disposal properly designed and conducted is an exceptionally desirable form of solid waste disposal. Air and water pollution are effectively controlled and land reclamation can be accomplished. I cannot say enough about the potential of land reclamation through the disposal of solid wastes. The State of Maryland partially supported by a solid waste demonstration grant is showing how solid waste can be used to reclaim strip mines. This could change a blight of America into a precious asset and at the same time effectively deal with a pressing community problem—solid waste disposal. Another demonstration grant to the Chicago Sanitary District will show how sewage sludge after its removal from waste water can be transported to low cost land and converted into a profitable resource of agricultural and recreational purposes. Perhaps the most infamous example of solid waste disposal, the Kenilworth dump in Washington, D.C., is being converted into a model sanitary landfill operation which will ultimately be transformed into a tree-lined, grass-covered park and recreational area. There is no reason why necessary community functions cannot result in a community asset if technology can but respond to the challenge.

The high cost of transporting solid waste to available land has limited use of land reclamation techniques especially in the eastern part of the United States where these distances can be substantial. A Public Health Service demonstration grant to the American Public Works Association is partially supporting a study and demonstration of the use of railroad facilities to haul solid waste from crowded

urban centers to areas where land is available for disposal and reclamation. This appears to be an exceptionally economical method of joining available land with great volumes of solid waste and is potentially a new innovation in solid waste management of major proportions. This could open new avenues which would allow consideration of alternatives in this field heretofore considered unthinkable. We are working closely with the American Public Works Association to make certain the results of their investigation are made available to solid waste managers as soon as possible.

Mr. DADDARIO. I am pleased to hear all that. But aren't you more optimistic than you ought to be in what this is accomplishing?

Mr. VAUGHAN. I don't think so.

Mr. DADDARIO. You say the State of Maryland is showing how solid wastes can be used to reclaim strip mines. There you are assuming this will happen, and you are extremely optimistic this is in fact going to happen. You use the Chicago example to show this can be transported to low-cost land and converted to a profitable resource for agricultural and reclamational purposes.

My understanding is that the Chicago situation does not really reach that particular goal.

I understand from what I have read about this that the hauling of solid wastes from crowded urban centers for reclamation by your Public Works Association does not in fact appear to be an exceptionally economical method of joining available land with great volumes of solid waste and is potentially a new innovation. I think these are nice statements and they can be said, but it becomes a matter of whether or not they really have a right to be that optimistic. I am not complaining about it, but I do think it is dangerous for us to come to optimistic conclusions in places where it might be better to be a little bit wary.

Mr. VAUGHAN. That is your view, sir. I am still optimistic and I have every confidence this will work. If it does not work, it does not. The work that has been done so far, which I reviewed last week again, it is getting more encouraging all the time.

Mr. DADDARIO. I think you should provide the specifics for the record, because we cannot possibly in a morning's hearing cover every point. I think it is going to be necessary for your people to sit down and prove these points out. I would like to be able to have the record show that we have a right to be optimistic. I would hope that you would be able to provide that.

Mr. VAUGHAN. A solid waste demonstration grant awarded to Raleigh, N.C., is demonstrating the systems analysis approach to this problem by the application of a mathematical model developed by a Public Health Service research grant to Northwestern University. This organized approach designed to maximize economics involved in collection of solid waste could result in significant savings to taxpayers across the Nation. Through the contract mechanism, we are obtaining an evaluation of the collection of solid waste using specially designed vehicles with one-man crews. The potential savings of such an approach is even more obvious when one considers that labor cost is the main factor in the overall cost of collection.

A demonstration grant was awarded to the town of Barrington, R.I., to demonstrate the feasibility of year-round solid waste storage and collection using paper bags and special holders provided by the

municipality. The effect of this method on collection and disposal practices was also demonstrated.

Agricultural wastes including animal wastes are included in the Nation's solid waste contribution to an extent not realistically considered by the average citizen. Reliable estimates of the magnitude are not only available but preliminary estimates indicate this contribution exceeds 1 billion tons per year.

Public Health Service solid waste research grants awarded to Purdue and Rutgers Universities are supporting study of new methods to dispose of dairy and poultry manure. A demonstration grant awarded to Washington State University is demonstrating facilities and techniques that will reduce the possibility of water pollution and increase the fertilizer values actually realized from dairy manure.

There are several special solid waste problems caused by technological advances in a particular industry or by other sociological and economic progress. As urban renewal and slum clearance grows, what does one do with the mountains of demolition material which results from this endeavor? Our country is the most affluent society in the world and has to worry about more abandoned automobiles than any other country has traveling down their highways. Sophisticated methods have been developed by private industry to compact and reclaim these vehicles but how about transporting them economically to the site and preparing or stripping them for disposal or reclamation without causing air pollution? Old railroad cars have for decades been ignited to dispose of the wooden portion and allow salvage of valuable metal parts. This can no longer be tolerated because of the threat to our air resources—but what do we do with them?

A Public Health Service research grant to New York University supported the development of a special incinerator to handle demolition material and other bulky solid wastes economically and effectively control particulate emission to protect air resources.

We would be glad to have our staff sit down with yours and give them whatever information they need.

The cost of collection of solid waste at its source and transportation of this material to a disposal site is estimated to be about 75 percent of the current total cost of handling solid waste. It is evident that the development of methods which improve technology and lower the cost of collection will materially affect the overall solid waste management picture.

Mr. DADDARIO. Hold it right there a moment.

Dr. Hibbard, we had some discussion on this problem when you appeared before the committee some time back.

As I recall it, your statement included the possibility of mixing solid wastes with taconite for certain steel production purposes. This does fall in this category. I wonder what comment you might have about where we stand in that at the moment?

Dr. HIBBARD. This subject is covered in my prepared statement, Mr. Chairman.

The procedure is technically feasible. We have carried it out in a pilot plant and we have plans for a demonstration plant at Hibbing, Minn. The funds for this plant have been put in reserve due to the current budgetary situation so there is a stretchout involved here.

This approach would have two advantages. It would not only use the scrap automobiles but it would also be the means of getting rid

of the piles of taconite which are part of the solid waste management problem. And it will minimize the cost of both of these objectives.

The problem, however, is the one that Mr. Vaughan has identified: How can these junk automobiles be transported to the site where they can be most effectively used or disposed of?

Mr. DADDARIO. Mr. Vaughan.

Mr. VAUGHAN. To continue, the incinerator developed by the research contract is now being constructed as a demonstration project at Stamford, Conn. The contract mechanism is being used to develop effective ways of dismantling old railroad cars to eliminate air pollution caused by burning these vehicles in the open.

Mr. DADDARIO. We have plenty of old railroad cars.

Mr. VAUGHAN. We sure have.

One approach is a special technique which eliminates burning altogether. A jet of high pressure water is used to cut through the wood and separate the metal fittings from the body of the car. This technique is being further investigated to see see if it might have value in stripping unwanted material—rubber, upholstery, et cetera—from abandoned automobiles prior to their disposal without utilizing incineration techniques. The technique might also be used to reduce the volume of bulky wastes.

A very special problem is now facing those in the Nation concerned with the disposal of solid wastes. This is the problem associated with packaging materials and disposable containers. The problem is really twofold. First, the increased use of this material in recent years has caused a significant increase in the volume of sold wastes that must be handled by the community; and, second, the nature of the disposable material is such that much of it is not amenable to decomposition and, therefore, presents special disposal problems. "Eternal" plastic and "unrustable" aluminum have made their way into solid waste technology and must be coped with if we are to effectively manage solid wastes.

A contract was awarded to study feasible methods of disposing of polyethylene plastic waste while another contract was awarded to the Midwest Research Institute to make a thorough study of packaging materials, trends in this industry, and possible solutions which would be amenable to solid waste disposal without hurting the industry. A part of this study includes the consideration of needed legislative programs to cope with this problem. I shall refrain from further comment on this subject since this committee will hear from a representative of Midwest Research on this important problem. When this study is received, it will be evaluated by our technical personnel and our future course of action determined.

The Solid Waste Disposal Act also directs the recover and utilization of potential resources in solid wastes. Transformation of solid waste into a beneficial product has the advantage of disposing of a waste product, conservation of natural resources, and economic benefit which lowers the net cost of disposal.

A Public Health Service research grant to the University of Florida is supporting development of a method to convert citrus processing plant waste to citric acid. Another research grant to the University of Maryland is supporting investigation of the possibility of transforming wastes formed in the production, packaging, and canning of vegetables and cheese, to new foods or food additives.

The research staff of the solid wastes program has a section devoted to the development of new uses for solid wastes. One internal project is attempting to transform cellulose from solid waste into sugars. Another project stresses the possibility of chemical transformation of solid wastes into protein. Still another is attempting to transform waste rubber into useful new rubber materials by improvement of separation techniques and changing technology to allow a greater proportion of used rubber in new products. Other internal research studies are studying the recovery of useful inorganic and organic compounds from incineration residue, animal, and vegetable wastes.

One method of solid waste disposal resulting in a useful end product is composting. This method has received much publicity during recent years—some good and some bad. Some plants were built to receive the municipal wastes of a municipality and closed their doors within a year while some have operated for years. We, too, wonder what the true story of composting as a solid waste disposal process in this country is.

What are its technological requirements? What are its economic considerations? What is its likely future as a major method of disposal of solid waste?

To answer these and other questions an in-depth study of composting was undertaken jointly with the Tennessee Valley Authority. This joint PHS–TVA composting project at Johnson City, Tenn., will evaluate composting of municipal solid waste and sewage sludge. The plant has been completed and is now operating. Studies will be made to determine:

(1) Potential agricultural use of the product;

(2) The marketing potential of the compost, including geographic limits of the marketing area; and

(3) Public health hazards involved in the use of this product.

Operating guidelines will be developed to assure maximum efficiency and plant environmental conditions will be evaluated. At the conclusion of this project the data gathered should permit a thorough and unbiased evaluation of this practice. The evaluation will include net cost figures and likely estimates of the market one might expect. There seem to be few neutral parties concerned with learning the whole story about this controversial method of solid waste disposal. We hope to shed much insight into this important matter.

Mr. DADDARIO. What is your time schedule in sharing this insight?

Mr. VAUGHN. July 1, 1969, is the target date for our first report. Actually, the project is in operation now. One final processing grinder is the only thing that keeps it from being complete and the evaluation beginning.

Mr. DADDARIO. Taking your previous sentence into consideration, when you have this information do you intend to be one of the few neutral parties?

Mr. VAUGHAN. Not at that time. We will take a stand as we see the picture.

Mr. DADDARIO. You seem to indicate we need more neutral parties.

Mr. VAUGHAN. What I meant by the statement, Congressman, is right now it seems to me people are for it 100 percent or against it 100 percent. Maybe middle ground is the better position. We want to know more about it before we decide in our opinion what role it has in the solid waste practices of the Nation.

Mr. DADDARIO. You expect when that time came you would not be a neutral party if it is something that would be necessary to accomplish in this area?

Mr. VAUGHAN. Yes. Perhaps "neutral" would refer to not having our mind made up one way or the other.

The protection of the Nation's health is a primary responsibility of the Public Health Service. Consideration of the health hazards involved in solid waste management is no exception. There are many health hazards associated with the flies and rats which frequent open dumps and areas where improper collection and storage of solid waste is practiced. Not so well known, however, are the health hazards involved in the collection of wastes. Those who perform this task are engaged in one of the most dangerous jobs in existence. Through the contract mechanism, a study was made of the relationship between disease and solid waste. The research staff of the solid wastes program is now evaluating current solid waste handling practices and will evaluate new methods as they are developed to assure that the public health is being properly protected as scientific technology advances.

Mr. DADDARIO. I have your solid waste-disease relationship and literature study, Public Health Service, U.S. Department of Health, Education, and Welfare. In the summary and conclusions you say:

> The literature fails to supply data which would permit a quantitative estimate of any solid waste-disease relationship. The circumstantial and even epidemiologic information presented does support a conclusion that as to some diseases solid wastes bear a definite, if not well-defined, etiologic relationship.

What does that mean? You seem to be talking about two things. You seem to be wording it so you can be on both sides of this. You say there is no waste-disease relationship, that "does bear a definite if not well-defined relationship." What does that mean?

Mr. VAUGHAN. What page is that?

Mr. DADDARIO. This is on page 5 of your prepared statement. It seems to me to fall into one of those categories of saying everything and saying nothing. Yet, it is under summary and conclusions.

You say "definite but not well-defined." How can it be both? We are talking about health and one of the problems in this whole area of pollution is we know so little about the effect it does have on health. I think it is important to say those things which can develop confidence rather than a lack of confidence and a statement of this kind seems to me to be one which would not do that.

Mr. VAUGHAN. I interpret this statement to mean that the problem of insects and rats as disease carriers and pests is known. The precise relationship of this problem to the solid waste problem is not yet defined. The problem of air pollution as a health hazard I think has been pointed out by the people from the National Center for Air Pollution Control. I do not think it has been precisely defined, however, how much of that comes from the burning of solid waste. Let's hope this relationship can be better determined.

Mr. DADDARIO. I agree with that last statement. That is something we will go into, and it does seem to me this is precisely the kind of statement we have to be extremely careful about. We are trying to accomplish so much and this is one of the reasons I thought perhaps you were too optimistic in some of these other areas. I do not mean we ought to be pessimistic, but we must be realistic. We sometimes

reach out and find ourselves saying things we ought not to. When we do—it is something we are all guilty of from time to time—we then spend more time working our way out of it than it is worth. We are at the time and place in this whole area of pollution where I think we can be extremely realistic. We must be.

Mr. VAUGHAN. Yes.

Our research studies include investigation of the hazardous materials in refuse, pathogens associated with incineration processes, and occupational hazards of solid waste handling. One might assume that the residue following incineration would be almost sterile. Preliminary investigation by our staff has discovered this is not necessarily true and surveys at several plants indicate gross contamination of this material with pathogenic organisms. Further investigation will determine the magnitude and applicability of this finding and hopefully develop an effective way of using this technique to determine the effectiveness of incinerator operation.

The studies of the occupational hazards of solid waste handling are being jointly undertaken by the research staffs of both the occupational health program and the solid wastes program of the National Center for Urban and Industrial Health, and will be devoted to reducing the accident and disease rate by pointing out defects in present technology which contribute to these rates. The studies will also help in the development of technology which is both effective, economic, and safe.

The most advanced technology can be used to develop a magnificent incinerator or sanitary landfill or compost plant capable of doing the job economically and effectively, but if it is not operated properly you have not accomplished a thing. In our rapidly changing world, great stress is placed upon new technology and scientific achievement, but woefully little attention is given to teaching the man who must operate the facility how to run it and making sure he does a good job. New technology is needed in this area just as much as in those areas normally considered scientific. How do we assure proper operation of multi-million-dollar structures?

The American Public Works Association is developing for the Public Health Service a comprehensive blueprint for the training of operating personnel in the field of solid waste disposal. This project, supported by a Public Health Service contract, will also identify and measure training needs to help guide those who will carry out such training. The technical staff of the Public Health Service's solid waste program is currently developing guidelines for the operation of sanitary landfill and incinerators using well-known authorities in these areas as consultants. Both reports are to be completed this year.

Perhaps the most difficult obstacle in getting new technology adopted and implemented is the reluctance of the public to accept solid waste disposal in the communities and the equally severe reluctance of communities to work cooperatively together to come up with one approach to solid waste management that is best for all the municipalities which make up a region or metropolitan area. People want their solid wastes problems solved but not near their home or near their community. Many small suburban communities know they could get by more economically by combining forces with others, but many times prefer to go it alone to preserve their autonomy.

The Public Health Service, through public information technology, is trying to gain public recognition of the solid waste problems and

gain public support for local solution to these problems. Certain demonstration projects such as the transformation of the Kenilworth dump to a model operation and land reclamation activity are designed to gain public support for proper solid waste management. A contract with the National Association of Counties is developing a program designed to educate public officials in solid waste needs, problems, and solutions.

Stimulating communities to work together on a regional or metropolitan basis is being approached by the Public Health Service's solid wastes program through the mechanism of study and investigation grants to demonstrate how communities overcome the legal, interjurisdictional, and public opinion difficulties in approaching their common solid waste problems on a regional basis. The regions being studied include metropolitan areas such as Louisville, Ky.; Erie, Pa.; New Orleans, La.; Des Moines, Iowa, and Oklahoma City, Okla. They also include entire counties such as Maricopa County, Ariz.; Fresno County, Calif.; Genesee County, Mich.; Jefferson County, Wis.; and Harrison County, Miss. Low population density regional areas are included such as the area near Farmington, Conn., and Great Falls, Mont.

The studies also include special regional areas such as the Tocks Island Recreational Area encompassing part of three States, several economically depressed counties in Appalachia, and the Quad-City area in New Jersey. The results of these studies will bring to light approaches which can be used by other communities with similar problems and similar circumstances, thus improving psychometric technology and providing answers which quite frankly have us and most of the country stymied at the present time.

I have pointed out to you many problem areas and have described our approach to their better understanding and solution. I am confident methods will be found which will allow air and water pollution control criteria to be met—methods which are technologically sound, economically feasible, and safe from the standpoint of protection of the public health and our environment.

Lest my remarks here today be interpreted as a deterrent to the use of current technology to solve existing solid waste management problems until a major breakthrough is made, let me set this issue straight right now.

There are no legitimate reasons (except perhaps financial) to hold up the immediate elimination of open burning dumps. The remodeling or replacement of antiquated incineration facilities without effective air pollution control devices, the abandonment of open broken-down collection vehicles which spew solid wastes along the route to the disposal site, and the cessation of feeding garbage to hogs. The Nation can improve its solid waste disposal practices—and it can do it now. We have the technology to do it now—and we are working to improve this technology and develop techniques which are not only more effective but more economical as well.

I feel personal sadness when I consider that the beautiful whooping crane is close to extinction. On the other hand, I look forward with a great deal of zeal, enthusiasm, and pleasure to one of the goals of the solid wastes program—the elimination of the open burning dump from our society. This disgrace to humanity truly belongs to history, not to the present, and certainly not to the future.

In conclusion, I would like to state that the Public Health Service is facing the technological problems I have mentioned today with vigor and enthusiasm. Some of the approaches we are using will succeed and some will fail. We are confident, however, that their undertaking will furnish technological facts for more effective solid waste management and a better and cleaner America.

I appreciate the opportunity to discuss the solid waste management activities of the Public Health Service with you today.

Mr. DADDARIO. Thank you, Mr. Vaughan.

Questions submitted to Richard D. Vaughan by the Subcommittee of Science, Research, and Development.

*Question 1. Solid wastes not only are precursors of air and water pollution but appear again as the result of waste treatment—i.e., the sludge from sewage plants and the residue from incinerators. are these latter residues ultimately going to have to be buried? What is the forecast for burial site acreage in the Northeast megalopolis? Can these solids be dumped at sea?*

Answer. Most areas must use a form of land disposal for sewage sludges. In some coastal areas these sludges may be hauled to sea. At present, the ultimate disposal of the residue from incinerators is invariably upon the land. Present incinerators produce residues of varying quality, most of which must be disposed of by burial. There is no indication that this residue quality will be greatly improved and therefore, it is believed that residue burial will remain as a required practice. There is every expectation that much of the sludge and incinerator residues produced will always have to be disposed of by land burial. The total amount that will have to buried will be directly influenced by the suitability of recovery and utilization processes as developed through the Solid Waste Program's efforts.

A summary of the present burial site acreage available in northeast megalopolis is unavailable at this time, a forecast of future sites would certainly produce an inaccurate appraisal of the situation.

There does not appear to be any technical impediment to the use of land for the proper disposal of sludge and incinerator residues either now or in the foreseeable future. The major limiting consideration is the cost involved in transporting and disposing of such wastes, not the amount of land available for their disposal. Studies are underway to solve this problem through better transportation methods, improved volume reduction methods, and advanced disposal techniques.

The technology concerning sea waste disposal is for all practical purposes nonexistent at this time. Until adequate technical information is available on the degradation and movement of these materials when dumped at sea it is impossible to adequately answer any question concerning the suitability and desirability of such disposal practices. It is possible that advanced technology may allow us to safely dispose of solid wastes at sea just as we now dispose of solid wastes in other environmental areas.

*Question 2. When solid wastes from municipal collection of trash is incinerated, what is the volume reduction? What is the weight reduction? What is the magnitude of the disposal problem of incinerator residue for a large incinerator?*

Answer. The volume reduction obtainable by municipal incinerators (as well as the weight reduction) depends almost entirely upon the configuration and operation of the particular facility. A 75% reduction in both weight and volume of municipal refuse is considered to be the average result of incineration today.

The magnitude of the incinerator residue problem is not only dependent upon configuration and operation, it is also dependent upon the size of the furnace and the amount and type of the refuse charged. Many very large incinerators minimize the residue problem by doing an efficient job of volume reduction. It is also just as common to see a municipal incinerator poorly operated, producing a very minimal volume reduction. If the present day incinerators could produce, under normal operating conditions, a sterile, stable residue, the problem of residue disposal would be considerably decreased.

*Question 3. What are the comparative areas required for composting versus incineration and other methods?*

Answer. Municipal incinerators and composting plants consisting of mechanical digesting facilities require approximately the same space for plant installation. The windrow method of composting, however, requires a considerably greater space since much of the digestion of the solid wastes takes place in open windrows upon composting aprons.

Both incineration and composting are volume reduction methods and additional areas are necessary for the final disposition of those materials which cannot or were not incinerated and those materials which cannot be composted nor have salvageable value. Using present techniques those additional areas required would be approximately equal for the two methods considered. We would predict that the amount of land for each type of operation, at least for the initial facility installation, is expected to change with the development and introduction of need salvage and recycling techniques. These techniques are expected to become increasingly important to solid waste management officials during the next decade.

*Question 4. What is the present status of the operations of composting plants in the United States? What has been the experience over the last ten years? What have been the fiscal experiences for plants serving less than 50,000 and more than 500,000 people? Realistically, how applicable are such procedures as composting in the economy of the United States?*

Answer. An evaluation of the composting plants status in the United States over a period of ten years reveals that of the 17 composting plants proposed to compost municipal wastes only 4 are presently maintaining a reasonably continuous operation. Two of the 17 were never constructed—the other 15 plants have had varying operating experiences ranging from less than one year to five years. We have been unable to discover any correlation between the size of population served and fiscal experience of the plant. Reliable technical and economic data on composting is not presently available—it is possible that a correlation could exist.

Dr. Samuel A. Hart in his report to the United States Public Health Service upon the subject of "Solid Waste Management: Composting—European Activity and American Potential" summarizes the potential for composting and compost utilization in the United States as follows: "It appears to the author that there are no real technological barriers to making compost. It does appear, however, that the utilization of compost is limited. There are successes in luxury agriculture, as evidenced in vineyard, flower, and landscaping uses, but basic agriculture cannot be expected to absorb the material. Further, the concept of composting must be considered from the municipality's viewpoint. Most municipal officials recognize that it is not possible to make money from garbage. The most that can be expected, with regard to composting, is that the net cost to the city for garbage disposal by composting will be less, or no greater, than the costs of disposing of the garbage by landfilling or incineration. The gross cost of composting could be more if a return could be realized on the sale of the compost, or a value could be put on the intangible factors of reduced rate of consumption of burial sites or reduced air pollution relative to incineration.

It does appear that in the United States there are three specific areas in which refuse processing and discharge through composting have real potential:

(1) Small amounts of compost can be marketed for luxury agriculture, in which case the overall economics—to the producing municipality and to the user—are favorable.

(2) The finished compost has value, but the economics—for the producer or for the user—must be related to intangible values.

(3) The finished compost is either not valuable or only marginally so, but the overall economics are nonetheless favorable. . . .

At this stage it is impossible to estimate what percentage of the nation's garbage might be so managed. It would appear that this system might have merit for communities with populations between 10,000 and 100,000. There are 1,760 such communities in the United States, with a total population of nearly 50 million, or 25% of the nation. If this method of refuse disposal were appropriate or even one-third of them, it would be a substantial avenue of waste disposal."

*Question 5. Are there any results available as yet on system analysis or operations research, which would improve collection procedures or would provide more economical handling? What significance have the studies in California and elsewhere had by the application of systems analyses to the problems of collection and disposal?*

Answer. Exceptionally few significant systems analysis projects in solid wastes have progressed beyond the first phase; analyzing present sytems and developing conceptual models. Preliminary results from some first phase attempts indicate that meaningful results will be forthcoming. Much of the work is in the descriptive stage and problem solving is not significantly present in either the California studies or elsewhere.

*Question 6. Are there any examples in the United States as elsewhere of new collection techniques or equipment or both?*

Answer. Very few new collection techniques have been developed within this country or abroad. National efforts have been towards the improvement of cur-

rent equipment design and optimization of current collection practices. A bigger and better compactor truck is an example of this practice. Similarly, the development of smaller, more mobile collection equipment such as the scooter or train system or the containerized technique for handling commercial, industrial, or high residential density wastes is also a current practice.

The Swedish pneumatic system or the liquid transport of ground solid wastes as being investigated at Drexel University is the closest thing to what may be a new collection technique. The research undertaken at Drexel University is in its very preliminary stages and cannot be considered as an imminent method for public use. The Swedish pneumatic system consists of a vacuum pipeline which moves refuse from piped apartment buildings to a centralized storage and disposal area. This system has not been tested in our country although we have reason to believe that an example of this collection system may be available in the coming months.

(Mr. Vaughan's prepared statement follows:)

PREPARED STATEMENT OF RICHARD D. VAUGHAN, CHIEF, SOLID WASTES PROGRAM, NATIONAL CENTER FOR URBAN AND INDUSTRIAL HEALTH, PUBLIC HEALTH SERVICE, U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, CINCINNATI, OHIO

Mr. Chairman, I am pleased to be here today and welcome this opportunity to present a report on the adequancy of technology in the field of solid waste management and what the Solid Wastes Program of the Public Health Service is doing to close existing gaps in this technology. The Solid Wastes Program was established to carry out the directives of the Solid Waste Disposal Act of 1965 which has as its objectives:

(1) To initiate and accelerate a national research and development program for new and improved methods of proper and economic solid waste disposal.

(2) To provide technical and financial assistance to appropriate agencies in the planning, development, and conduct of solid-waste disposal programs.

In enacting this legislation Congress recognized the increasing problems of solid waste management which have been accentuated by continuing technological progress and improvement. The Congress also recognized the fact that inefficient and improper methods of solid waste disposal threaten the health and well-being of the Nation including interference with community life and development. Following the directives in this Act, the Public Health Service has established an organizational entity to address itself to these problems and find solutions for today and tomorrow and thus, assure adequate protection of the air, land, and water resources of this country from degradation through inadequate and improper management of solid waste.

During his testimony before this committee on July 21, 1966, Mr. Wesley Gilbertson, then Chief of the Office of Solid Wastes, discussed the history of federal activities in the solid waste management area and described the National solid waste problem as he saw it at that time. He described the Solid Waste Disposal Act and its provisions as well as the structure of the organization established by the Public Health Service to carry out the provisions of this legislation. Mr. Gilbertson pointed out to this committee, plans of the Office of Solid Wastes to learn more about solid waste practices in this country and hopefully close the technology gap in this area. I shall not repeat this information but rather would like to discuss with you what has been accomplished in the interim by the Public Health Service to better understand the adequacy of solid waste practices and problems in this country and develop effective technology to cope with these problems.

The improved technology we seek must satisfy other requirements in addition to being scientifically sound. These innovations must also be economically feasible for our society and must be safe from the standpoint of public health and the protection of our precious natural resources—our land, air, and water.

Technological development alone—no matter how effective, how economical or howe safe—will not do the job that is needed to be done to improve solid waste management in this country. Once new solutions are found and proven effective by research and development, their practicability and applicability to a real situation must be demonstrated. The public's attitude towards solid waste management must be changed to allow acceptance of new concepts. Communities which are jurisdictionally autonomous but collectively make up regional or metropolitan areas, must learn to cooperate and work together for the adoption and implementation of solid waste collection and disposal techniques which economically and effectively serve the best interests of all. No matter how innovative new technology is, the facilities involved must be operated properly to achieve the benefit intended by the developer. This then is the com-

plete job of solid waste management—the approach to which the Solid Wastes Program of the Public Health Service is dedicated.

I should point out that the full financial and personnel resources of the Solid Wastes Program are utilized on an integrated basis to get the results we desire. Problem areas discovered in fact-finding surveys lead to intra and extra-mural research activity which in turn leads to development and demonstration activity to show the practicability of a solution. As a final step public information documents and solid waste training conducted by universities and the Public Health Service convey this information to personnel in the field to aid them in making wise solid waste management decisions and meet pollution control criteria imposed upon them by regulatory agencies. The lack of valid information effectively describing the present status of solid waste practices in the United States presents a major obstacle to effective assessment of the solid waste problem in this country and what type action programs should be undertaken to assure proper solid waste management now and in the future. The paucity of such information has been recognized in previous testimony before this and other committees investigating solid waste management in this country.

Recognizing this need, we have utilized State Planning Grants to help fill this void. These grants have been awarded to 38 State and interstate agencies to first survey solid waste practices within the State and then develop a comprehensive State solid waste plan. Our own technical staff are at this moment taking the results of all the surveys which have been totally or partially completed and preparing a report which for the first time will show, on a statistically reliable basis, the following:

(a) The magnitude of municipal and commercial solid wastes being handled in the United States today and future use projections.

(b) The type of disposal and collection techniques being used today and their frequency of distribution.

(c) The adequatecy of present practices.

(d) Solid waste management needs for today and for the future (financial and technological).

This activity has a high program priority and is scheduled to be completed this summer. At the same time our technical personnel are conducting specialized studies of selected industries to get better insight into the solid waste problems associated with industrial operation.

A solid waste information retrieval system has been established within the Solid Wastes Program and is now operational. Technical journals and other periodicals and reports have been abstracted, categorized, and catalogued. A researcher interested in what information is available in a broad or very specific field can inquire and be furnished appropriate material.

Incinerator technology represents a pressing problem facing many solid waste managers and city officials today. Incineration of solid waste is a volume reduction technique to materially reduce the amount which must ultimately be disposed by some other technique such as land disposal. Since combustion of waste is an integral process of all incinerators, air pollution can and has resulted unless effective control measures are utilized. Furthermore inadequate or improper design and/or operation have resulted in pollution of our land and water resources. Some cities have received rather shocking news lately when construction bids have been opened on incinerators which have incorporated air pollution control devices required by regulatory officials. The increased capital investment and operation unit costs represent a ⅓ to ½ increase over costs previously associated with this type of disposal facility without effective air pollution controls. We believe that all incinerators must be designed and operated to assure adequate protection of our air and water resources. We, however, are appalled when these increased costs prevent effective community action to eliminate open burning in dumps, and incineration in outmoded facilities which cannot even be modified to assure efficient operation and protection of air resources. The answer to this debacle in our opinion is to either find effective substitutes for costly incineration or where this does not appear to be feasible, develop new incineration methods which are economically feasible and effective in controlling air pollution. The Public Health Service's Solid Wastes Program is addressing itself to both approaches.

The City of Brockton, Massachusetts, supported by a Public Health Service solid waste demonstration grant is evaluating a newly developed ultra high temperature incinerator purported to have low capital and operating costs and great flexibility in the size and type of solid waste it can receive. This incinerator operates at such a high temperature that it produces an inoffensive residue

which can be used widely in many community operations in lieu of gravel. The inventors claim the high operations temperature will greatly reduce the need for air pollution control devices and thus lower the costs even more. If the evaluation proves successful, a demonstration in an appropriate community could follow and perhaps a major contribution in incinerator technology.

The small community has been unable to utilize incineration because of the inability to take advantage of economy of scale. A demonstration grant to the City of Shippensburg, Pennsylvania is supporting the evaluation and demonstration of a small mechanically stoked rotary grate incinerator developed in West Germany which if successful will allow communities in the 25,000 population range to consider incineration as a satisfactory method of disposing of solid waste and effectively meeting air pollution control criteria.

Through the contract mechanism the Solid Wastes Program is in the process of developing a new concept in incineration which may lead to a major breakthrough in incinerator technology. Many incinerators here and abroad have considered utilization of waste heat to lower the net cost of operation by generating steam for purposes of heating or electric power generation. Our new approach takes advantage of jet engine technology to transform waste heat from combustion directly to a gas turbine and generate electric power with far greater efficiency and thus lower net cost. If this method, which includes effective air pollution control devices, proves to be as successful as it now appears likely, the net cost of operation may be substantially lower than present incinerators operating *without* any air pollution control devices.

Since the irregular size of solid waste can contribute to ineffective operation and actually produce greater amounts of particulate matter to pollute the air, a demonstration grant awarded to the City of Buffalo, New York, is supporting a demonstration of a crusher to effectively presize refuse prior to incineration and thereby increasing the efficiency and air pollution control effectiveness of the incineration process which follows.

At the present time the most commonly used alternative to incineration is land disposal. The sanitary landfill is currently recommended as the most desirable technique. This method prohibits burning at any time, is designed and engineered to prevent pollution of ground and surface water, and is covered daily with an adequate layer of clean earth to prevent insect and rodent infestation and eliminate other insults to our environment. Too often the sanitary landfill degenerates into an open burning dump through poor operation—giving this method a bad name. If not used instead of incineration some method of land disposal is generally used with it to dispose of residue and outsized material which cannot be handled by the incinerator. Rising land costs and shortages of suitable areas have restricted use of sanitary landfill as have such factors as lack of citizen acceptance because of bad publicity. When public opinion or lack of available land forces the location of this operation long distances from the source of the waste, the resultant transportation cost may equal or even exceed the savings one might expect from land disposal as opposed to proper incineration. Lack of reliable information concerning settlement of sanitary landfills and the effects of methane gas produced as a result of decomposition of buried and compacted solid waste have also hindered effective utilization of this technique.

The Public Health Service is approaching these problems on the basis that land disposal properly designed and conducted is an exceptionally desirable form of solid waste disposal. Air and water pollution are effectively controlled and land reclamation can be accomplished. I cannot say enough about the potential of land reclamation through the disposal of solid wastes. The State of Maryland partially supported by a solid waste demonstration grant is showing how solid waste can be used to reclaim strip mines. This could change a blight of America into a precious asset and at the same time effectively deal with a pressing community problem—solid waste disposal. Another demonstration grant to the Chicago Sanitary District will show how sewage sludge after its removal from waste water can be transported to low cost land and converted into a profitable resource for agricultural and recreational purposes. Perhaps the most infamous example of solid waste disposal, the Kenilworth dump in Washington, D.C., is being converted into a model sanitary landfill operation which will ultimately be transformed into a tree-lined, grass-covered park and recreational area. There is no reason why necessary community functions cannot result in a community asset if technology can but respond to the challenge.

The pancake-flat terrain around Virginia Beach, Virginia, will have a welcome

hill for entertainment as recreational purposes, thanks to another PHS solid waste demonstration grant designed to effectively join land reclamation and solid waste disposal.

Through the contract and demonstration grant mechanism the PHS Solid Wastes Program is supporting a study and demonstration to develop effective methods for controlling methane gas production in sanitary landfills and diminishing its adverse effects on land use.

The high cost of transporting solid waste to available land has limited use of land reclamation techniques especially in the eastern part of the United States where these distances can be substantial. A Public Health Service demonstration grant to the American Public Works Association is partially supporting a study and demonstration of the use of railroad facilities to haul solid waste from crowded urban centers to areas where land is available for disposal and reclamation. This appears to be an exceptionally economically method of joining available land with great volumes of solid waste and is potentially a new innovation in solid waste management of major proportions. This could open new avenues which would allow consideration of alternatives in this field heretofore considered unthinkable. We are working closely with the American Public Works Association to make certain the results of their investigation are made available to solid waste managers as soon as possible.

We are actively supporting the development, evaluation and demonstration of new devices and techniques to reduce the bulk or volume of solid waste and allow greater utilization of precious land for sanitary landfill operations. Crushing, baling, or grinding devices in New York City, New York; Madison, Wisconsin; Tacoma, Washington; and San Diego, California partially supported by Public Health Service solid waste demonstration grants are demonstrating techniques of volume reduction of solid waste to effectively increase the life of sanitary landfills. Similar grants support the demonstration of refuse disposal machines in Lockport, New York and Seattle, Washington to effectively compact and place solid waste into the ground in a manner designed to prolong the life of the sanitary landfill.

The cost of collection of solid waste at its source and transportation of this material to a disposal site is estimated to be about 75% of the current total cost of handling solid waste. It is evident that the development of methods which improve technology and lower the cost of collection will materially affect the overall solid waste management picture.

A solid waste demonstration grant awarded to Raleigh, North Carolina is demonstrating the systems analysis approach to this problem by the application of a mathematical model developed by a Public Health Service Research grant to Northweastern University. This organized approach designed to maximize economics involved in collection of solid waste could result in signficant savings to taxpayers across the Nation. Through the contract mechanism, we are obtaining an evaluation of the collection of solid waste using specially designed vehicles with one-man crews. The potential savings of such an approach is even more obvious when one considers that labor cost is the main factor in the overall cost of collection.

Innovation technology in the collection field is being investigated by the University of Pennsylvania supported by a Public Health Service solid waste research grant. This project is determining the feasibility of transporting solid waste in pipes as a liquid slurry. Recently developed in Sweden a vacuum system is transporting solid waste in highly urbanized areas short distances in pneumatic tubes. This method is being evaluated by the technical staff of our own Program and if justified will be applied to an appropriate system in the United States.

A demonstration grant was awarded to the town of Barrington, Rhode Island to demonstrate the feasibility of year-round solid waste storage and collection using paper bags and special holders provided by the municipality. The effect of this method on collection and disposal practices was also demonstrated.

Agricultural wastes including domestic animal wastes are included in the Nation's solid waste contribution to an extent not realistically considered by the average citizen. Reliable estimates of the magnitude are not now available but preliminary estimates indicate this contribution exceeds one billion tons per year.

Public Health Service solid waste research grants awarded to Purdue and Rutgers Universities are supporting study of new methods to dispose of dairy and poultry manure. A demonstration grant awarded to Washington State University is demonstrating facilities and techniques that will reduce the possibility of water pollution and increase the fertilizer values actually realized from dairy manure.

There are several special solid waste problems caused by technological advances in a particular industry or by other sociological and economic progress. As urban renewal and slum clearance grows, what does one do with the mountains of demolition material which results from this endeavor? Our country is the most affluent society in the world and has to worry about more abandoned automobiles than any other country has traveling down their highways. Sophisticated methods have been developed by private industry to compact and reclaim these vehicles but how about transporting them economically to the site and preparing or stripping them for disposal or reclamation without causing air pollution? Old railroad cars have for decades been ignited to dispose of the wooden portion and allow salvage of valuable metal parts. This can no longer be tolerated because of the threat to our air resources—but what do we do with them?

A Public Health Service research grant to New York University supported the development of a special incinerator to handle demolition material and other bulky solid wastes economically and effectively control particulate emission to protect air resources. This incinerator is now being constructed by the City of Stamford, Connecticut, partially supported by a Public Health Service solid waste demonstration grant.

The contract mechanism is being used to develop effective ways to dismantle old railroad cars to eliminate air pollution caused by burning these vehicles in the open. One approach is a special hood enclosing the entire car, but one of more promising value is a technique which eliminates burning altogether. A jet of high pressure water is used to cut through the wood and separate the metal fittings from the body of the car. This technique is being further investigated to see if it might have value in stripping unwanted material (rubber, upholstery, etc.) from abandoned automobiles prior to their disposal without utilizing incineration techniques. The technique might also be used to reduce the volume of bulky wastes.

A very special problem is now facing those in the Nation concerned with the disposal of solid wastes. This is the problem associated with packaging materials and disposable containers. The problem is really two-fold. First the increased use of this material in recent years has caused a significant increase in the volume of solid wastes that must be handled by the community and second, the nature of the disposable material is such that much of it is not amenable to decomposition and, therefore, presents special disposal problems. "Eternal" plastic and "unrustable" aluminum have made their way into solid waste technology and must be coped with if we are to effectively manage solid wastes.

A contract was awarded to study feasible methods of disposing of polyethylene plastic waste while another contract was awarded to the Midwest Research Institute to make a thorough study of packaging materials, trends in this industry and possible solutions which would be amenable to solid waste disposal without wrecking the industry. A part of this study includes the consideration of needed legislative programs to cope with this problem. I shall refrain from further comment on this subject since this Committee will hear from a representative of Midwest Research on this important problem. When this study is received it will be evaluated by our technical personnel and our future course of action determined.

The Solid Waste Disposal Act also directs the recovery and utilization of potential resources in solid wastes. Transformation of solid waste into a beneficial product has the advantage of disposing of a waste product, conservation of natural resources, and economic benefit which lowers the net cost of disposal. A Public Health Service research grant to the University of Florida is supporting development of a method to convert citric processing plant waste to citric acid. Another research grant to the University of Maryland is supporting investigation of the possibility of transforming wastes formed in the production, packaging, and canning of vegetables and cheese, to new foods or food additives.

The research staff of the Solid Wastes program has a section devoted to the development of new uses for solid wastes. One internal project is attempting to transform cellulose from solid waste into sugars. Another project stresses the possibility of chemical transformation of solid wastes into protein. Still another is attempting to transform waste rubber into useful new rubber materials by improvement of separation techniques and changing technology to allow a greater proportion of used rubber in new products. Other internal research studies are studying the recovery of useful inorganic and organic compounds from incineration residue, animal, and vegetable wastes.

One method of solid waste disposal resulting in a useful end product is composting. This method has received publicity during recent years—some good and some bad. Some plants were built to receive the municipal wastes of a municipality and closed their doors within a year while some have operated for years. We too wonder what the true story of composting as a solid waste disposal process in this country is. What are its technological requirements? What are it economic considerations? What is its likely future as a major method of disposal of solid waste? To answer these and other questions a study in depth of composting was undertaken jointly with the Tennessee Valley Authority. This Joint PHS–TVA Composting Project at Johnson City, Tennessee will evaluate composting of municipal solid waste as well as a mixture of municipal solid waste and sewage sludge. The plant has been completed and is now operating. Studies will be made to determine: (1) Potential agricultural use of the product; (2) The Marketing potential of the compost including geographic limits of the marketing area, and (3) Public Health hazards involved in the use of this product. Operating guidelines will be developed to assure maximum efficiency and plant environmental conditions will be evaluated. At the conclusion of this project the data gathered should permit a thorough and unbiased evaluation of this practice. The evaluation will include net cost figures and likely estimates of the market one might expect. There seems to be few neutral parties concerned with learning the whole story about this controversial method of solid waste disposal. We hope to shed much insight into this important matter.

The protection of the Nation's health is a primary responsibility of the Public Health Service. Consideration of the health hazards involved in solid waste management is no exception. The health hazards associated with air pollution from improper burning of solid wastes is well known as are the hazards from flies and rats which frequent open dumps and areas where improper collection and storage of solid waste is practiced. Not so well known, however, are health hazards involved in the collection of wastes. Those who perform this task are engaging in one of the most dangerous jobs in existence. Through the contract mechanism a study was made of the relationship between disease and solid waste. The research staff of the Solid Wastes Program are evaluating current solid waste handling practices and will evaluate new methods as they are developed to assure the public health is being properly protected as scientific technology advances.

Our research studies include investigation of the hazardous materials in refuse, pathogens associated with incineration processes and occupational hazards in solid waste handling. One might assume that the residue following incineration would be almost sterile. Preliminary investigation by our staff has discovered this is not necessarily true and surveys at several plants indicate gross contamination of this material with pathogenic organisms. Further investigation will determine the magnitude and applicability of this finding and hopefully develop an effective way of using this technique to determine the effectiveness of incinerator operation.

The studies of the occupational hazard of solid waste handling are being jointly undertaken by the research staffs at the Occupational Health Program and the Solid Wastes Program of the National Center for Urban and Industrial Health, and will be devoted to reducing the accident and disease rate by pointing out defects in present technology which contribute to these rates and develop technology which is both effective, economic, and safe.

The most advanced technology can be used to develop a magnificent incinerator or sanitary landfill or compost plant capable of doing the job economically and effectively, but if it isn't operated properly you haven't accomplished a thing. In our rapidly changing world great stress is placed upon new technology and scientific achievement many times of a very sophisticated nature but woefully little attention is given to teaching the man who must operate the facility how to run it and making sure he does a good job. New technology is needed in this area just as much as in those areas normally considered scientific. How do we assure proper operation of multi-million dollar structures?

The American Public Works Association is developing for the Public Health Service a comprehensive blueprint for the training of operating personnel in the field of solid waste disposal. This project supported by a Public Health Service contract will also identify and measure training needs to help guide those who will carry out such training. The technical staff of the Public Health Service's Solid Wastes Program are currently developing guidelines for the operation of sanitary landfills and incinerators using well known authorities in these areas as consultants. Both reports are due to be completed this year.

Perhaps the most difficult obstacle in getting new technology adopted and implemented is the reluctance of the public to accept solid waste disposal in the communities and the equally severe reluctance of communities to work cooperatively together to come up with one approach to solid waste management that is best for all the municipalities which make up a region or metropolitan area. People want their solid wastes problems solved but not near their home or near their community. Many small suburban communities know they could get by more economically by combining forces with others but many times prefer to go it alone to preserve their autonomy.

The Public Health Service through public information technology is trying to gain public recognition of the solid waste problems and gain public support for local solution to these problems. Certain demonstration projects such as the transformation of the Kenilworth dump to a model operation and land reclamation activity are designed to gain public support for proper solid waste management. A contract with the National Association of Counties is developing a program designed to educate public officials in solid waste needs, problems, and solutions.

Stimulating communities to work together on a regional or metropolitan basis is being approached by the Public Health Service's Solid Wastes Program through the mechanism of Study and Investigation grants to demonstrate how communities overcome the legal, interjurisdictional and public opinion difficulties in approaching their common solid waste problems on a regional basis. The regions being studied include metropolitan areas such as Louisville, Kentucky; Erie, Pennsylvania; New Orleans, Louisiana; Des Moines, Iowa; and Oklahoma City, Oklahoma. They also include entire counties such as Maricopa County, Arizona; Fresno County, California; Genesee County, Michigan; Jefferson County, Wisconsin; and Harrison County Mississippi. Low population density regional areas are included such as the area near Farmington, Connecticut and Great Falls, Montana. The studies also include special regional areas such as the Tocks Island Recreational Area encompassing part of three states, several economically depressed counties in Appalachia, and the Quad-City area in New Jersey. The results of these studies will bring to light approaches which can be used by other communities with similar problems and similar circumstances thus improving psychometric technology and providing answers which quite frankly have us and most of the country stymied at the present time.

Many problem areas have been pointed out and our approach to their better understanding and solution. I am confident methods will be found which will allow air and water pollution control criteria to be met—methods which are technologically sound, economically feasible, and safe from the standpoint of protection of the public health and our environment.

Lest my remarks here today be interpreted as a deterent to the use of current technology to solve existing solid waste management problems, let me set this issue straight right now. There are no legitimate reasons (except perhaps financial) to hold up the immediate elimination of open burning dumps, remodeling or replacement of antiquated incineration facilities without effective air pollution control devices, the abandonment of open broken-down collection vehicles which spew solid wastes along the route to the disposal site, and the cessation of feeding garbage to hogs. The Nation can improve its solid waste disposal practices and it can do it now. We have the technology to do it now—we are working to improve this technology and develop techniques which are not only more effective but are more economical. I feel personal sadness when I consider that the beautiful whooping crane is close to extinction and only heroic efforts have prevented it. On the other hand, I look forward with a great deal of zeal, enthusiasm, and pleasure when I consider one of the goals of the Solid Wastes Program—the elimination of the open burning dump from our society. This disgrace to humanity truly belongs to history not to our present and certainly not to our future.

In conclusion I would like to state that the Public Health Service is facing the Technological problems I have mentioned today with vigor and enthusiasm. Some of the approaches we are using will succeed and some will fail. We are confident, however, that their undertaking will furnish technological facts for more effective solid waste management and a better and cleaner America.

I appreciate the opportunity of discussing the solid waste management activities of the Public Health Service with you today.

Mr. DADDARIO. Will you proceed, Mr. Darnay?

Chairman MILLER. May I ask a question?

Mr. DADDARIO. Yes, Mr. Chairman.

Chairman MILLER. I am very much concerned with the disposal of waste. My city of Alameda used to open-burn, but the area air pollution board stopped us. The first thing the mayor did was to scream to high heaven that as the result of stopping this burning, we were going to have rats, but somehow or another we stopped the burning, improved the method of cover, and I do not think we have had so many rats. But this is not the point I want to get at.

How many disposable bottles from soft drinks and beer and other things are distributed today in this country?

Mr. VAUGHAN. I do not have that information, Mr. Miller but I think Mr. Darnay has.

Mr. DARNAY. I believe I can answer that. Perhaps not on a day-by-day basis, but we have some data on the total.

Chairman MILLER. If you have that in your paper——

Mr. DARNAY. It is in my statement; yes, sir.

Chairman MILLER. I had a discussion with a man when I was home this year about our own East Bay area in California. He is a distributor of beer. I said, "How many disposable bottles do you think you distribute a day?"

He said about 50,000. He is talking of a population area of a million and a half to two million people. I do not think that is too far out. It may be correct for beer, but how many bottles of Coca-Cola and Pepsi Cola and all of these other things that we now buy in disposable bottles, are there? How long will we find places to hide this material? If you have cellulose material or something of vegetable material, they will eventually disintegrate. A few archeologists 10,000 years from now will run across a mass of these bottles and wonder what they were used for. They may be here for 10,000 years. They still find the resin the Greeks were putting in their wines 5,000 years ago.

What are we going to do with this?

Mr. VAUGHAN. This is a very serious problem, and is one of the reasons we let a contract with Midwest Research to come up with some answers which will be reported on today.

Chairman MILLER. It is more economical to use a disposable bottle because if you return the bottle, it has to be sterilized before it can be reused. So somebody is making a better profit by using so-called disposable bottles.

Should not perhaps the people share some of this profit with the Government to help dispose of the bottles they use? Should we put a tax on them?

Mr. DAVIS. Charge them a dumpage fee.

Chairman MILLER. Some type of a fee, because the fellow is making money since he does not have to bring the bottles back and take care of them. It is cheaper for him to buy new bottles than to reuse them.

There was a time during World War II if you wanted to get a six-pack of Coca-Cola, you had to bring back six empty Coca-Cola bottles. Now you do not need bottles.

Mr. DAVIS. If the gentleman will yield very briefly, there is coming into government a concept known as a dumpage fee, which is be-

ginning to apply to such things as air pollution and water pollution, which might well be applied to solid waste disposal.

Mr. VAUGHAN. This concept, I understand, is used now in the Ruhr River Basin in Germany. You pay on the basis of how much you use, or the magnitude of the problem your wastes might cause.

Mr. DAVIS. Yes.

Chairman MILLER. I think this is one of the things that has to be looked at. Of course, I realize the bottle manufacturers will raise the dickens if you get into this dumpage fee, but why not face it squarely.

Mr. VAUGHAN. One of the more interesting statistics is that the per capita solid waste contribution in this country has doubled in the last 25 years, and to a large part, because of such problems as packaging material, disposable bottles, tin cans, and aluminum cans.

Mr. DARNAY. May I comment on your question?

Chairman MILLER. Yes.

Mr. DARNAY. I believe the concept of a disposal fee that you mention is quite reasonable. Such a fee is one of the things we are going to recommend in our study to the solid waste program.

I ought to, also, at the same time, point out that industry is not alone in guilt in this entire question of disposable bottles. The American consumer likes to have a disposable type of container. As a consequence, even returnable type of bottles have been thrown away. We are a very affluent and hedonistic society, or at least we are becoming such a society. As a consequence, the penny-conscious youngsters are disappearing, and the housewife, on the other hand, does not wish to lug many different cartons of bottles back to the store. This is at the root of the popularity of nonreturnable containers.

Chairman MILLER. I think this is very true and I accept it, but because my wife does not want to lug bottles back to the store, is that any reason why Mr. Carpenter, for example, should pay an increment of tax to take care of things she does not want to do, or other wives do not want to do? I think one way of measuring it would be to put the tax perhaps on the bottle, but it is not the fault entirely of the consumer. We like to get rid of bottles all right. But I think it is a new thing, this business of disposable bottles. It is going to give us one of the greatest headaches in the next 10 years that we are going to face.

Mr. DADDARIO. Mr. Darnay, do you presume in this recommendation that you may make, there will be a tax on people in industry, that they will pay a tax to a system which we will have developed to properly dispose of the material they are dumping. The fact remains at the moment, a lot of people are paying tax by paying the fine which comes about as a result of dumping materials into a dump or into a river, and yet the pollution problem is not in any way abated.

Mr. DARNAY. That is true. The concept that we have developed would work somewhat like this: when you purchase color film, for instance, you purchase the processing of the film when you buy it. Conceivably, when you purchase a particular commodity, you could at the same time pay for the disposal of the packaging in which it comes. This would work best on a local level where the local conditions are known, let us say in a fairly large city or jurisdiction. The money collected on the containers could be routed directly to local disposal operators and could perhaps even pay for some of the innovations and some of the improvements that are necessary.

On the basis of our study, we developed a technique of ranking different materials or different containers to indicate their actual resistance to processing in different types of processes. If this ranking system were to be extended and refined, it could possibly become the basis for imposing a differential type of disposal fee, whereby paper containers perhaps would pay a lower fee than glass, metals or plastic, which are not as disposable.

This is a cumbersome type of approach because many decisions would have to be made as to what particular fee should be imposed on a particular container. But ultimately this would be in a way of recovering some of the disposal costs created by the containers without regulating the packaging industries, which would, in our opinion, be a much more cumbersome job.

Mr. DADDARIO. That assumes that you rate these in a graded pattern of some kind because you developed ways and means to dispose of them so they are not going to be harmful, and that is a big order, is it not?

Mr. DARNAY. I believe we do have adequate means of disposing of our waste. Certainly packaging materials. Packaging materials are inorganic and as such they do not degrade. This is one of the problems involved with them. With the exception of some of the plastics, there are no real air pollution hazards associated with the burning of packaging materials as such. I believe a disposal fee could be imposed on the basis of present technology.

Chairman MILLER. You might have a so-called tin can, or steel can coated with tin used for beer, as the original cans were. Now they are going to use aluminum cans, are they not?

Mr. DARNAY. Yes, some.

Chairman MILLER. Tin cans exposed to the weather would eventually disintegrate?

Mr. DARNAY. That is correct.

Chairman MILLER. Or with buried tin, there is moisture. How about the aluminum cans?

Mr. DARNAY. Aluminum cans will be around for a long, long time. So will plastic containers of various types.

Chairman MILLER. And so will glass containers. If you take a glass container and grind it down, it turns into sand, but the aluminum and plastic of course stay even if you were to reduce them.

Dr. HIBBARD. May I comment on this particular point?

Chairman MILLER. Yes.

Dr. HIBBARD. Our analyses show that each ton of residue from municipal incinerators contains about 550 pounds of metal, about 500 pounds of which is iron and the rest consisting mainly of aluminum, copper, lead, tin, and zinc. In the Bureau of Mines, as part of our mission, we have been looking at the long-range need for these metals. We find that if the metal requirements are projected to 1985, or to the year 2000 in some cases, these very commodities we are throwing away today may be in seriously short supply.

For example, at this moment we are importing 40 percent of our iron ore. With respect to aluminum, we are importing 85 percent of its ore, bauxite. For each ton of refuse incinerated about 20 pounds of fly ash is generated and this contains gold and silver. Approximately 40 million troy ounces of silver are used every year for photographic

purposes and a good part of this is just thrown away. We have found enough values in the fly ash from incinerators to be comparable to the assay of gold and silver in a normal mine out in the West. We think that the loss of these metals in municipal refuse is a very serious problem from a resource standpoint and that these solid wastes are a source of values that can help us to balance our supply-demand situation.

So we believe that aside from the pollution problem, we must develop the technology to recover and recycle every bit of these metals. And we think this is entirely possible.

For example, in our own State, Chairman Miller, we have been looking at the mill tailings on the mother lode around Grass Valley to see if we can make brick or stone or aggregate out of them. We found we are making gold bricks up there, for some of these tailings have values as high as $2 a cubic yard. This is well worth recovery.

So again, I think a key aspect of this problem is to make the economics as attractive as possible for gathering and reusing every bit of the values.

Chairman MILLER. I believe they are using tin cans now. They burn the tin off to process some of the tailings from the copper mines.

Dr. HIBBARD. Yes, they do.

Chairman MILLER. And they can reclaim copper cheaply and practically this way.

Mr. DAVIS. May I inquire as to a definition?

As an elementary chemistry student, I recall the definition of a solid was that which is distinguished from liquid or a gas. In this discussion of the solid waste disposal, is that the definition you gentlemen would use?

Mr. VAUGHAN. I think the act itself defines solid or solid waste by defining what comes under its jurisdiction. That is pretty broad.

Mr. DAVIS. I am not familiar with it. I am interested if it includes vegetable matter.

Mr. VAUGHAN. Yes, it does; all agricultural wastes.

Mr. DAVIS. It might be helpful to read that.

Dr. HIBBARD. It says:

Garbage, refuse and other discarded solid materials, including solid waste materials resulting from industrial, commercial, and agricultural operations, and from community activities, but does not include solids or dissolved material in domestic sewage or other——

Mr. DAVIS. That would be, chemically speaking, liquid?

Mr. VAUGHAN. That is right.

Mr. DAVIS. Thank you.

Mr. DADDARIO. Proceed, Mr. Darnay.

(Mr. Darnay's biography follows:)

ARSEN J. DARNAY, JR.

Arsen J. Darnay joined Midwest Research Institute in mid-1965. His fields of primary specialization are market research, technological forecasting, and long range planning studies. Related special abilities include advertisting research, public relations, and sales strategy planning. Mr. Darnay has done work in the international trade area, aided by specialized linguistic abilities.

Since joining Midwest Research Institute, Mr. Darnay has been project leader on a specialized short range techno-economic study project. The program calls for individual reports, issued in a series, dealing with technological and socio-

logical subjects of near term significance. Studies on process control computerization, undersea technology, urban mass transit, medical electronics, water desalination, air and water pollution control, metal working, total energy systems, information retrieval, and educational technology have been issued.

Additional assignments have included research work on shipyard diversification, the dissemination of NASA generated technology to private industry, commercial construction forecasting, and the technological forecasting studies dealing with petroleum products and markets.

From 1961 to 1965, Mr. Darnay was a member of the embarketing staff of J. F. Pritchard & Company, an international process engineering and construction firm. He was responsible for promotion planning, market research, technical writing budget management, and public relations.

From 1956 to 1961, Mr. Darnay served in the United States Army as a Civil Affairs Specialist, Military Government Section, on the divisional level. Later he was assigned assistant to the commanding general of division artillery, involved in liaison work with the German community and German military forces in United States Army, Europe. He was decorated with the Commendation Ribbon for outstanding work.

Mr. Darnay attended Rockhurst College and the University of Maryland (overseas campus) where he studied history and economics.

Mr. Darnay is a member of the American Economic Association.

## STATEMENT OF ARSEN J. DARNAY, JR., PROJECT LEADER, MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.

Mr. DARNAY. Mr. Chairman and members of the subcommittee, my name is Arsen Darnay. I am a project leader with Midwest Research Institute. It is a pleasure to appear before you with this statement, which will outline in brief form the role packaging plays in solid waste.

Packaging and the solid waste problem are closely linked in the public view, and this with good reason. Discarded packages are visible all around us. It is impossible to take a stroll through city streets, drive in the country, walk in a park, or ride a boat on our rivers and lakes without encountering the tell-tale signatures of our affluence: discarded cans and bottles, cigarette packs and paper sacks, candy wrappers and similar objects. It is not surprising, therefore, that packaging materials are placed high on the list of items which create esthetic blight.

Until recently, no systematic analysis of the relationship between packaging and solid waste has been undertaken. About 9 months ago, a study was initiated at Midwest Research Institute, under contract to the Public Health Service, solid wastes program, to develop some clear-cut definitions of the role packaging plays in solid waste at the present—and will play in the year 1976. I directed that study, and this morning I should like to share some of our conclusions with you.

### VARIOUS ASPECTS OF PACKAGING

Both packaging and solid waste disposal are complex activities. Consequently, the interaction of the two is difficult to discuss with precision. Packaging plays not one but several roles in waste disposal, depending on which part of the system we are looking at. One important overall observation, however, can be made. The aims of packaging and solid waste disposal are mutually exclusive, on the whole. The packager wants a container which will not burn, break, crush, degrade, or dissolve in water. The waste processor wants a package

which is easy to reduce by burning, breaking, compaction, or degradation. More specific aspects of the relationship between packaging and solid waste disposal are these:

The sheer quantity of packaging wastes imposes a general load on the disposal facilities of the Nation. That is one aspect.

Collection of packaging materials is extremely costly if containers are thrown away carelessly, easy if they are discarded in waste cans.

Processing of packaging wastes may be easy or difficult depending on whether they are simply dumped or whether they are incinerated or landfilled. And different materials cause different degrees of difficulty.

Finally, reuse and recycling of packaging wastes presents yet another aspect, distinct from collection or disposal.

## THE QUANTITATIVE ASPECT

First, let's look at the quantitative aspects of packaging. Forty-six million tons of packaging materials were produced and sold in the United States in 1966 (enclosure 1).

PACKING MATERIALS CONSUMPTION, 1966 AND 1976

[In millions of tons]

| Material | 1966 | | 1976 | |
|---|---|---|---|---|
| | Tonnage | Percent of total | Tonnage | Percent of total |
| Paper and paperboard | 25.2 | 55 | 36.9 | 57 |
| Glass | 8.2 | 18 | 11.9 | 19 |
| Metals | 7.1 | 16 | 8.4 | 13 |
| Wood | 4.1 | 9 | 4.4 | 7 |
| Plastics | 1.0 | 2 | 2.5 | 4 |
| Total | 45.6 | 100 | 64.1 | 100 |

Source: Midwest Research Institute.

This massive tonnage—made up of many billions of individual units, most of them weighing much less than a pound each—represented about 12 percent of the 350 million tons of residential, commercial, and portions of industrial rubbish generated. This excludes agricultural manure, 1.3 billion tons yearly; mining wastes, 1 billion tons; scrapped automobiles, 6 million units or about 15 million tons, and building rubble, for which we have no estimate. The total comes to about 10 pounds per person per day, a figure roughly double the one you may have heard because it includes commercial rubbish and some industrial rubbish, not residential waste alone. Of this, packaging materials accounted for slightly over 1 pound per person per day.

Packaging materials tonnage will have grown to 64 million by 1976—up 18 million tons. This increase cannot be attributed to population growth alone. Americans will be using much more packaging in 1976 than 10 years earlier—122 pounds more, to be exact, for every man, woman, and child. Per capita package consumption will jump from 466 pounds to 588 pounds in the 10-year period.

Many factors underlie this dramatic increase, but chief among them is the continuing rise of self-service merchandising, which creates

a growing need for packages which sell the product without the help of a sales clerk.

Mr. DADDARIO. Mr. Darnay, your statistics, I expect, assume the continued use of the type of packaging presently in existence and the growth of our population.

Mr. DARNAY. Yes, the basic assumption underlying this study is that the findings of this study, in themselves, will not be a factor in the forecast. We are assuming that the historical trends which presently exist will continue in force without interference.

Mr. DADDARIO. Have you, during the course of your studies, discussed with the packaging people ways and means through which the situation might be improved in one way or another, however that might be?

Mr. DARNAY. Yes, of course. That has come up in almost all of our interviews.

Mr. DADDARIO. Is there a possibility that these statistics might change with the development of different kinds of packaging? It could even take into consideration the development of a different mental approach on the part of the American people. Recognizing that this problem continues to grow in such proportions, somewhere along the line there needs to be developed a different way to handle it which would include psychological adjustments as well as the simple matter of disposal.

Mr. DARNAY. You are absolutely correct. Our study is a prediction of the type you might make about a danger. You make the prediction of the type you might make about a danger. You make the predictions in order to see the danger. Of course, you would modify your actions in accordance with your forecasts. If we were to do nothing about this general situation, we believe firmly that the findings would be as I have stated them in terms of tonnage.

Mr. DADDARIO. Do you include in that the fact that there needs to be adjustments of the kind I am discussing?

Mr. DARNAY. Yes, sir; the 18 million tons I referred to will have to be handled if we do not do anything. Needless to say, I believe we should do something.

### PACKAGING AND WASTE COLLECTION

Collection of packaging wastes presents no special problems if the householder places rubbish in waste containers. The sheer quantitative increase in packaging, however, will put an added burden on waste collecting agencies by 1976. Just to haul the increase in packaging volume, waste collection trucks will have to make 4 million trips in 1976 which they didn't have to make in 1966. If new equipment has to be installed to transport the increase, expenditures exceeding $100 million would have to be made in the 10-year period.

### PACKAGING AND LITTER

A much greater waste collection headache is presented by packaging materials carelessly flung from cars or left in our parks and along our rivers and lakes.

A vast difference in trouble and cost exists between collecting a ton of cigarette wrappers placed in cans and a ton thrown away thoughtlessly.

We were unable to ascertain just how much of the packaging material tonnage turns into litter—but we have found indication that well over half of the items in litter are packages or package components. This is on the basis of number of items rather than on pounds or tons.

In 1976, the litterbug will have considerably more ammunition at his disposal. Particularly noteworthy will be the greatly expanded use of beverage containers (enclosure 2). Disposable bottles and cans are expected to shoulder out the traditional deposit-type bottle.

BEVERAGE CONTAINER CONSUMPTION, 1966 AND 1976

[In billions of units]

| | 1966 | 1976 |
|---|---|---|
| Total | 30.5 | 62.9 |
| Returnable glass | 2.5 | 1.7 |
| Nonreturnable glass | 9.5 | 25.2 |
| Metal cans | 18.5 | 36.0 |
| Beer containers | 18.5 | 28.1 |
| Glass | 5.6 | 9.1 |
| Metal | 12.9 | 19.0 |
| Soft drink containers | 9.5 | 31.7 |
| Glass | 3.9 | 14.7 |
| Metal | 5.6 | 17.0 |
| Liquor and wine (glass) | 2.5 | 3.1 |

Source: Midwest Research Institute.

In 1966, eight beverage containers out of every 100 were returnable. Ten years later, only three out of 100 will be returnable. In the same period, per capita consumption of beverage containers will have shot up from 155 units in 1966 to 283 units in 1976; nearly a doubling of container use.

Unless an effective national conscience can be developed before then, the litter problem will have intensified as a result of this packaging development.

## THE DISPOSABILITY OF PACKAGES

Once packaging materials have been collected, they must be processed. Just how disposable a package is depends on the package and on the disposal method. It is evident that a beer can is more difficult to handle in an incinerator than a paper sack. In a sanitary landfill, cans can be processed with somewhat less difficulty than paper.

As Mr. Vaughan has pointed out, the overwhelming bulk of our wastes—more than three-quarters—end up in open dumps. Wastes are simply deposited on soil. They may be burned to reduce their bulk, and thereby create air pollution. And that is all. Open dumping is not considered an acceptable disposal process, yet it is the dominant form disposal takes in our Nation. In this technique, the disposability of packaging materials cannot be measured. No processing takes place in any strict sense of the word, and package characteristics cannot be compared to process requirements.

In the two other major processes—sanitary landfilling and incineration—packaging materials appear to present relatively few difficulties to the waste processor.

One reason for this is that more than half of all packaging is paper, and paper is the most readily disposable of all packaging materials. The other major materials, arranged here in an ascending order of difficulty, are wood, plastics, metal, and glass. Metals and glass are roughly equal in terms of disposal difficulty.

In landfill operations, the greatest single difficulty presented by packaging materials is the resistence to degradation in the soil of certain materials. Aluminum, glass, and plastic containers are virtually indestructible and persist for decades and much longer. Even paper tends to have a long life underground. We have found some indication that paper has lived for about 60 years in the landfill and when extracted the text on it could still be read.

In incinerators, metals and glass show up as inert residue—which must be hauled away. Plastics can cause trouble when they appear in high concentrations. This can occur when industrial discards, high in plastics content, must be handled. Packaging materials do not yet contain sufficiently high percentages of these materials to disrupt operations consistently; nor will they appear in high enough concentration by the mid-1970's.

By 1976, the relative difficulties of processing packaging wastes will have increased somewhat. But this will be due to the fact that many open dumps will have been shut down—replaced by sanitary landfills and incinerators in which much more material processing has to take place. The relative dominance of materials will remain about the same. Paper will still be in the lead and will, in fact, have enlarged its share of total packaging. Plastics will have doubled in tonnage; but in 1976, they will amount to only one-fourteenth the size of paper.

### REUSE OF PACKAGING MATERIALS

In an ideal system, packaging materials would never be discarded—they would be reprocessed by industry and made into new packages or other products.

We are very far from such a situation today. Of the 46 million tons of packaging materials produced in 1966, only about 4.5 million tons were recovered—mostly old corrugated boxes and returnable glass containers.*

Once packaging materials have passed through the gamut of the trash barrel and the compactor truck, they are hopelessly contaminated with organic matter, dirt, and moisture and intimately mixed with other wastes. It would be virtually impossible to separate them economically from the trash even if they were clean. The result is that we squander billions of dollars worth of materials every year—valuable fibers, metals, plastics, and glass. In 1966, materials worth $16 million were converted into packages. This will give you an idea of the value thrown away.

This situation might be improved slightly if packaging wastes could be separated before disposal. But the American homemaker has a marked distaste for separating waste materials. On the other hand, she is an eager buyer of "disposable" packaging. Monumental efforts

*Recovered packaging materials are made up of 2.5 million tons of old corrugated boxes, 1.1 million tons of returnable glass containers, and 900,000 tons of all other materials.

at public education would be required to bring about a change in her attitude in a period of relative national security and prosperity. Even if she could be persuaded to separate her wastes into bins labelled steel, aluminum, plastics, paper, glass, and so forth, her efforts would only ease the problem.

The reason is that the aims of the package manufacturer and the conservationist not only fail to coincide but conflict. The purposes of conservation would be served best by packages which are homogeneous in composition and relatively uniform in size and shape. The evolution of packaging is in the direction of more types of packages and more combinations of dissimilar materials.

Relatively few packages are "pure" in the sense that they are made of a single material. Steel cans contain tin, lead, organic adhesives, and are overwrapped with paper. Some glass bottles come with twist-off caps that leave a ring of aluminum adhering to the bottle neck. Steel bottle caps are commonly gasketed with plastic or cork. Paper is laminated to metal; coated with clay, plastics, or wax; fastened with organic glues or steel staples; printed with a variety of inks. Plastics are combined with paper or laminated with other plastics and sealed with steel or aluminum closures.

The various technologies to process such compound materials are nonexistent. At the same time, highly advanced systems for the conversion of virgin materials have evolved over time. Not surprisingly, contaminated packaging wastes are not viewed as an economical resource by industry.

Relative abundance of raw materials—expected to continue for at least the next 10 to 15 years—makes it seem unlikely that salvage technology will make any rapid strides in the near future.

By the turn of the century, at least some categories of waste materials may be economically recovered in substantial quantities. By that time, our demand for paper is expected to outstrip our capacity to produce pulpwood, in the view of some observers. Such a situation need not produce a crisis if we develop economic means of recovering our waste materials. Each ton of recycled wastepaper saves 17 pulp trees. There is need, however, to ready a technology to make recycling feasible before the necessity for it becomes urgent. Since few corporations using waste materials plan more than 5 years into the future, the Federal Government should assume leadership in this area.

### RESEARCH NEEDS

Research in five areas seems to be called for to forestall future problems:

1. Automation of waste collection;
2. Separation of refuse into its components;
3. Refining of heterogenous waste masses;
4. Development of secondary uses for wastes; and
5. Improvement of salvage operations to promote waste material use.

Our waste collection practice today is analagous to water distribution practice on the American frontier in the early parts of the 19th century. Waste collection remains the last residential utility which is not automated. In part this may always remain so. A high proportion

of residential wastes, however, and most of the packaging materials which reach the home, could be conveyed to central facilities by pipe following some form of waste reduction. Automation could substantially reduce the costs of collection: gathering and transport of wastes absorb approximately 90 percent of all expenditures on waste handling today, or about $3 billion, and the bulk of collection outlays are in the form of labor costs.

Separation of wastes by type cannot be accomplished without manual labor. Innovative techniques of sensing materials and separating them by materials handling equipment are needed. Such hardware, once developed, might be too costly for today's use; but without such equipment, a major problem of future waste reuse would remain unresolved.

Suitable technology should be developed for refining heterogenous "waste refinery" by pipe. Such a technology might encompass chemical refining and extraction, mechanical separation, magnetic removal, mechanical sorting, et cetera. Our ingenuity in the processing of virgin materials would indicate that such a technology is within our reach.

Research should be intensified for secondary use of wastes—waste combustion to generate electricity, production of soil conditioners, use of selected waste components as substrates for animal feed production, conversion of wastes into building products, and the like.

Most urgent is the need to work closely with the packaging industries to increase the quantity of waste materials they recycle. This could involve such moves as elimination of tin from steel cans substitution of new paper coatings for those which create difficulties in the repulping of these fibers, elimination of inks which resist de-inking or improvement of de-inking processes. All of these steps would require much work and would be far from easy to accomplish.

Work to improve the technology of salvage would also pay dividends in the long run. Most needed are new techniques of pelletizing, shearing, baling, compressing, and sorting of scrap materials.

Finally, and this lies beyond the strictly technological scope, sufficient economic incentives should be created to tap industrial talents for the accomplishment of the tasks enumerated above.

Waste disposal, including waste reuse, is an area we have largely ignored. Only recently have we come to recognize the existence of problems connected with large accumulations of waste resulting from affluence and urban congestion. The genius of our Nation has not yet been aroused to deal with this problem. When it is, solid wastes—and particularly packaging wastes—may be transformed into a national asset.

That, Mr. Chairman, concludes my statement.

Mr. DADDARIO. As the result of your study, what would you deem to be sufficient to tap industrial talents?

What are you talking about?

Mr. DARNAY. Specifically, it might be an investment tax credit that would be applicable to machinery to handle or process wastes. For instance, de-inking type plants, which make it possible to recycle more wastepaper, or pelletizing machines to reduce paper into pellets, or scrap handling machinery in general. Or if we were to use disposal

fee, a disposal fee system could serve to create incentives by permitting a lower fee to be charged on a particular package that is more disposable.

For instance, a tinless steel can could be assigned a lower fee because it would be possible to recycle it to the steel industry.

Mr. DADDARIO. Are there any questions, gentlemen?

Mr. MILLER. No. I want to congratulate Mr. Darnay. I think it is a very fine paper. It lays out some of the problems.

Mr. DADDARIO. Mr. Davis?

Mr. DAVIS. Yes, I have a brief question. We have one more witness, do we not, Mr. Chairman? I will make my question as brief as possible and I would like to address it, if I may, to the whole table.

It seems to me there has been too little emphasis placed on the social lag, may I say, or maybe the political lag, of our governmental structures as to dealing with waste disposal.

My own experience has included a great deal of problems in that connection. I was formerly a judge of a court in the northwest corner of Georgia. One of the edges of my circuit was the Tennessee line, the other was the Alabama line. We have a great deal of outpouring of citizens, I should say, from the city of Chattanooga and part of my present congressional district. We had a great problem with garbage disposal. Our governmental structure just was not competent to deal with it. We did not have a municipal government in many areas where the problem assailed us. We had garbage dumps that just materialized out of nowhere.

We did not have a garbage collection system. We had a law against dumping garbage, but you cannot catch them. It is sort of like trying to catch an arsonist, it is almost impossible. It seems that one of the major problems in this whole area of inquiry is that of getting social acceptance of the size of the problem. I think maybe you gentlemen may not have emphasized that enough. I think it is something that we have to sell to the public. I think we have to generate a sense of social responsibility that will cause people to realize, not only the corporations, but the individual citizens that that is part of their responsibility, to bear the cost of disposing of their garbage.

Mr. VAUGHN. Mr. Davis, I could not agree with you more. I assure you that the problem of garbage disposal is not just restricted to Georgia and Alabama. It is applicable to the whole United States.

This is one reason why we have studies and investigations to try to show people various methods in which they can work together across State boundaries or other governmental or jurisdictional boundaries to get the job done. We have to show people what good practices are, so that they will realize that much more needs to be done in their own communities.

Mr. DAVIS. Thank you, Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I have no questions, but I would just comment that this table on page 6 gives the answer to Mr. Miller's original question about the number of bottles. It looks like one bottle per week per person; if you have a hundred thousand people that is a hundred thousand bottles per week.

Mr. DARNAY. May I comment on that?

Mr. DADDARIO. Yes, sir.

Mr. DARNAY. This table might be slightly misleading. It shows beverage containers that are produced. It does not necessarily show all the beverage containers that are in circulation. In 1966 there were about 68 billion beverage containers in existence. In 1976 the figure will be 82 billion. The returnables are cycled back and forth and as a consequence they do not show up in exactly the same ratio as they exist. But about 2.5 billion were made in the year 1966. I think that might clarify some of the figures.

Mr. DAVIS. Mr. Chairman, may I add one more comment to what I have said? We have a saying back home if you want to get along with somebody, keep your hands off his wife and his pocketbook.

I believe this gentleman made the statement a while ago that there seems to be an inclination on the part of some small communities to go it alone and not to adopt a regional aspect.

I am familiar with that. The reason for that is you are trying to get your hands on a man's pocketbook when you tell him he has to pay more money for garbage collection. That is implicit in all of these annexation problems we have.

For example, in the south end of my district, if you will forgive me for keeping on referring to my own problems, we have what we call the Stop Atlanta Movement, which is on the south end. It is just a question of a man's pocketbook. It costs more money to have garbage picked up, or solid waste disposed of, if you want to phrase it that way. That is just one of the human aspects of the problem that has to be conquered. It is just a matter of enlightenment as one way of looking at it.

Mr. DADDARIO. I think Mr. Davis has added something to this discussion which is necessary, because he has been touching on the development of consciousness on the part of people as well as the development of a national conscience. When we were developing our report on the adequacy of technology for pollution abatement, and went into this question of solid waste, we had a key phrase which calls to mind the importance of that. I will just quote it because I think it fits exactly in here. It is "Whether the intrusion of Washington will engender a permanent increase in local consciousness and conscience remains to be demonstrated." That is really the job of you people who have been charged with this to develop the answer to that particular proposition that we proposed prior to the passage of this legislation.

Mr. MILLER. If I may make this comment: I do not think it is such an impossible thing.

It was not so long ago that out in our part of the country we did not take air pollution very seriously. In about a decade we have become pretty well conscious of it. I think in a decade you could do a lot to educate people in this field.

Mr. DADDARIO. I do not assume, Mr. Chairman, that it is impossible, but I do think it is important to stress the point Mr. Davis raised, because it appeared to this committee at the time we made this investigation that this was one of the great problems.

In order to be able to achieve a favorable situation so that this does not become an impossible task we must develop a consciousness on the part of the people.

Dr. Hibbard.

Dr. HIBBARD. Shall I go ahead?

Mr. DADDARIO. Please.

Dr. HIBBARD. If I may, Mr. Chairman, I would like your permission to insert my statement in the record and then to summarize it.

Mr. DADDARIO. We will put the whole statement in the record. We will allow you to summarize it and give you a chance to go over your extemporaneous remarks.

## STATEMENT OF DR. WALTER R. HIBBARD, DIRECTOR, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Dr. HIBBARD. The statement includes the source of our authority, a review of our cooperative activities with the Public Health Service, and a discussion of our concentration on three areas, municipal wastes, tailings, and scrap. I want to emphasize that our efforts are aimed at recovering the metal and mineral values from solid wastes, and in particular finding ways and means of disposing of the solid wastes that are generated by the extraction, processing, and utilization of minerals and mineral fuels.

As I mentioned before, the problems confronting the Nation with respect to mineral supply are such that in the mining industry there has been a tendency to rework the tailings or waste materials wherever values have been found in them.

For example, in the Salt Lake City area a large corporation is processing their old waste materials and finding values in them which make it profitable to retreat them. We believe that one of the ways of disposing of these materials is to determine the values in them and to identify the technology so that the normal process of our economy will move the activity to industrial realization.

If this does not succeed the next step is to find out ways and means of disposing of them or covering them by seeding and fertilization so that they will not be an eyesore. With respect to the municipal wastes, again, we believe there are values here. We have been working with Montgomery County officials in the collection of residues from the county incinerator in order to find ways and means of treating this material for metal and mineral recovery.

We find that there are values here, in many cases comparable to ores found in the West but the major problem is collection and transportation. Here again, the minerals industry has had experience with pipeline transportation of coal and other materials as slurries or through pneumatic techniques and I believe technology is available to do this kind of thing provided the economics can be worked out.

Mr. DADDARIO. Would you go into that? You just said provided the economics can be worked out. That follows your emphasis on the reuse or recycling. The development of a potential leads to the key that there needs to be an economic value. What is the hope that this can be done?

You talk about gold and silver, and what not? I understand Eastman Kodak, as an example, has thrown away a lot of its material. From what I understand, it seems that they have not been able, even though they know there is a lot of material in that refuse, to economically take it out.

What you say is so, if it could be done it would alleviate our problems. What is the chance of such a return so that it will be economically feasible?

Dr. HIBBARD. We must try to predesign our processes for producing automobiles and other products to enhance their recycle value. We must apply the total systems concept to the use and reuse of our entire supply of minerals.

Many scrap materials from obsolete automobiles contain metal values in combinations, both mechanical and chemical, that are not normally encountered by the extractive metallurgist. Vast tonnages of pure metals and alloys are trapped in manufactured products. The profusion of copper wiring locked between panels in automobiles and electrical appliances is an example. Many of the ever-increasing variety of alloys returning as scrap continue to accumulate in junk piles for want of extractive methods for separating and reclaiming the metals they contain. This problem is compounded by the fact that many of these alloys—some containing metals in critical supply—were developed to resist just such conditions as are used by the extractive metallurgist for making separations. That is, they are extremely refractory and corrosion resistant to most chemicals. New technology must supply answers to these problems, and show the way to recovering these natural resources and returning them to our economy. The reuse of these resources would be advanced by properly designing systems which will (1) extend the life of our products; (2) assist in ease of maintenance and repair; and (3) simplify the salvage of metals.

With respect to the gold and silver in the flyash from an incinerator, this ash is a solid particulate matter normally removed by a precipitate, or other techniques, from the incinerators' stack gases.

The values per ton in this flyash are equivalent to mineable values in the West.

If one could find a way of collecting this flyash, either by a pneumatic or slurry technique, or getting it concentrated in some other manner, the material would be well worth shipping to a smelter for recovery of gold and silver.

Mr. DADDARIO. You are working on this.

Dr. HIBBARD. Yes, sir. We have been in contact with the New York City government, and we believe that they have enough incinerators to supply an adequate quantity of material to make metal recovery economically feasible.

Mr. DADDARIO. Who else in government, just from the standpoint of how this is working out, is working on this same kind of a proposition, the economic feasibility requirement being so important? How are you working together? What is the size and scope of the whole proposition?

Dr. HIBBARD. The Public Health Service is working on municipal refuse as well, and we are cooperating with them. We have a memorandum of understanding of areas in which we are going to work in and techniques by which we will keep each other informed. I think this cooperative effort worked out extremely well.

Mr. DADDARIO. You are working together or separately on the same proposal letting each know what you are doing?

Dr. HIBBARD. The area of Bureau of Mines activity is in those solid wastes which are generated by the extraction, processing or utilization of minerals, and mineral materials. Where there is an overlap, for example, in the case of the incinerator, we are not concerned with incineration per se. In working with Montgomery County our only interest is collecting what comes out at the bottom of the incinerator and seeing if this can be treated as a source of metals. Through this coordination we are not duplicating efforts and we are keeping each other informed. We each have an area of responsibility where we are putting forth our efforts.

Mr. DADDARIO. Could we get a copy of that memorandum of agreement?

Dr. HIBBARD. Yes, sir.

Mr. DADDARIO. We appreciate having it for the record.

(The memorandum follows:)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
*Washington, D.C., June 3, 1966.*

Mr. WALTER R. HIBBARD, Jr.
*Director, Bureau of Mines,*
*Department of the Interior,*
*Washington, D.C.*

DEAR MR. HIBBARD: There is attached an original and 2 copies of the Memorandum of Understanding between your agency and the Public Health Service defining the principal areas of program interest of our respective agencies and establishing mutually acceptable working relationships for programs under the Solid Waste Disposal Act of 1965, P.L. 89-272. After signature for the Bureau of Mines, please return the original to me, retaining the signed copy for your office.

Since Mr. Wesley E. Gilbertson is responsible for solid waste disposal activities with the Public Health Service, I have designated him as the principal official to work with your agency on program matters relating to P.L. 89-272.

Sincerely yours,

WILLIAM H. STEWART,
*Surgeon General.*

MEMORANDUM OF UNDERSTANDING, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE, AND THE DEPARTMENT OF THE INTERIOR, BUREAU OF MINES

Relative to Implementation of Title II, the Solid Waste Disposal Act of 1965, Public Law 89-272

The Department of Health, Education, and Welfare, Public Health Service, and the Department of the Interior, Bureau of Mines, each has an area of responsibility for implementing the provisions of Public Law 89-272, the Solid Waste Disposal Act, and are mutually desirous of developing a coordinated program toward the attainment of common objectives under the Act. The report of the House Committee on Interstate and Foreign Commerce (Report No. 899, Page 27, lines 19 through 36), states that, under the provisions of the bill, subsequently enacted as Public Law 89-272, the Department of Health, Education, and Welfare "would be responsible for administration of the Act, except that the Secretary of the Interior will be responsible for 'solid waste resulting from the extraction, processing or utilization of minerals and fossil fuels where the generation, production, or reuse of such wastes is or may be controlled within the extraction, processing or utilization facility or facilities and where such control is a feature of the technology or economy of the operation of such facility or facilities.' This arrangement would make the Secretary of Health, Education, and Welfare responsible for administration of the Act with respect to solid waste problems of communities, including those problems which may affect the general environments of communities, and including those solid wastes or solid waste residues that result from business and industrial activities and become part of the community's solid waste disposal system. The Department of

the Interior, as above indicated, would be responsible for solving industrial solid waste problems within facilities engaged in extraction, processing, or utilization of minerals and fossil fuels in the circumstances above defined." To accomplish these objectives, the Public Health Service and the Bureau of Mines have entered into this Memorandum of Understanding in order to define and describe the principal areas of program interest of each agency and to clearly establish a mutually acceptable working relationship which insures proper coordination of all programs under Public Law 89–272.

It is mutually agreed that:

A. The Public Health Service and the Bureau of Mines will designate officials to act as the principal contacts and liaison officers at the program level in interagency matters pertaining to Public Law 89–272.

B. In regard to demonstration grant applications under Section 204 of Public Law 89–272, the Public Health Service will refer to the Bureau of Mines for necessary action, those demonstration grant applications pertaining primarily to mineral of fossil fuel solid waste problems as defined under Section 203(1) of the Act; and the Bureau of Mines will refer to the Public Health Service for necessary action those demonstration grant applications pertaining to other solid waste problems.

C. The Public Health Service will refer to the Bureau of Mines for review and comment those demonstration grant applications which give major emphasis to components involving mineral, metal, and fossil fuel solid waste problems as part of a broader solid waste disposal program; and the Bureau of Mines will refer to the Public Health Service for review and comment those demonstration grant applications in which the mineral and fossil fuel solid waste problems have significant community implications. In the above cases, it is understood that any comments the reviewing agency wishes to make will be forwarded within a period of fifteen (15) working days from the time of receipt.

D. The Bureau of Mines and the Public Health Service may support, on a joint basis, demonstrations, research, or training projects which have implications for disposal of solid wastes from minerals or fossil fuels and from community sources.

E. The Public Health Service and the Bureau of Mines will perform reimbursable services for each other, when such action is appropriate and feasible and mutually beneficial to the agencies.

F. The Public Health Service and the Bureau of Mines will exchange information regarding program activities under Public Law 89–272. This will include information on grant awards and similar actions.

G. The Public Health Service in carrying out its responsibilities for developing comprehensive State and local solid waste programs, and in providing technical assistance to State and local agencies and industry, will need technical information from the Bureau of Mines. From time to time such information will be made available by the Bureau of Mines to the Public Health Service.

H. Since the processing and disposal of automobile and other metallic scrap involve problems of community environmental pollution, blight, and parallel resource problems in the technology of salvage and utilization, the Public Health Service and the Bureau of Mines may jointly conduct projects on broad phases of the junk and scrap auto problem, and individually on specific appropriate complementary segments.

This Memorandum of Understanding shall become effective upon acceptance of both parties, and shall continue indefinitely, but may be modified at the request of either of the cooperative agencies. This agreement may be terminated by either agency upon thirty (30) days notice in writing.

DEPARTMENT OF THE INTERIOR,
BUREAU OF MINES,
(S) WALTER R. HIBBARD, Jr., *Director.*

JUNE 7, 1966.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
(S) WILLIAM H. STEWART, *Surgeon General.*

JUNE 3, 1966.

Dr. HIBBARD. The second part of this problem, assuming that it is not going to be economically feasible to do this on a straight profit venture, is to use the same technology to minimize the cost of the disposal as small as possible.

So there are two possible uses of this technology.

Mr. DADDARIO. Then you get into subsidizing the removal of garbage and other solid wastes.

Dr. HIBBARD. It is going to cost a certain amount of money to dispose of municipal refuse and if we can minimize that cost through the recovery process, this will be helpful. The second angle is that we do need these metals, and we are going to need them more and more as time goes on.

I have had the opportunity to spend some time around the country this year lecturing in various areas where we have research centers, and I have pointed out to the housewife that when she takes a piece of aluminum foil and bakes a potato in it and throws it away, she is throwing away a valuable metal. Because we are importing 85 percent of our aluminum needs, the recovery from municipal refuse will benefit our total economic situation. I believe that the public can become responsive to this and I believe that if they see that this issue is important to the country and that they can contribute to it, they will respond to it.

May I continue? In the scrap area, there is in existence a going industry which does reprocess scrap. Between 25 and 50 percent of our metals are recycled annually. Nevertheless, there is still a large amount of material that is not recycled. This is, in fact, the material which is difficult to separate. Part of our program is working on ways and means of helping with this separation. As I mentioned the silver waste in fixer and photographic materials is very valuable and the major photographic companies have programs for collecting spent fixer and recycling the silver.

We believe this can be improved through a public awareness of the need for such activity.

With respect to automobile scrap and refrigerator scrap, there is a very large inventory of iron and steel in this form, and it is, I think, absolutely essential that we find economically feasible ways to use this scrap from the standpoint of our natural resource requirements.

I have here a list of our existing projects. If I may I submit this to the staff. I do not know whether you want it in the record or not.

Mr. DADDARIO. Thank you, Dr. Hibbard, if you would give it to the staff.

(The information referred to may be found in the committee files.)

Dr. HIBBARD. In conclusion, we are continuing our programs both in-house and contract, and our joint venture research with industry in an effort to solve these problems in the most effective way.

We believe that much of the required technology already exists.

The major problem is economics. I suspect this will require additional technology before it can be solved.

Mr. DADDARIO. Mr. Vaughan, do you have anything to add to the question of economic feasibility and the work that is going on in developing the necessary techniques?

Mr. VAUGHAN. I do not have anything to add.

I agree with Dr. Hibbard that we have the technology to do the job now. One of our major needs is for more widely applied economic technology.

Mr. DADDARIO. What is your feeling about this relationship you have developed where you are both working on this problem? Is it a proper relationship, is it a sensible one?

Mr. VAUGHAN. I think it is a proper one, yes. I hope we can make it even more so. I am fairly new to the job. It is my intention to make it even more profitable.

Mr. DADDARIO. I wonder if we might have, since we do have the memorandum of agreement in the record, a breakdown of the people who are involved with it in both areas and just how the liaison is set up through a committee or otherwise?

Dr. HIBBARD. This information is in the agreement.

Mr. DAVIS. If I may ask one more question. Maybe this is Mr. Vaughan's question. In the question of composts, is that limited to vegetable wastes?

Mr. VAUGHAN. No.

Mr. DAVIS. Is it possible to compost paper products, for example?

Mr. VAUGHAN. Some, yes.

Mr. DAVIS. It is pretty slow, is it not?

Mr. VAUGHAN. Yes, it is. The cardboard boxes are more difficult, but paper can be ground up.

Mr. DAVIS. Is it slower than wood would be?

Mr. VAUGHAN. No; it is not as slow as wood would be.

The process consists of separating bulky items that cannot be composted or are difficult to compost such as plastics and large cardboard boxes.

Mr. DAVIS. How long would it take to compost a pasteboard box?

Mr. VAUGHAN. I cannot give you an exact estimate but I would say approximately a couple of months.

Mr. DAVIS. That is not too long.

Mr. VAUGHAN. No. It depends on its size and thickness and also on the effectiveness of the grinding mechanism. One of the most important things in composting, after separation of the unwanted material, is through grinding and moisture control. You must keep it moist and stir it up. From that point, some people put it into a tank and add air to it to accelerate the compost. Others let nature do this by putting it out in windows, keeping the moisture content proper, and turning it over from time to time to make sure it has enough oxygen so it won't smell. This changes it into humus material, which is not a fertilizer but can be used as a soil conditioner.

Mr. DAVIS. Or as a mulch.

Mr. VAUGHAN. Yes. The final processing, maybe 2 or 3 weeks later, is grinding to a desirable consistency for application.

Mr. DAVIS. Would you consider that such things as insecticides, DDT, and things of that kind might enter into the effectiveness of composting?

Mr. VAUGHAN. If the volume of insecticides that got mixed in the wastes, were big enough, it could interfere with the bacterial action that takes place. From a practical standpoint, I doubt if this would occur unless you had a very unusual situation. There are some areas where the contribution of this type of waste to the percentage of the solid waste is very high.

Mr. DAVIS. Thank you.

Mr. DADDARIO. Dr. MacKenzie, I have a question I would like to ask you about in this area of recycling. Does the Public Health Service, because it has such a heavy requirement in the area of health, and because of the emphasis that needs to be placed on it, find itself inhibited in any way in doing research in recycling, which seems to be a part of this particular problem? Because you have necessary mission emphasis, do you find it more important to solve these problems than to have heavy research work which needs to be done in the recycling area?

Dr. MACKENZIE. I think I can only answer this in general terms, Mr. Chairman. The importance of recycling has appeared obvious to all technical people who have examined the problems of waste management. It is particularly true in my view in the water field and in the solid wastes field. We have special interests in relation to recycling in connection with possible buildup of residues that may build up in a recycling process and might affect health. This in no way limits our interest in recycling as a method or as a procedure which should be fully evaluated. It merely throws in a cautionary element to which we must give particular attention.

Mr. DADDARIO. Could you emphasize the precautionary elements?

Dr. MACKENZIE. For example, there is a great deal of talk about recycling water for reuse. In some of the processes that are under consideration, there is associated buildup of, let us say, dissolved materials in the water, unless one is using a distallation technique which can effectively remove these.

We must look at the buildup of such dissolved materials in the water as this might have physiologic or toxic effects, particularly if water is going to be used for household or drinking purposes. This does not mean that we are against reuse, and I want to emphasize this, because one of the major ways of reducing water pollution obviously for many years has been to attempt to "bottle up" the waste material by recycling the water in industrial processes. This is an accepted method and one which should be highly encouraged for use now and further development. I see no conflict, Mr. Daddario, in these objectives if one looks at the total picture and takes into account the limitations that might be imposed under a particular circumstance.

Mr. DADDARIO. From the standpoint of the way in which we are handling the research activities in all of this, are you satisfied—recognizing that we have not gone very far since the legislation has been passed to allow full development to take place—are you satisfied with the structure that exists in order to attack this problem? Or would we be getting at it more quickly if we were to put all of the responsibility in one place?

Dr. MACKENZIE. I think we have a variety of organizational structures in the waste management field on the Federal level, sir.

Mr. DADDARIO. It is this variety which causes us so much concern.

Dr. MACKENZIE. I can understand this concern. I do not have any panacea that would solve this, or any pat solution for it. I think there are a variety of ways in which these activities can be organized. I think the important consideration is that there not be undue duplication and that there be full coverage of what needs to be done.

Within this overall concept, I think there are several ways in which each of the components of the problems and the activities associated with them can be organized.

Fundamentally, I lean toward the concept of a designated agency to have prime responsibility in an area of operation. I think fundamentally this perhaps is the soundest approach from a management point.

Although this may be the best theoretically, I think we must still deal with the practicalities of the way the Federal Government is currently organized in the departments and agencies, and the locations in which there is expert competence to deal with the problems that are involved.

If one takes, for example, the matter of the health interests in some of these elements, in my view the Public Health Service has background, competence and facilities on which the health component of the activities to be undertaken can best be built. This competence could be used in various ways.

For example, rather than having the entire activity in the Public Health Service on this account, one might also incorporate this competence by detail of personnel to other agencies. Basically, I think one must tailor the organization to the job that needs to be done, and take into account the capabilities that exist in the organizations as they are now set up in the Federal Government, in the executive branch. I think there is going to be a continuing problem, Mr. Chairman, as we go down the pike in all of these waste management fields, to organize our activities in the best way, so that we can accomplish the objective that is desired most economically and most effectively.

While there are general principles that attach to organizing these activities I think we must tailor them individually at various times with the realities of the existing situation firmly in mind.

I realize that I am not fully responsive or offering you a general solution here, but I do not think it is feasible to do so.

Mr. DADDARIO. You are as responsive as you think you can be under the circumstances, and I think responsibly responsive, because this is a problem which we do run into from time to time.

Our concern is that at this stage of the game when we find ourselves with public support to accomplish objectives in this whole area, and also in a time of budgetary restraint, that it becomes incumbent upon us to be more proficient in the accomplishment of research and management techniques than we have been in the past.

The one thing I do find in these last several years, where agencies would fight to the end in order to maintain the integrity of their in-house competence, so to speak, that there is developing a philosophy somewhat similar to the one you have propounded here. There is not so much of a fight to maintain jurisdiction which in many cases, artificial as it was, in fact did hurt the progress of the work. I am heartened by what you said. I think it will be helpful to us. One of the objectives of this committee in these hearings is to develop an attitude about the way in which these things are in fact being managed.

Dr. MACKENZIE. I appreciate your interest in this matter because it is an important one.

Mr. DADDARIO. I appreciate what you have said. It is extremely helpful. We want to thank all of the witnesses here this morning.

I regret that we had to call you on a Friday, but it was necessary this week.

(Dr. Hibbard's prepared statement follows:)

PREPARED STATEMENT OF WALTER R. HIBBARD, DIRECTOR, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Mr. Chairman and members of the Subcommittee on Science, Research, and Development:

I appreciate the opportunity to appear before you today and to discuss the programs and activities of the Bureau of Mines relating to Solid Waste Disposal. Our research in this important area was initiated under the authority of Public Law 89–272, The Solid Waste Disposal Act. One of the purposes of this Act was to—

"initiate and accelerate a national research and development program for new and improved methods of proper and economic solid waste disposal, including studies directed toward the conservation of natural resources by reducing the amount of waste and unsalvageable materials and by recovery and utilization of potential resources in solid wastes."

Authority for the work rests with both the Department of the Interior and the Department of Health, Education, and Welfare. To make sure that the problem areas were fully covered and to prevent duplication of research, a letter of agreement was drawn up between the two agencies in which the responsibilities of each were clearly defined.

Following passage of the Act, the Bureau of Mines organized a research program directed toward solving the problems involved in utilizing or disposing of the enormous quantities of solid wastes generated in mining and in the mineral and metal processing industries. As a first step a survey was initiated to appraise the magnitude and nature of solid wastes accumulated to date with emphasis on delineating those waste piles which pose the greatest threat to the quality of the environment. Concurrently, investigations were started on the problems that appeared to be the most urgent. A program of contract and grant research also was organized to supplement the Bureau's own work and to aid in the training of engineers and scientists in the field of solid waste research. The total research program covers three major categories: munipical wastes, tailings, and scrap.

MUNICIPAL WASTES

Although the overall responsibility for the disposal of municipal wastes is with the Department of Health, Education, and Welfare, the Bureau of Mines is interested in the recovery of the large metal and mineral component of these wastes for recycle to industry. Under the present methods for disposing of municipal wastes, which amounts to about 165,000,000 tons per year, nearly twelve million tons of valuable metal are buried every year in dumps and landfills. The total value of ferrous and nonferrous metals in the 165 million tons of waste, based on current prices is estimated at over $1 billion.

The Bureau's preliminary work on this problem has been on recovery of metals and minerals from municipal incinerator residues. Since most of the refuse from large cities, and approximately one-third of the total municipal refuse, is processed by incineration which concentrates the metal and mineral values, the residue from municipal incinerators represents a good starting material for recovery of these values. When refuse is incinerated, it is reduced about 75 percent by weight. Our analyses show that each ton of residue from municipal incinerators contains about 550 pounds of metals. Of this about 500 pounds is iron and the rest consists mainly of aluminum, copper, lead, tin and zinc.

In addition to the metallic residue, for every ton of refuse incinerated about 20 pounds of fly ash is generated. Our analyses have indicated that this waste may become an important source of secondary silver, since it contains silver in amounts ranging from 2 to 9 oz. per ton, and gold in amounts ranging from 0.02 to 0.05 oz. per ton. About 500,000 tons of the fly ash is now generated annually from municipal incinerators and, if economic methods could be developed for collection of the ash and extraction of the metals, this seemingly unlikely source could yield appreciable quantities of silver and gold to help meet the Nation's industrial and commercial demands.

The current status of the research on munipical wastes is as follows: Mechanical separation methods have been devised to separate the residue into several components. Some of these would be saleable to scrap processors without further treatment, while other need additional processing to enable them to be fully utilized. Work has been started on the development of methods for this processing.

### TAILINGS

Tailings are materials rejected during concentration of minerals and there are hundreds of millions of tons of such material throughout the country. Because of the varying composition of tailings piles from different sources, no one process can be found to solve the total problem. We are working on several techniques that can be broadly applied to the majority of tailings piles.

There are tailings that contain minerals which should be extracted and utilized from the standpoint of conservation. A prime example of this type is the red muds generated during the production of alumina from bauxite. These muds (now being generated at the rate of over 5 million tons per year) contain large quantities of iron, aluminum, and titanium. We have already worked out a process for recovering part of the aluminum along with significant quantities of soda (added during the processing step) and returning them to the process. Work is currently directed toward recovery of the remaining aluminum and iron. Other research on tailings involves the possible use of these wastes as a component of bricks, building blocks, or other construction material.

Many tailings piles are composed of relatively barren material. In these, the originally desired mineral has been efficiently extracted and there are no accompanying minerals worth removing. For these tailings, the only solution is disposal in an efficient and unobjectionable manner. We are investigating two methods for doing this. One involves chemical treatment for temporary stabilization, followed by fertilization and seeding with selected seeds to provide a permanent cover of vegetation which will minimize or prevent wind and rain erosion and the accompanying air and water pollution. The scenic blight caused by barren tailings dumps is also minimized by this procedure. The other approach to disposal involves injection of slurried tailings into underground strata. This technique has been shown to be technically feasible even for relatively coarse material, and the economics are now under investigation. In addition studies are in progress to develop costs of solid waste disposal at selected mineral and fossil fuel mining and processing plants and to develop guideline and expertise for disposing of solid wastes that may accumulate in the future. Particular attention is given to mined-land-reclamation practices which start with the opening of the mining and/or processing plant, continue through the period of active operations, and provide for reclamation or restoration of the mined-out area to a useable condition after active operations have ceased.

### SCRAP

Although the scrap processors are generally quite efficient at returning scrap metals to industry for reuse, there are some types of scrap that are not used to their full potential. Low-grade iron scrap, contaminated by nonferrous attachments, appears to be one of the major problem areas in the scrap picture. The largest source of this type of scrap is the obsolete automobile, although large appliances such as refrigerators, stoves, and washing machines also fall in this category.

We have developed a process by means of which nonmagnetic taconite (an iron-bearing mineral now being put in waste piles around taconite plants) can be converted to useable magnetic iron ore by roasting with low-grade iron and steel scrap. In the process the scrap, while converting the taconite to useable form, is itself converted to high-grade iron ore. We have successfully operated the process on a small scale using automobile scrap, old refrigerators, tin cans, and other forms of scrap.

Another segment of our scrap research is concerned with the development of hydrometallurgical or chemical leaching methods for producing clean scrap from automobiles or from byproducts of auto-scrap processing yards.

### FUTURE PLANS

Now with this description of our research in municipal wastes, tailings, and scrap in mind, let me take just a few moments to tell you something of our fu-

ture plans. In our work on municipal wastes we intend to study the feasibility of recovering metals from raw (as collected) refuse. Funds permitting, a demonstration plant, designed to operate on a continuous basis, will be established, preferably at the site of a modern municipal incinerator. This plant will allow a complete economic analysis of the recovery system to be made and will serve as a model for municipalities which wish to establish similar plants.

Tailings stabilization work on test plots will be continued. Major copper and uranium producers in the Southwest are cooperating closely with the Bureau in this work and, if small-scale tests are promising, large areas will be treated by the companies with Bureau experts acting as consultants. Work on converting tailings into a raw material for construction and for making clay and ceramic products will be continued until the work reaches a stage where it can be taken over by commercial producers of these products. Research on underground disposal of wastes will be continued until fairly reliable economic data are available. If the process appears to be feasible, cooperation will be sought from a company with tailings-disposal problems in conducting a large-scale test.

Research will also be continued on the upgrading of nonmagnetic taconite by roasting with scrap. In cooperation with the Institute of Scrap Iron and Steel and the American Foundrymen's Society, an extensive program of research will be started to evaluate the feasibility of preparing low-grade scrap for efficient foundry or steel plant use by various melting processes.

We will continue the research-grant and contract program to supplement our inhouse research. The grant and contract program is closely coordinated with the solid waste research activities of the Department of Health, Education, and Welfare. The program includes financial support and technical guidance in the training of engineers and scientists in the field of solid waste disposal. Results of the program will add significantly to the store of knowledge needed for an effective attack on solid waste problems and the information gained will be applied wherever practicable for the benefit and welfare of the general public.

Solid wastes from mining, milling, and smelting of minerals are increasing rapidly as consumption of metals and minerals increases and the ore producers are forced to mine and process greater quantities of lower-grade materials. In the public interest, we need to exploit the knowledge and skills of personnel at universities and research organizations to supplement that of our own personnel in their attack on the problems involving utilization or disposal of these wastes. Of approximately 18 grants in force in 1968 about a dozen will be continued in 1969. The program includes work on the potential use of tailings of various types for the fabrication of ceramics, building materials, and insulating materials and the recovery of mineral values where possible. Removal of anthracite refuse banks in the heavily mined region of northeastern Pennsylvania, and recovery of useful materials from such banks are included in the grant program. The six contracts in force in fiscal year 1968 will be completed but no new ones will be started.

In more than 150 years of mining in the Anthracite Region of Pennsylvania over 900 million tons of mine refuse have accumulated. Today there are some 22 refuse piles containing more than 60 million tons of material that are on fire. These "burning banks" pose a menace to public health and safety and in general seriously affect the economy and welfare of a large and heavily populated region.

A demonstration project is underway at the Baker Bank in Scranton, Pennsylvania for the purposes of evaluating methods for extinguishing and disposing of burning refuse banks. Information gained from this demonstration could be used for planning action programs for the orderly quenching and removal of refuse banks that significantly contribute to the degradation of the environment.

This concludes my statement, Mr. Chairman. I shall be pleased to answer any questions that may have occurred to you or the committee members.

Mr. DADDARIO. This committee will adjourn to the call of the Chair.

(Whereupon, at 12:10 p.m., the subcommittee adjourned to the call of the Chair.)

# ENVIRONMENTAL QUALITY

TUESDAY, MARCH 12, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
*Washington, D.C.*

The subcommittee met, pursuant to adjournment, at 10:30 a.m., in room 2325, Rayburn House Office Building, Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

We are late this morning because the full committee was called to vote on another matter. That always takes priority over subcommittee meetings.

I would like to say that we have already entered the era of ecological management at the time when man must base his decisions on knowledge of an entire ecosystem and its future status, not just local short-term effects.

I make this rather sweeping assertion because the testimony in these hearings on environmental quality makes it clear that any alternative procedure for society contains great and immediate hazards.

We are all aware of the excited voices which urgently present examples of unanticipated consequences of applied technology—and we need to listen to them. We are all aware that our standard of living depends on an expanding industrial economy, accelerated by scientific research and development—and we want to maintain these conditions for ourselves and extend them to all peoples of the world.

These viewpoints are not contradictory in my opinion—for man is the dominant species. It is not wrong to manipulate nature for the benefit of human beings. Applied science and technology have momentum and direction of themselves but they can be controlled by man.

My optimism stems from the conviction that our instincts and precepts in the progress of civilization have been right and are right today. The complexity of decisionmaking has increased enormously—but so has the collective knowledge and the means of applying it. Courage is indicated, not despair.

Ecology is a major discipline in the IBP organization and I am pleased to have an opportunity in these hearings to bring out more detailed information on this science and profession.

Today we will hear from some outstanding ecologists who have not been content to remain at their "Waldens" but have taken up the task of bringing their profession into the arena of public affairs.

Our witnesses are Dr. LaMont C. Cole, Cornell University, president of the Ecological Society of America; accompanied by Dr. John E. Cantlon, Michigan State University, president-elect of the Ecologi-

cal Society, and Dr. Frederick Sargent II, University of Wisconsin-Green Bay, chairman of the Committee on Human Ecology; and Dr. Edward S. Deevey, National Science Foundation, section head, Environmental and Systematic Biology.

(Biographical sketches of Drs. Cole, Cantlon, and Sargent are as follows:)

DR. LA MONT C. COLE

*Born:* Chicago, Illinois, July 15, 1916.
*Degrees:*
S.B. University of Chicago (Physics), 1938.
M.S. University of Utah (Biology), 1940.
Ph. D. University of Chicago (Zoology), 1944.
*Positions:*
Fellowships and Teaching Assistantships, 1940–44.
Officer, U.S. Public Health Service, 1944–46.
Instructor and Assistant Professor, Indiana University, 1946–48.
Assistant Professor and Associate Professor, Cornell University, 1948–53.
Professor of Zoology, Cornell University, 1953–65.
Chairman, Department of Zoology, Cornell University, 1964–65.
Professor of Ecology, Cornell University, 1965–.
Chairman, Section of Ecology and Systematics, Cornell University, 1965–67.
*Editorial experience:*
Associate Editor, Ecological Monographs, 1951–53.
Associate Editor, Ecology, 1946–48.
Review Editor, Ecology, 1952–54.
Zoological Editor, Ecology, 1958–63.
Member, Publications Committee, American Institute of Biological Sciences, 1963–.
Chairman, Publications Committee, Ecological Society of America, 1966–67.
Author of about 75 papers in various scientific journals.
*Offices in societies:*
Biometric Society, Member, Regional Advisory Board for Eastern North America, 1952–54.
Ecological Society of America, Vice-President 1964, President-Elect 1966, President 1967.
American Institute of Biological Sciences, Member, Governing Board 1964–, Member, Executive Committee 1965–, Vice-President and President-Elect 1967.
*Miscellaneous:*
Member, Natural History Survey Committee, Indiana Academy of Sciences.
Special Advisor on Population Problems, University of Pittsburgh, School of Public Health.
Several times member special advisory panels for Office of Naval Research, American Institute of Biological Sciences, U.S. Public Health Service, National Institutes of Health.
Member, Advisory Committee on Environmental Biology, National Science Foundation, 1958–61.
Visiting lecturer, NSF summer institutes for teachers, University of Utah, Montana State College, Oregon State University, Bucknell University, Colby College, University of California, Santa Barbara.
Member and Acting Chairman, Committee on Public Affairs, Ecological Society of America.
Member, Ecology Study Committee, Ecological Society of America; Chairman, Subcommittee on Environmental Pollution.
Commissioner, Commission on Undergraduate Education in the Biological Sciences (CUEBS).
Chairman, Special Review Team for Mathematics-Statistics, National Institutes of Health.
Member, Panel on Systems Ecology, National Academy of Sciences-National Research Council.
Member, Bioinstrumentation Advisory Council (BIAC), American Institute of Biological Sciences.

### Dr. John Edward Cantlon

*Date of Birth:* 6 October 1921

*Education:*

Bachelor of Science, University of Nevada, 1947
Ph. D. Rutgers University, New Brunswick, N.J., 1950

*Experience:*

1940
Field Assistant, U.S. Department of Interior, Grazing Service, Summer
1942–1945
Aviator, U.S. Navy
1947
Teaching Assistant, University of Minnesota Biological Station, Summer
1947–1950
Teaching Assistant, Botany, Rutgers University
1950–1952
Assistant Professor, Botany, George Washington University
1953–1954
Senior Ecologist, Arctic Studies, Physical Research Laboratory, Boston University, Boston, Massachusetts, for field investigations in Alaska
1954–1958
Associate Professor, Michigan State University, Ecology
1958–present
Professor, Michigan State University, Ecology
1959, 1960, 1962
Visiting professor, University of Michigan Biol. Sta., Pellston, Mich.
1965–1966
Program Director, Environmental Biology, Division Biology & Medicine, National Science Foundation, Washington, D.C.

*Honorary Societies:*

The Society of the Sigma Xi, Chapt Pres. 1966–67, Phi Epsilon Phi, National Botanical Honorary Society
Phi Kappa Phi

*Membership in Learned Societies:*

Ecological Society of America, Secretary 1958–61; Vice Pres. 1965–66; President 1968–69
American Association Adv. Science-Fellow
Botanical Society of America
American Institute of Biological Scientists—Member Gov. Board 1962–65
American Society of Naturalists
Michigan Academy of Arts, Science and Letters

*Consultantships, Panels, etc.:*

Advisory Panel, Env. Biology Program, BMS, NSF 1961–1965, Advisory Comm.
Health Physics Program, Oak Ridge
National Laboratory 1966; Division Environmental Sciences Advisory Comm., NSF 1966–.

### Dr. Frederick Sargent II

S.B., M.I.T., 1942; M.D., Boston U., 1947
1948–1967—Univ. of Illinois
Clinical instructor in medicine (1948–1950)
Professorial lecturer in medicine (1962–1967)
Assistant, Associate and Professor of Physiology
Director, Center for Human Ecology (1965–1967)
Director, CIC Biometeorology Graduate Program (1963–1968—Univ. of Wisconsin, Green Bay
Professor of Human Ecology
Dean, College of Environmental Sciences
Acting Dean, College of Human Biology

Member, USNC for IBP; Chairman, Subcommittee on Human Adaptability, NAS
Member, Biometerology Panel, USNC(IBP) and Committee on Atmospheric Science, NAS
Member, Committee on Environmental Physiology, Div. of Med. Sci., NAS
Chairman, Committee on Human Ecology, Ecological Society of America
Member, Air Pollution Training Committee, NCAPC/USPHS (1963–1967)
Member, Committee on Bioclimatology, American Meteorological Society

## STATEMENT OF DR. LA MONT C. COLE (CORNELL UNIVERSITY), PRESIDENT OF THE ECOLOGICAL SOCIETY OF AMERICA; ACCOMPANIED BY DR. JOHN E. CANTLON (MICHIGAN STATE UNIVERSITY), PRESIDENT-ELECT OF THE ECOLOGICAL SOCIETY; AND DR. FREDERICK SARGENT II (UNIVERSITY OF WISCONSIN, GREEN BAY), CHAIRMAN OF THE COMMITTEE ON HUMAN ECOLOGY

Dr. COLE. Thank you, Mr. Chairman. I am happy to be here. I have prepared a short statement, or rather short statement and then I would like to touch on a couple of other points.*

Ecology is the most interdisciplinary of the sciences. Properly, it should provide the scientific basis for, among others, such diverse fields as agriculture, wildlife management, fisheries, forestry, some areas of public health, exploitation and utilization of mineral resources, city planning, and the impact of man on the environment.

In actuality, agriculture, mining, and industry have grown to their present state virtually without consideration of ecological principles. The impact on the environment is becoming intolerable. Soils, bodies of water, and the atmosphere are polluted with a great variety of materials. Areas of originally usable land have been destroyed as have potentially valuable bodies of water.

The lack of consideration of ecological principles has created problems with pest species, and attempts at correction have been singularly little influenced by ecological knowledge. At the same time other actually or potentially valuable species of plants and animals have been exterminated.

Many ecological relationships are very subtle. Had ecologists been consulted they might have anticipated the disastrous effect of the Welland Canal on Great Lakes fisheries. Ecologists did predict the demise of Lake Erie. Ecological studies now could be used to forecast the consequences of cutting or defoliating tropical rain forests whether in Africa, Asia, or Latin America.

Tropical ecosystems (plant and animal communities together with their nonliving environments) are often very fragile and can be permanently destroyed by unwise attempts to manage them. Again the ecological factors are very subtle and involve the nature of the community itself, the types of soils, the microorganisms in the soil, the climate, and the ways in which the climate will change as a result of altering the plant community. These complexly interacting factors are all too often not considered when man sets out to alter a region, and ecology is not a traditional factor in the planning.

Today we are polluting the environment more rapidly and with more materials than ever before, and the rate is increasing. We are generating more inert wastes such as plastics and glass than ever before, and vastly more highly reactive wastes such as radioisotopes. Before

*See also app. B, p. 551, for additional information furnished by Dr. Cole.

the controlled release of atomic energy it is estimated that all of the radioisotopes under human control consisted of about 10 grams of radium. Today a nuclear plant is being built near Oswego, N.Y., which, it is estimated, when in operation, will every day release into the atmosphere radioactivity equivalent to 130 grams of radium.

We are hearing recommendations for major modifications of the earth which have drastic ecological implications. Some of these are utterly irresponsible and others are well-intentioned proposals from able persons who are simply unaware of the ecological implications. I have several times heard leading chemists, thinking about ways of aiding agriculture, propose ways of intervening in the nitrogen cycle which, if successful, could spell the end of life on earth.

We are talking about modifying the weather (which, incidentally, man has inadvertently been doing since his early history), of connecting the Atlantic and Pacific Oceans by a tropical sea-level canal; of mining the ocean bottoms and at the same time trying to farm the surface waters, and of innumerable other schemes with vast ecological implications which are simply not recognized by their proponents.

All this is very frightening to one who does see some of the implications, and I know ecologists who have simply given up and hope that they will not be around to see the final disaster for man. However, in the Ecological Society of America, we have not given up. We have formed a vigorous Committee on Public Affairs which represents a place that policymakers can come to for competent ecological advice.

The Ecology Study Committee, which represents the long-range planning arm of the society, has studied alternatives and has concluded that we must establish some sort of a "National Institute of Ecology" which can bring together in readily retrievable form the existing information about ecosystems, which can insure that research is conducted on vital questions where we are at present largely ignorant, and (perhaps of greatest interest to this subcommittee) which can put a mass of authoritative knowledge and thinking at the disposal of policymakers who need advice on ecological questions. We want this institute to have the capacity to undertake studies in depth when it is presented with a problem for the solution of which the necessary data do not yet exist.

The trouble in the past, at least in this country, has been that policymakers have either failed to recognize ecological implications or have directed their questions to bodies of scientists and engineers that were not qualified to give advice on ecological problems. Environmental management policy has been based on considerations of economics, engineering convenience, and political expediency, but seldom on esthetic consideration and even less often on sound ecological considerations.

Mr. DADDARIO. Dr. Cole, when you say that in this country we haven't done these things, where have they handled the situation better or are you just pointing to our own problem.

Dr. COLE. I just didn't want to be too broad on this. I think England has done a bit better than we have, but it has been far from what it should be anywhere.

Chairman MILLER. Doctor, isn't England putting rather high-level atomic waste into the North Sea?

Dr. COLE. I don't know the amounts going into the North Sea. Of course they are creating high-level atomic wastes and they have had at least one rather serious reactor accident.

Chairman MILLER. As you know, there is a counter current under the Gulf Stream.

Dr. COLE. Yes.

Chairman MILLER. Can the effect of this high-level waste, if enough of it gets into the North Sea, do some damage on the Grand Banks and to the fisheries off the New England coast? I believe these isotopes have an affinity for shellfish, particularly.

Dr. COLE. It would depend on what they are putting in there. If they are putting strontium-90 or cobalt-60 in there these could accumulate in shellfish and could cause tremendous damage. Cobalt-60 wasn't even known to be produced by the bomb that contaminated the island of Rongelap in the Pacific and yet 2 years after the blast, the shellfish there were extremely radioactive. They wouldn't be safe to have on your table.

Mr. DADDARIO. My reason for asking the question was just to get the definitions right. You are just referring to what we are doing and you are not in any way intending by this to make comparisons to other areas?

Dr. COLE. No.

This proposed National Institute of Ecology, in addition to its functions as a research organization, data center, and advisory body will seek to further the infusion of ecological information into education at all levels. In testimony I gave 2 years ago before the Senate Committee on Interior and Insular Affairs I emphasized that we do not now have enough qualified ecologists and that not enough are being trained to conduct the studies and furnish the advice that society urgently needs.

The Ecology Study Committee of the Ecological Society of America has just undertaken, by means of a questionnaire, to learn what the training situation actually is. A summary of the results will be presented to you by Dr. Edward S. Deevey, Jr., of the National Science Foundation who is a regularly attending observer of the ecology study committee.

It is clear to me that the Nation simply must step up the training of ecologists. There is simply no substitute for the type of interdisciplinary approach which is instilled in ecologists. Attempts to solve our environmental problems solely by the narrower traditional approaches employed by physical scientists and engineers will, in my opinion, invite disaster.

Now there are two other things that I wanted to include in the testimony but in the haste in which itw as prepared I didn't get time to put these in. Incidentally there are copies of the present statement about the National Institute of Ecology available to you. One is the question of giving ecologists field training. This is an outdoor science, and our people just simply have to get out and see how ecosystems really work and it is a pet project of mine that I hope we can bring to fruition, that we will perhaps under this Institute operate a number of field stations and laboratories, one with access to interesting bodies of fresh water, one marine station, one in the Tropics, one in the Arctic or Alpine situation, and one in an arid land situation, and if we are

going to have thoroughly trained ecologists that can answer the questions and provide advice on the things we are doing, they need experience in all of these areas.

The second point I wanted to make has slipped my mind at the moment. It will come back to me.

Mr. DADDARIO. Yes.

Are the next two statements going to touch on the National Institute of Ecology and spell it out a little bit?

Dr. DEEVEY. Mine will not.

Dr. SARGENT. Mine will not.

Mr. DADDARIO. If we could touch on that a moment, how do you structure it, where do you place it, or who is going to be involved?

Dr. COLE. I am preparing letters to approximately 20 ecologists representing schools that have established programs in ecology. These will go out probably next week, along with this summary statement on the Institute which you have available here, and will ask for an expression of interest and willingness to form a corporation of individuals as the parent body for this National Institute.

Our plan is that this Institute will be run by a consortium of universities, and our thinking at the moment is that this corporation of individuals will be converted over into a corporation of universities, a consortium, when a certain number, perhaps three universities, have actually agreed to come in and support the program.

I have received a tremendous number of letters expressing interest from schools that don't want to be left out of this, places that I would never have thought of as having an ecological program, so there is a very great deal of interest in this and a strong feeling of need.

Mr. DADDARIO. Dr. Deevey, how does this fit into the planning of the National Center for Atmospheric Research?

I am concerned about this because we have a tendency to develop new institutional concepts rather than take into consideration those that presently exist and meld them together so that you do have a mixture of thinking. A mixture, it seems to me, is extremely necessary in this regard. Have you given this any thought?

Dr. DEEVEY. At the moment the group that has been making the plans assumes, not perhaps having thought it through, that the National Center for Atmospheric Research is a model and not a stage for a National Institute of Ecology. The procedures that ecologists would adopt in developing such an Institute are closely similar to those the atmospheric scientists adopted 15 years ago or so. But atmospheric science now has its own momentum and a very great deal of its high quality has been generated in the theater of this relatively spectacular, strong, and influential group of central premises there at Boulder.

The idea that ecology might be conducted in the way the ecologists believe it must be from that institute; that is, from NCAR, has not really been given much thought. Ecology needs and gets close collaboration with atmospheric scientists, but what that would amount to is you would have to transform a substantial fraction of them or add to them a substantial fraction of biologically trained rather than physically trained scientists. It might come about that the two institutes, if the Ecology Institute had central premises, might sit side by side at Boulder. In any case, the field stations that the Ecology

Institute would be concerned with would not in all cases be the same field stations that the atmospheric people need. However, there are some that well might be the same.

Mr. DADDARIO. I don't ask the question because I contemplate you have this all fitted into your mind, nor do I believe that you do, Dr. Cole, but you are thinking about the establishment of an Institute, which you would have to in some way work harmoniously into presently existing activities.

Mr. COLE. Yes; we appointed a subcommittee of the Ecology Study Committee to prepare the original proposal for the National Institute and they met out in Boulder and looked over the NCAR organization very carefully, so there was a good deal of input from there into our plans.

If I may, the other point I wanted to touch on has come back to me, and this is related to the Institute. There is a very great need to acquire natural areas, natural ecosystems that can be preserved for research purposes. The analogy has been made that medicine didn't get very far until they began intense study of the healthy human body anatomically and physiologically and the same thing applies to ecosystems. None of us know enough now to look at even such a small ecosystem as one drainage basin for a river and predict just what some particular modification may do to the life there. These things have to be studied in their entirety and they need to be set aside for research before man destroys them, and the same would apply to marine communities and estuaries and bodies of fresh water and so on.

(The following additional information has been supplied for the record:)

A NATIONAL INSTITUTE OF ECOLOGY: SYNOPSIS OF THE PLANS OF THE ECOLOGICAL SOCIETY OF AMERICA

Ecology is the scientific study of life-in-environment. It is not, for instance, the science of management, which is a form of political engineering. It is not the study of resource allocation, which is a form of economic engineering with sociopolitical components. Nevertheless, sociopolitical and economic decisions regarding resource management and allocations are, in significant degree, ecological decisions; professional ecologist have the necessary knowledge, as well as the duty, to participate in such decisions. They expect to do so, not by "calling for a stronger voice for ecology in public affairs", or by combating some hypothetical opposition, but simply by doing better ecology.

STATUS OF THE PLAN

The Ecological Society of America has sought for at least twenty years to find better mechanisms for doing better ecology. It now proposes a *national institute of ecology*, with research-and-development centers on the pattern established by the National Center of Atmospheric Research, as such a mechanism. The proposal has been received in draft form by the Study Committee of the Society (LaMont C. Cole, chairman). It was drafted, with the assistance of a grant (G–6073) from the National Science Foundation, by a small planning group (Charles Cooper, Shelby Gerking, R. S. Miller, chairman) appointed by the Study Committee. At the meeting (Washington, D.C., December 8, 1967) that considered the report, the Study Committee voted to implement the proposal by asking several distinguished ecologists (names and number suggested but left unspecified) to take legal and fiscal advice and incorporate themselves as a national institute. It was understood that operating ownership of the institute would quickly pass to a group of universities, and it was suggested that the founding members should hand over control when five universities had agreed to join the institute. The "committee of founding fathers" has not yet (February 16, 1968) been formed.

The Program Director for Environmental Biology, NSF, attended the December 8 meeting. At the suggestion of the chairman, he has prepared this synopsis of a longer document for the information of the NSF staff and others who have reason or wish to discuss the Ecological Society's concept. Word of the developing plan has reached the press (e.g. *Science*, January 19, 1968, page 287), and has been brought (without written documentation) before the Executive Committee, NAS/NRC Division of Biology and Agriculture, and before Committee I (Research) of the National Science Board. It must be emphasized that in no sense is this interim report a proposal before the National Science Foundation.

OUTLINE OF THE PLAN

1. *Need.*—A national institute of ecology is needed, (1) to conduct those kinds of ecological research that cannot be conducted by independent investigators working in single universities and laboratories, but require substantial field facilities and concerted multidisciplinry team effort; (2) to help coordinate the nation's ecological research by providing centralized information-storage-and-retrieval facilities on which ecologists and public agencies can draw; (3) to coordinate and strengthen those activities of ecologists that (in Rep. Daddario's words) "involve ecology in relation to public affairs as well as the education of ecologists and the infusion of ecology into general education at all levels"; (4) to perform advisory services for agencies of government and industry that express in some meaningful and constructive way "an ecological view" of action programs affecting environment. Of these needs, (1) and (2) are immediate and obvious, and can be fulfilled *only* by a national institute and a professional staff; (3) and (4) are thought of as no less urgent, and *may* be fulfilled by a national institute, if only because of its strong research programs and high visibility; but a single national *research* institute is not the only mechanism, or necesarily the best mechanism for fulfilling them. These matters need continued discussion, in which the Society's Public Affairs Committee will undoubtedly take a leading role.

2. *Need for research on ecosystems.*—Ecosystems, being partly conceptual, are elastic units; for some purposes, mainly literary, "spaceship Earth" or all of North America are ecosystems. Working ecologists rarely concern themselves with such large units. Very small ecosystems, such as old fields, small lakes, or those that can be synthesized in the laboratory, need much more reserach, but most of it can continue to be independent and the facilities required are conventional. However informative, the results of such studies cannot be extrapolated to larger patches of nature, containing more biological and environmental diversity, without loss of rigor or predictability. Ecosystems that require substantial field facilities and new modes of concerted team research are those of intermediate scale, of the order of drainage basins, "airsheds", and biomes such as grassland and tundra. Such systems are geographically dispersed, and their geographical variability is intrinsic to their scientific interest. As they cannot be brought into any laboratory, laboratories must be brought to them.

New technologies, mainly geophysical, geochemical, and statistical, have only recently enabled ecologists to study terrestrial systems of such magnitude. (In aquatic ecology, especially oceanography, the ecosystem concepts and the technologies have been available for a longer time.) The necessary intelectual resources obtained by interdisciplinary collaboration, are rapidly being developed. Any kind of team research needs careful attention to its organization if high quality and scientific initiative are to be preserved. It is this kind of organization, as much as the day-to-day conduct of the research, that a national institute of ecology is intended to provide.

In all systems defined and studied on this comparatively large scale, man's activities are environmental parameters that range from important to dominant. Man-dominated systems, like other systems, do not produce energy, but only transform it. If attention is concentrated on the output of ecosystems, the ecological term is "productivity." When the focus is on internal transformations and frictions, one appropriate word is "pollution." "A pollutant is a resource out of place." It follows that understanding of the metabolism of ecosystems—both positive and negative aspects—is the chief practical benefit, as well as the chief intellectual satisfaction, of ecology.

Examples of projects on large-scale ecosystems, all genuinely multidisciplinary, are the Yale-Dartmouth-U.S. Forest Service project at Hubbard Brook, New Hampshire, the OTS tropical-forest project in Costa Rica, and the IBP-sponsored program on Analysis of Ecosystems, which plans intensive and comprehensive study of six major biomes.

These examples are from terrestrial ecology. Older, more familiar examples are all aquatic, such as the AEC-sponsored study of the Sargasso Sea, or the International Indian Ocean Program. A much older example (ca. 1916) is the work of the San Francisco Bay Marine Piling Commission, a pioneer estuarine project that badly needs re-doing. It is as examples of "pure" science applied to large systems that ecologists find these projects intellectually exciting. It is noteworthy that all are using or plan to use human influences ("disturbance") as a technique of experimental or quasi-experimental manipulation. The notion is that only under controlled stress can the homeostatic properties of complex systems be fully tested. As this familiar strategy is applied to large and complex systems containing men and their culture, any distinction between "basic" and "applied" research tends to become meaningless.

3. *Research and "development" functions.*—The primary function of the national institute, with its scientific staff working out of one or more well-equipped laboratory centers, should be to conduct research in general ecology. It would do this by bringing all the resources of modern science to bear on understanding large ecosystems in their totality. Projects would be partly self-generated, and partly undertaken at the request of government agencies and industry. Funding of the latter, at least, would be contractual; the independence of the institute to accept or reject projects must be assured. "Development" in this context is not management or exploitation; it is understood to be the *methodological* development (remote sensing, computer technology, etc.) needed to do better fundamental research. Human influence on ecosystems can never be ignored, but the focus of the institute's research should be on life-in-environment, not on human ecology *per se*.

4. *Educational and public-information functions.*—As a coordinating research arm of several universities, the institute would play a major role in ecological education. Its explicitly educational functions are regarded as secondary, however, in the sense that most of them would proceed automatically from a program of high-grade comprehensive research. Initially they would be exercised through such tested devices as pre- and post-doctoral traineeships, foreign-exchange fellowships, affiliate professorships, lectures, seminars, and short courses, and informal "institutes of advanced study". More innovative and perhaps more effective devices for improving ecological education at all levels would have to be developed with care, if propaganda and political advocacy are to be avoided. Particular care would have to be exercised if *any* educational or advisory functions are undertaken with the support of public funds.

5. *An economic model.*—Ecologists see no essential differences between ecology and economics, in respect either to academic orientation or social significance. In fact ecology can be considered the natural-science component of economics, and at a very abstract level its governing concepts are mathematically equivalent. Ecologists therefore note with respect and some envy the degree to which economic ideas are internalized by all educated persons. Moreover, politically concerned but conservative ecologists admire the ability of economists' professional organizations to devote themselves to free though socially-oriented inquiry while remaining politically uncommitted. Such an organization as the Brookings Institution is therefore an attractive model for a national institute of ecology. Its organization and research programs were studied by the subcommittee, and emulation is strongly recommended. The Brookings' private endowment is not so easy to emulate, however.

6. *An atmospheric-sciences model.*—A closer analogy, in that both are natural sciences, utterly dependent on data from a global field, and use partly identical methods, exists between ecology and atmospheric science. The subcommittee therefore looked at the National Center for Atmospheric Research (NCAR) with special care. In some respects the NCAR model may be unnecessarily elaborate. Ecology has less need than meteorology for synoptic data, gathered simultaneously on a continent-wide or world-wide scale, and some of the instrumental and human apparatus that is essential for good meteorology would be wasteful duplication in ecology. The idea of a central facility that is both a palladium and a cynosure, though strongly appealing, was not considered essential by the subcommittee. In all important respects, however, good ecology and good atmospheric research have identical needs—for a nuclear scientific staff and flexible research program, for coordinated field stations and mobile laboratories, and for central premises and program services—and NCAR was found to be a near-perfect model of a national institute of ecology. Outstanding among its attractive features are

NCAR's strong and responsive relations with university-based science and education, and the subcommittee paid special attention to the sponsoring and governing roles of UCAR, the parent consortium of universities.

7. *Institutional arrangements and alternatives.*—A national institute of ecology is so clearly in the national interest, and would so obviously be dependent on contractual relations with the federal government for much of its funding, that the plan for an independent, private research agency may seem to usurp the prerogatives of government. Federal laboratories for the study of life in environment already exist. Many members of the Ecological Society work in them. Could not one of these be enlarged, or several of them be linked together, to accomplish the objectives of a national institute? The idea has much appeal, especially to foreigners familiar with such research arms of national governments as the Natural Environment Research Council (UK), the C.S.I.R.O., the D.S.I.R., and many others.

Only a little familiarity with U.S. federal research is needed, however, for the idea to lose much of its charm. Which federal laboratory or agency might assume the functions that ecologists have in mind? To which department should it be attached? Ecologists note with mingled amusement and despair that polluted water "belongs" to Interior, polluted air "belongs" to HEW, polluted soil "belongs" to USDA, while AEC, potentially the most dangerous polluter of all three environments, is the chief federal sponsor of research on ecosystems. All these agencies have responsibility for action programs, for surveillance, and for enforcement of policies. In this context, fundamental research rarely carries highest priority when funds are reduced.

No disrespect is intended by these remarks. Federal scientific research is excellent science. There are many good reasons for the situation that exists, and there is a great variety of coordinating devices. But it seemed to the subcommittee, after some reflection (and much first-hand familiarity with several kinds of federal support for ecology) that no government agency is (or no new government agency can long remain) nimble enough, far-sighted enough, or in close enough touch with the universities where the nation's real scientific strength lies, to substitute for an independent national institute of ecology.

In calling, not for "better liaison", but for action that is within the capacity of university-based ecologists, the subcommittee was aware that the recommended institutional arrangement, a consortium of universities, is also beginning to lose some of its charm. At least academic administrators are doubtful that their own institutions can participate in many more of them, without detriment to their own fundamental objectives. As public-administration devices, consortia are undergoing rapid evolution; some are already quasi-independent "management corporations", and some may follow the COMSAT route to a "public-private corporation". The subcommittee recognized its own ignorance of administrative matters, and preferred to leave the corporate form of the national institute of ecology to development in more experienced hands. It suggested only that (as with UCAR) a fiscal officer of each founding university be included among the "founding fathers". In any case, the subcommittee was familiar with the Organization for Tropical Studies (OTS), recognized its near-identity of purpose with a national institute of ecology, and assumed that the members of OTS would be the most appropriate member universities, at least initially. The fact that the Central University of Costa Rica is a member seemed to point in the right direction; the participation of Canadian, West Indian, and Mexican Universities would add enormously to the strength of the proposed organization.

8. *Open questions.*—At this stage in the Study Committee's planning, a large number of questions, including the name and some aspects of the nature of the proposed national institute of ecology, are left open. The Committee can and does recommend, but all further decisions remain to be taken. These include the form and provisions of the articles of incorporation, the list of "founding fathers", the mode of financing, the choice of a Director, the size and nature of his staff, the scope and direction of the research program, the number and location of operating centers, and the degree to which the institute goes beyond its research functions to perform roles in ecological education and public affairs. Advice will be needed from many people, and not just from ecologists. Presumably, by the time suitable candidates for staff positions are identified, and a Director chosen, most policy decisions and many research plans will have been made. The Committee hopes for expeditious progress but does not urge haste.

9. *The role of the Society, and of the National Academy.*—The Ecological Society of America is a learned society, founded on a 17th century model, and its

main (and vitally important) function is to promote interchange of scientific ideas between scientists. Those who expect it to restructure its own organization "to meet the needs of science in the 20th century" simply do not know scientists, or understand how science is done. Some of the best-endowed learned societies in the U.S. have strong organizations and central offices but do not *conduct* scientific researach, though they sponsor a great deal of it, and publish much more. Neither can the Ecological Society accept corporate responsibility for research that it sponsors, evaluates, or publishes. Still less can it be placed in any nonscholarly stance involving political advocacy, "educating the decision makers", or many of the action programs some of its critics would like to undertake.

It follows that in recommending and in effect sponsoring a national institute of ecology, the Society neither changes its own role nor becomes legally or even scientifically responsible for the institute's organization or program; it expects to remain free to criticize, to publish, or not to publish ecological research done by or under the auspices of the national institute. Thus, if its Study Committee's recommendations are followed, the Society's position will be that of godfather, not parent, and it can only hope that the relation will be one of which it can be proud.

Similar considerations apply to the National Academy of Sciences. Through its study groups, the committees and boards of the National Research Council, the Academy would be bound to take notice of the existence of a national institute of ecology. It would often be obliged to appraise its programs, recommend or perhaps contract for new ones, or (a function which seems imperative to ecologists) refer many environmental problems to the national institute for study and advice. The Academy's National Research Council, however, is not an "operating arm", as research councils are in other countries. It evaluates, stimulates, and sponsors research projects, but it owns no institutes and conducts no research in its own name. There is no reason to expect it to own a national institute of ecology.

In 1962 the Academy issued a report (NAS/NRC Pub. 1000A) that said, in part, "It seems vital to establish without delay a broad-gauged agency charged with the continuing examination, identification, and assessment of changes in the natural resources picture, and of their potential effects upon each other . . . Such . . . an intelligence agency (would) be able to feel the pulse of the ecosystem, as it were, and to register and assess incipient developments before they have reached critical dimensions . . . The contemplated agency should not, however, be given powers of decision or enforcement, and it should steer clear of the political arena." Noting that this sounds remarkably like a national institute of ecology, the Study Committee assumes that the NAS/NRC will look with favor on its own efforts to bring such an agency into being.

Mr. MOSHER. Mr. Chairman.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. One of the practical examples mentioned in the testimony is the disastrous effects of the Welland Canal on Great Lakes fisheries. I don't want a long dissertation on that, but I would like two or three further sentences. What are you talking about there?

Dr. COLE. I might qualify that to the extent to say that the original Welland Canal opened in 1833, I believe, and if this started the disastrous effects, ecologists couldn't have predicted it. The present canal was opened in 1932 and then they could have been predicted.

What happened was little forage fish, the alewives, moved through the canal into the upper Great Lakes and the sea lampreys moved in. They are predatory on trout and similar fishes. The sea lampreys increased in numbers until they wiped out the white fish industry in Lake Michigan and Lake Huron and they damaged it in Lake Superior.

Now the trout were apparently keeping down the alewives by preying on them. With the demise of the trout as a result of the sea lampreys, the alewives could multiply without limit, essentially. Consequently last year we had the situation of Chicago and Milwaukee beaches just littered with piles of dead alewives.

Mr. MOSHER. You mean the canal gave access to the Lakes?

Dr. COLE. Yes; you see they couldn't cross the Niagara Falls and the Canal goes around it.

Mr. MOSHER. You think that someone might have anticipated that, if consulted?

Dr. COLE. By 1932 I think they might have, yes.

Chairman MILLER. Doctor, I think there are lots of examples where people use live bait when they fish and when they are through fishing, if they haven't used all of the bait, they dump them into the stream and the first thing you know these fish are taking over the stream.

Dr. COLE. Those are usually carp and they have damaged a great many lakes in that way.

Chairman MILLER. The Sacramento River and San Joaquin River, are filled with carp. I would be interested in knowing how they got there. There was a man of German extraction that had some land on a low-lying island in the Sacramento River. He sent to Germany and had the lake stocked with carp. Then he invited his friends up because these are great fish in Germany. Then a break came and the carp washed from the lake into the river.

Dr. COLE. There are many such examples. Both the starling and English sparrow were brought into this country deliberately and rabbits were introduced deliberately in Australia. In fact, they didn't take the first time. It took a second introduction to get them established.

Chairman MILLER. Mongoose were brought into Hawaii.

Dr. COLE. And in Jamaica too. They would love to know how to get rid of the mongoose now.

Mr. DADDARIO. You touched on the need to set aside certain areas untouched and uncluttered by man at this time. Considering the problems we have here and recognizing that in most instances it is impossible, how do you intend for your National Institute, from an ecological point of view, to get the kind of a reading on the problems that presently exist in the various river basins? Each of these is different. Would you be able to make recommendations so that we can readjust and turn them back into unusable streams?

Dr. COLE. I think we will have a very important start on that from the international biological program. There are proposals to study in detail the desert biome, the grassland biome, and a number of studies on different types of river basins. These will be interdisciplinary studies going into the chemistry and hydrology as well as the biological situation and putting all of this together we will be able to form much better judgments about the functioning of these systems we can at present.

Mr. DADDARIO. Your answer to that then is that the Congress should take into consideration programs presently before it, such as the international biological program, and see to it that those programs are funded so that you can develop this capability which doesn't presently exist and will not exist unless that program is properly funded?

Dr. COLE. I think that is very important. Now it could be done through a national institute, but since detailed proposals have already been prepared to get started on this, why that seems to me like the logical way to proceed.

Mr. DADDARIO. Dr. Cole, you have been quoted to the effect that the oxygen in the atmosphere might be depleted by certain manmade

changes. I wonder if you could touch upon the evidence that is there. How can this be understood so that man could with good judgment do what is necessary to overcome the problem?

Dr. COLE. Well, the only reason there is oxygen in the atmosphere is that green plants are continuously putting it there by photosynthesis. These are plants not only on land but also in the oceans where about 70 percent of the oxygen is generated. Photosynthesis stops at night in the dark and on land and high latitudes it practically stops during the winter, so we are dependent for oxygen being produced in other places being brought in.

Now, every year we are burning fossil fuels faster than we did the year before, and all of this is using up oxygen, so we are increasing the rate of use and at the same time we are cutting off plants on land and the Food and Drug Administration estimates that we are putting half a million different types of chemicals into the oceans without any study being made of whether these might be poisonous to the marine plants or not.

If we should by some miscalculation poison all of the marine diatoms, this would cut off 70 percent of our oxygen supply and the oxygen content of the atmosphere would start to decrease unless we agreed to a moratorium on burning fossil fuels.

I have attempted some very rough calculations for this country. The data aren't very good, but I took the 1966 rate of use of fossil fuels in the United States, the coal, petroleum and natural gas, and assumed that it was all completely oxidized, and I compared this with what could be produced in the way of oxygen by the plants in the 48 coterminous States, and to the extent you can trust these rough figures, we are using oxygen 1.6 times as fast as our plants can produce it, so we are absolutely dependent on its being brought in from the Pacific Ocean and Mexico and similar places.

As I say, I am not very happy with these data, but I think we are in the right ballpark with that estimate. We can't go on paving a million acres of land each year and putting it out of productivity without risking eventually some at least local crisis with the oxygen in the atmosphere during winter nights, say, but these widescale atmospheric movements are not even well enough known to let us put down really precise figures on this risk.

Dr. SARGENT. Mr. Daddario, I would like to add another dimension to Dr. Cole's statement. I draw from my article "Adaptive Strategy for Air Pollution," a reprint of which you have. Weather modification from the burning of fossil fuels and the discharge of other wastes into the atmosphere is now well recognized by meteorologists. Information published last year in Science by Ludwig and McCormick from the Taft Sanitary Center in Cincinnati indicated that the turbidity of an atmosphere has increased about 77 percent at Davos, Switzerland, where there is a meteorological station of 100 years' duration, located at 1,604 meters above sea level, far away from big cities. An increased turbidity of the atmosphere means that radiant energy coming to us from the sun is being reduced and the photosynthetic process which Dr. Cole talked about depends on the receipt of this solar energy.

With still greater increases in the turbidity of the atmosphere, a point may be reached at which the input of solar energy becomes inadequate to drive the photosynthetic process.

Another influence that man has had that is reducing the input of solar energy is the jet airplane. These aircraft produce a vapor trail. Dr. Roberts of the National Center for Atmospheric Research has produced some beautiful pictures showing these contrails evolving into cirrus clouds. The cirrus clouds reflect sunshine back into space and it does not get to the plant.

There is also an increase in the number of freezing nuclei. Vincent Schaeffer of the State University of New York at Albany has shown an increase in freezing nuclei. These nuclei contribute to the growing haziness of the atmosphere. These influences, which are over and above what Dr. Cole has mentioned, threaten the oxygen supply of the atmosphere because they reduce the energy that drives the photosynthetic process.

Mr. DADDARIO. On your jetstreams, are you theorizing?

Dr. SARGENT. I do not refer to the jetstreams, but to the contrails made by jet aircraft. The picture on the front of my article which you have shows—illustrates this phenomenon. Dr. Roberts gave me that photograph.

Mr. DADDARIO. By jetstreams, I really meant jet aircraft disturbances. Are you theorizing there or do you believe it is a hard reality that this is what is taking place?

Dr. SARGENT. Yes, I believe it is taking place. More and more frequently one sees the vapor trail or the contrail evolving into a cirrus deck.

Mr. DADDARIO. Why don't we continue on? Either Dr. Cantlon or Dr. Sargent can continue with their remarks.

Dr. SARGENT. I think we had Dr. Cantlon scheduled next.

Dr. CANTLON. Let me first make one observation about the oxygen matter since it is before you.

It is worth reflecting that a fairly sizable percent of the oxygen released from the sea is released in a relatively small number of the major upwelling areas in the ocean surface. The recent disaster on the English coast of an oil tanker, and the more recent one in Puerto Rico, is enough to give us pause. What happens if one of these increasingly more massive tankers flounders in a place that contaminates these big upwelling areas, and what happens if the petrochemicals it is carrying happen to be reasonably herbicidal in nature?

We are dealing now with phenomena, the scale of which requires somewhat more care. These matters shouldn't alarm us, but we should be thinking forward to what might be the result of, and what are the probabilities of occurrence of a series of these kinds of things. I don't think it is necessary to be overly worried about this at the moment, but these are things we ought to begin getting better data on.

Chairman MILLER. Where do these upwellings in the ocean take place? Aren't they pretty much located all over the ocean?

Dr. CANTLON. No; they are highly localized. For instance, the big Peruvian upwell. As a matter of fact they occur in the very places in which the great world fisheries occur, and the reason the fisheries are there is the presence of the upwell.

Chairman MILLER. I can tell you a story about that. I used to be executive officer of California fishery and game. We used to catch sardines off the coast of California and they made extensive studies trying to find out why this took place, but it wasn't until after I was

in Congress that they were briefing me on what might be the effects of dumping atomic wastes into the Pacific, and a young biologist mentioned this. I said, "Why do you catch them there?"

He said, "There is a big sea mount down there, Mr. Miller, and the ocean current comes in and it wells up." Of course, this brought the fish, the food life of the fish and such to the surface. I thought these upwellings were well scattered pretty much throughout the world.

Dr. CANTLON. That is right, and if you look at the matter of percentage of oxygen release, we need not contaminate the total ocean. Enough herbicide unintentionally released in a relatively selected group of local areas might add a serious additional burden on our oxygen circulation system.

Mr. DADDARIO. I have another question in my mind, but I think Dr. Deevey has something.

Dr. DEEVEY. If I may simply interject a related biogeochemical point to what Dr. Cantlon has said. The matter of the sulfide system is of extreme importance, likewise, to the maintenance of oxygen in the oceans and in the atmosphere. We have now begun to realize that the sulfate-reducing bacteria, most of which probably exist in the sea bottom or on the continental shelves in blue muds, and also in the bottom of lakes and marshes—in anaerobic situations, make their living by reducing sulfate to sulfide. That leaves the oxygen behind, you see, in the course of reducing the sulfur. Thus, although one understands this not at all on a global scale, it is essential to get a clear picture of the relative metabolism of sulfur as compared to the metabolism of carbon, which is what this amounts to.

It looks as though the sulfide-sulfate system is the major balance wheel that keeps the system operating. What follows then is that a threat to the metabolism of all of the sulfur bacteria in the sea would be as great a threat to the maintenance of oxygen in the atmosphere as the destruction of all the green plants.

Mr. DADDARIO. Dr. Cantlon, in answer to the chairman's question, you sort of capped it off by saying it is nothing that we really ought to be so concerned about at the moment. One of the points that sticks in my mind in Dr. Cole's statement is that these things ought to be planned. We are putting much of our land under concrete and macadam and what not, and in Vietnam we are certainly not planning what is going to happen by the defoliation processes. Shouldn't we be concerned and shouldn't we put this thing into perspective so it can be understood?

One of the problems in this whole area is that statements are made, some of them scary and some of them not so scary, so finally people just kind of shrug their shoulders about them. The more I hear about it the more I am convinced that there is a present need for planning so the people will understand why it is important.

Chairman MILLER. Mr. Chairman, the areas being defoliated in Vietnam would be miniscule compared to the rain forests in Vietnam and in Southeast Asia, let alone the rain forests in South America. I don't think we want to get too scared of what is going on there. It is a comparatively small strip. I think what we must be concerned with is the effect of chemical pesticides and certain chemical fertilizers that get into the river basins and are washed to sea and into our estuaries.

I think they are consuming as much oxygen as some of these other things. Isn't this a real threat that we are concerned with right now?

Mr. DADDARIO. Mr. Chairman, I am subject to the same problem in my thinking process as you people. When these points are raised, such as defoliation, and it may not be the most important, but certainly you have to take all of these things into consideration.

They all play a part; don't they?

Dr. COLE. Yes.

Chairman MILLER. Long before the word "defoliation" was introduced, 'way back in the eighties, a copper plant was established in California that completely defoliated 10 times more, or 100 times more area as will be defoliated in the war in Vietnam. It left red hills that eroded. I know you know where the area is I am talking about. Now fortunately it is under water. It is part of that area that forms Lake Shasta. However, as a result of a copper operation, you went through lands that looked like the deserts of Australia.

Dr. COLE. I agree with Mr. Daddario and I am worried about these things. I think the important point is that man is now so completely predominant in the world and he is doing all of these things at once and just trusting to luck that he won't bring on a disaster.

For example, DDT is now practically a normal constituent of the world environment. It has turned up in the fat of penguins in the Antarctic and can be found in the ice on Alaska glaciers and places where it has never been used, but if that happened to be a deadly poison for some of the essential microorganisms, we could have put the world out of business by now.

Chairman MILLER. Isn't it deadly to microorganisms?

Dr. COLE. Very recent studies have shown DDT is definitely damaging the algae growth in Long Island Sound.

Mr. DADDARIO. You did say that ecological studies now could be used to forecast the consequences of defoliating tropical forests, and ecology is not a traditional factor in planning. I don't understand that to mean it is a dangerous situation, but because it has been done it gives you a laboratory within which you can come to some determination about what this does mean and you can put into better perspective what ought to be done in other areas.

Dr. COLE. Some tropical rain forests probably can stand the use of defoliants and others can't. The important thing is that most of these tropical soils are very low in nutrients and the nutrients that come down with leaf fall and falling trees and so forth have to be recycled. The plants have to be in growing condition there to seize these or they leach out in the ground water.

Now this can be studied ecologically. You can study the streams draining an area before and after defoliation and actually measure the losses of these essential nutrients, such as fixed nitrogen and phosphates and things of that sort. A very recent study published in Science refers to an area up in New Hampshire where they have done just this. They have measured the mineral content over several years of the streams draining this watershed and then they cut the trees off up there and sprayed a herbicide to keep the vegetation from regenerating and found a tremendous increase in the outflow of nutrients that plants require.

In tropical regions this is likely to be much more serious because the soils are so poor in nutrients in the first place, but you would have to study this situation in Vietnam to tell whether you are doing something that will prevent that rain forest from regenerating.

Mr. DADDARIO. The opportunity to study it ought to be taken advantage of.

Dr. COLE. I would think so; yes.

Chairman MILLER. I think that it is highly essential that you study it.

Mr. DADDARIO. Would you proceed?

Dr. CANTLON. I would like to start off with paraphrasing the remarks of a scientific colleague at an advisory committee for one of the Federal agencies in which we were discussing ways of attacking our burgeoning environmental problems. His remarks brought this discussion to a climax and this is approximately what he said:

I keep hearing strong pleas for encouraging the investigation of natural purification phenomena and the need for more and better ways to halt increasing pollution. Why aren't we concentrating our scientific efforts instead of increasing tolerance to pollution?

That is a rather interesting thought, and at a quick assessment, it looks like this is indeed an oversight. Yet with a little quiet reflection, you can see that such a view is itself symptomatic of the aimlessness with which we have addressed ourselves to our environment because it is based on two rather false premises.

First, it assumes that the present forms of pollution that we now suffer are themselves essential and inescapable byproducts of our modern industrial living; and, second, that man and a very few domesticated plants and animals are the only creatures on earth that we need to worry about.

Now setting aside one's own moral and ethical considerations about which organisms deserve to live on this planet, we can address ourselves to man's strategy for maintaining a satisfactory environment in a more coldly scientific way.

It has been said many times that resources out of place really are pollution. Pollution wouldn't exist if we effectively managed our resource system. Sewage-contaminated water is not only degraded water, it also represents potentially useful organic materials. Heat pollution from our powerplants might actually be utilized in a more effective waste processing system. An engineer faced with designing a system for processing wastes would like to have a cheap source of energy, while in another part of the same surburban area unutilized heat may be creating its own separate pollution problems.

An approach which looks at the overall pollution mix may well yield not only useful insights into improving environmental quality, it could lead to intrinsically valuable technological breakthroughs. I think it would be a disaster indeed to assume we are stuck with our present kinds and amounts of pollutants. We surely shouldn't expend scarce public funds to increase tolerances to today's stupidities. I think this would be the worst possible thing to do.

However, generating even more trauma in ecologically aware persons is this widely held nonsense that man and a veritable handful of domestic plants and animals are all that are essential to maintain the ecosystems that sustain us. If this were true, we could learn to love

pollution, we could breed our domestic plants and animals to resist pollution and evade forever the responsibility and the expense of halting our accelerating rate of pollution. A moment's reflection on Dr. Cole's earlier remarks clearly demonstrates that we don't have this option.

We cannot permit the demise of large numbers of the earth's essential, but poorly known organisms. This is just not a possible course of action. A rather spine-chilling observation in this regard is that no man and no group of men right now can tell us which of the creatures that are on this earth are necessary to continue in good health the systems that sustain us and those that inspire us. There is no way at this moment to figure out what the irreducible biota for our biosphere is.

Mr. DADDARIO. Does that lead us to the conclusion that they all are important?

Dr. CANTLON. In the absence of positive information it is safer and more comfortable to assume they can all play a role.

It is rather interesting to note that it now costs something to keep 30-odd whooping cranes from becoming extinct. At what point do we shift each additional species to a special jeopardized species list and assume the burden of preventing its extinction?

Chairman MILLER. You ought to take that off the record because you will have some conservationists in here who value the whooping crane.

Dr. CANTLON. I would be on their side. Don't misunderstand me. I am not opposed to conserving species. I think this is a highly pertinent operation, but it is an expense we need not have to bear. We should not permit species to be driven to so precarious a position.

Mr. DADDARIO. Any concern about the ones being killed off without our knowing anything about it?

Dr. CANTLON. Very much so. The very large bulk of the organisms in the soil are as yet unknown. We not only don't know which forms are there, we don't know what impact herbicides, insecticides and chemical fertilizers are having on them. Nor do we know what the impact of smoke, smog, and changes in plant cover will be. We don't know what is happening to the biota of the estuaries, the Continental Shelf and the ocean in rigorous detail. We have no clue, really.

Now to think that we could breed resistance to any sizable list of pollutants (Dr. Cole mentioned a list of a half million chemicals going into the sea)—imagine trying to breed resistance in any sizable number of species to a half million, or even 50 pollutants.

Mr. DADDARIO. Don't you develop resistance every time you ride up the Jersey Turnpike?

Dr. CANTLON. I don't know whether it is resistance or resilience.

Mr. DADDARIO. It is certainly not tolerance.

Dr. CANTLON. You are right.

Chairman MILLER. I am glad you used that and not George Brown's Los Angeles area.

Dr. CANTLON. It is obvious that this idea of breeding tolerance is patently absurd as a fundamental pollution strategy. I referred earlier to a case of a competent scientist advising such a course of action to a group of people addressing themselves to pollution and environmental quality problems. How can we explain having a man that well educated and that ignorant? This is really a worrisome thing because the

Congress, the Federal agencies, State and local governments are all seeking advice and they are getting mixed signals.

Mr. DADDARIO. Maybe he was just trying to stir people up, that is all.

Dr. CANTLON. He succeeded.

Chairman MILLER. Doctor, how are you going to do this when scientists themselves or people who are accepted in a discipline make mistakes, or make statements that you would expect a layman to make. I am a layman. During the war when food was scarce there was great pressure on us to increase the amount of fish that could be taken off the Pacific Coast and no less than a dean at the now University of California, at Davis—then the farm school—made a very dogmatic statement that you could produce so much food per acre on lands, you could produce so much food out of each acre of the ocean.

Do you agree with that?

Dr. CANTLON. It depends on the piece of ocean.

Chairman MILLER. That is it, but he didn't say that. It was just so many millions of acres of ocean and what we could take out of it. He knew more about that than perhaps a good fisherman.

Dr. COLE. This is why we are trying to tell you to come to the ecologists for advice.

Mr. DADDARIO. That is the point. We would like to know what the prescription is, rather than the warning about these things. How do we put it all in place? Do we have enough ecologists, and education? What is the program? What do you suggest?

Dr. CANTLON. Let me move ahead then since you are already aware of the need for improvement.

First of all let us look at public education, it is here I think we have to start. It is worthwhile noting that every State to my knowledge, requires that every student in the public schools be required to take a course that tells him how his Government works. These are courses in civics, American Government, or whatever. Most public school curricula also require, for example, either in physical education, hygiene, or other courses, instruction in how his own body works. These are essential things, but to my knowledge there isn't a single State in these United States that requires a course that instructs the student in how the systems that sustain him work—not one State. This is a rather remarkable thing, a glaring gap in a modern urbanite's education.

Now currently there is in operation around the country some attempts to instill a sort of conservation ecology in the grade schools and there are various kinds of training programs in this regard. While I think these are rather useful, I think that we may in fact be making another rather serious blunder.

If we are going to communicate to the urban dominated population of this country at the moment, we have to give him a systems view of his world and give him some comprehension of how this "complex machine" works that gives him his food and his water and removes his wastes. He doesn't get that. You can't give it to him by taking him out and showing him a beautiful, pristine brook or lake or waterfall or a forest. He has to learn it in terms of the system he knows, which is his home. There is no reason in the world why you couldn't instill a fairly adequate systems knowledge in a youngster in terms of how his home works, considering what it takes to sustain it. How much watershed, how much agricultural land, how much energy, transportation, oxygen, and so forth.

Maw bringing in the groceries is bringing in a quantity of energy. We have the tables for converting various produce to energy units. This could be a fairly adequate mathematics problem for the youngster learning his mathematics. The weight, energy and crude chemistry of his garbage and waste materials again could be calculated. How much water does it take to serve a family and how many square miles of watershed are necessary to guarantee this much water, etc.

We could incorporate such instruction from elementary level through high school and replace a fundamental flaw in our whole educational system. This flaw is the total absence of a systems look at the world in which he lives. This would be one of my first recommendations.

Now I think a second kind of thing that we need to seriously consider is deliberate stimulation of more research into the natural purification phenomena. There is a whole array of natural purification processes operating in our ecosystem; for example, atmospheric particle scrubbing, phosphorous uptake in streams, et cetera. It has been suggested (and I don't have the slightest clue as to whether this a valid, scientific assessment or not) that one might be able to scrub a large part of the smog out of the California airshed by artificially generating small thundershowers. If this can be done by some reasonably economical means, it might be cheaper to use atmospheric scrubbing rather than direct source removal. I don't suggest that this is wise; I use it as an illustration only.

We ought to know a great deal more about the biological uptake of inorganic nutrients by aquatic and terrestrial ecosystems. Here you have 2-billion-odd years of evolution which has been operating to favor organisms with elegant nutrient scrubbing capabilities. These species have lived in a world in which nutrients are scarce. They are microscopic systems that are self-generating and self-maintaining. I would defy any engineer to design a system that is self-generating, self-maintaining, minutely divided, and can run on solar energy. We ought to be exploiting these systems much more effectively than we are in abating pollution. It occurs to many of us that appropriate coupling of the need for green space, and processing of waste water could be explored. Southern California has already begun and many untried avenues beg exploration. Again, the gain comes from a systems view of the whole array of opportunities. What is waste in one context can in another be a valuable resource.

Thirdly, I would say that modeling and simulation of natural and manmade ecological systems ought to be greatly expanded and encouraged. Chairman Daddario mentioned this at the beginning and I am in complete agreement. We don't have enough data at the moment to do this adequately. Nevertheless some rather interesting and even startling first approximations have been made by Dr. Frederick Smith at Ann Arbor. He has been using the crude but best available data for computer simulation studies of stability in ecological systems. What happens when one species is reduced or doubled by an order of magnitude in these complex systems? The outcomes in the computer simulation were unpredicted by the ecologists who have been looking at these systems. We just don't know enough about them.

The International Biological Program may be one means of getting a better understanding of these complex systems. I think we could

enhance a very fundamental piece of this Nation's science and technology by supporting the U.S. contribution to the IBP.

We ought also to be thinking in terms of semidomestication of relatively complex microcosms. By microcosms I have in mind small arrays of multiple species such as the little terrarium we have probably all seen as youngsters in school. These microcosms have beautiful experimental properties, but more than that they have absolutely irreplacable bioassay capabilities.

We need to be able to predict what the systems outcome of a particular pollutant might be. Now, if one deals with pure cultures and makes a study of the behavior of one organism, it may not give you a clue about the behavior of a system of species. While no two systems behave the same a consistent effect of a pollutant on a range of bioassay microcosms could be useful in understanding more about pollution.

We ought really to be screening major parts of the world's genetic and ecological information for its potential in pollution abatement. The USDA has for many years operated a plant introduction center and an animal introduction center. They have been looking at a small fraction of the world's biological diversity with the idea of how you might eat it, wear it or enjoy looking at it. No one to my knowledge is seriously searching the world's biota to find a better species—or more likely—better species combination to crack the phosphorus problem before it destroys our lakes. We ought really to be exploring this sort of thing.

Now to return to the matter of advisers—and it's worth noting that you don't have anything like unbiased people sitting in front of you here today. We think ecologists have some useful things to say and we are delighted you have given us a chance to say some of them, but I think that a word of caution is due here.

Ecologists working alone don't provide a really useful advisory unit. The ecologists, the engineers, the economists, the sociologists and the political scientists together make the kind of body ultimately that you are going to need. Those of us who have been active in the Ecological Society have observed the creation of an environmentally oriented board or advisory committee that pronounced and evaluated programs in this area, but on which there wasn't one ecologically knowledgeable member. Prestigious, yes; intelligent, yes; ecologically educated, no.

Now I think that the idea of a Council of Ecological Advisers is one kind of way. I don't pretend to have thought this one through enough to know whether that is the best way to do it. This issue is really your realm anyway, not ours. It does seem to me that an interagency committee working alone is utterly ineffective for this type of need. I don't believe an interagency committee can in fact override the vested, long-entrenched interests of the respective individual Federal agencies. Interagency coordination is an absolutely essential partial ingredient, but by itself it cannot create and it can't really evaluate long-range merits between alternatives. So I would close by saying there are a number of avenues I think that we could move ahead on and I am very pleased to know you gentlemen are seriously considering it.

Thank you.

Mr. DADDARIO. You are very kind, Dr. Cantlon, to come and give us this statement. I hope we will have a chance to come back and ask you some questions.

I think we ought to proceed, however, with Dr. Sargent and Dr. Deevey.

Dr. SARGENT. I am chairman of the Human Ecology Committee, and in that capacity would say a few words about the area of human ecology. I am also a dean, so I hope you will be kind to me, Mr. Miller.

Chairman MILLER. Oh, I am very kind. Don't get me wrong, Doctor. I just tell you these things because sometimes even in the sacred white towers you need a little cleaning out. Maybe it is in some of those towers that the ecologists find most of its resistance rather than here.

Mr. DADDARIO. There are hardly any of those white towers left any more.

Dr. SARGENT. In Green Bay we just have a large field, in which someday there will be a university campus.

The area of human ecology has only recently been established within the ecological society but it has had a long tradition which has been rather stormy. I think the position that the current Committee on Human Ecology prefers to take is that really there is only one ecology; what we need to do is bring man back into the ecological thinking.

I think Dr. Cole's remarks emphasize that point of view. Man is a unique organism among the animals that inhabit the globe primarily because he has chosen a somewhat different way to adjust to his environment than other organisms. He has what we call culture. He can modify his environments. For a long time he modified his environment without much regard to the impact the modifications might be having. Now we are faced with a situation where his capability of capturing energy, molding and extracting from the landscape, and so on is producing effects which are harmful not only to him but to the whole living environment.

Our task in human ecology, within the context of the Ecological Society of America, is to bring the human component back into ecology. We are really dealing with one ecology and man's dependence on one terrestrial ecosystems, if you will.

The committee has posed several questions which are in line with John Cantlon's remarks. These are questions which we would like to deal with in a national conference for which we are currently seeking financial support. These questions would be of interest to you, I think, because they relate to the work of your subcommittee.

The first question is, Can systems analysis be used to solve the problems of urban integration? I don't pretend to know the answer to this question, but it does raise some intriguing possibilities.

The second question is, what insights into the use of resources can be derived from basic strategic processes of social and political behavior? The use of resources is largely determined by these behaviors and about them we need to have much more understanding.

What are the alternative strategies for managing the introduction of manmade substances into the biosphere? Here an example is the use of silver iodide in weather modification. Silver is a toxic substance. Not very much is known about biogeochemistry of silver. The evidence so far from measurements of silver in the environment resulting from cloud seeding is that it is at very low levels, but Dr. Charles Cooper of the University of Michigan and I have become concerned about whether or not silver might concentrate as it flows through the ecosystems in the same way that the DDT concentrates.

Somewhere along the line in an organism in the hierarchy of organisms from the primary producers up to the higher consumers, there will be a buildup of silver and a toxic level will be reached in the tissue.

Since so little is known about silver and its biogeochemistry, it would behoove us to look at this matter. How is silver managed in ecosystems? We are using it very extensively in cloud seeding operations at the present time. Of course this same concept applies to the question of biocides which Dr. Cole has covered quite adequately.

Another question is, What are the economic implications of environmental quality control via recycling of wastes and regulation of technological productivity? I think you dealt with this question in your report on "Environmental Pollution." This is an unanswered question that needs to be given serious consideration.

Still another question is, What are ecological implications of the quest to broaden man's resource base, for example, the quest for water and food? One of the programs aimed at broadening the water resource base is weather modification. In this context a high priority is modeling ecosystems. With mathematical models of ecosystems, one can experiment through the use of computers rather than actually manipulating natural processes. Dr. O. W. Roberts has stressed this viewpoint in a number of recent talks. It would be much less disastrous for man to examine the ecological consequences of weather modification by manipulating the meteorological factors in a mathematical model than to proceed empirically with intervention in natural processes.

In our quest to increase our capability to produce food, we introduced fertilizers and pesticides; these practices have produced problems such as those Dr. Cole has alluded to. We can look on agriculture really as dealing with manmade ecosystems. These ecosystems have to be managed by man and they have to be kept rather primitive so they will have maximum productivity. Because it did seem to be a major factor enhancing productivity, we have greatly augmented the nitrogen used as fertilizer. This material is now running off into our ground waters where it may lead to nitrate intoxication in those drinking the water. Eutrophication of streams and lakes is another end result of such wasteful use of fertilizers.

So these implications have to be looked at very carefully. One matter that has increasingly bothered me about the handling of the environmental quality problems is that we have fragmented our approach. Separate agencies, groups, boards, and committees tend to focus their attention only on water or only on land or only on air or only on the urban environment. Each is really a part of one system and I think in order to make an effective approach to these problems we have to work more closely together. The interactions among these various system components, as we understand from ecology, is very great. Therefore we need to focus our attack on environmental pollution more broadly more ecologically.

In your report of 1966, you urged that a way to attack these problems would be to create an effective consortium of government, industry, university, and community. My feeling here is that the university must play a stronger role than it has in the past. The ecological problems are truly exciting and they are as worthy of serious attention from scholars and students as the problems adopted by the so-called basic sciences.

Some would argue such ecological problems as I have in mind here as we have been discussing this morning, are in the province of applied science, that the responsibility of the university is to train young people in basic disciplines and basic sciences. I say this is a hollow argument for the tradition that has hallowed this position is that research is only basic when it is human activity pursued in the laboratory where conditions can be precisely regulated, variables isolated and causal relations among dependent and independent variables readily proven.

Reality is complex and causation stems from shifting multifactor configurations frequently acting over a long span of time. Because there is now little basic information on which to meet the solutions to these ecological problems, the scholars' attitude towards these problems must change and universities must shoulder the responsibility of leadership, move out of insular laboratories into the human environment and attack the problems for their own sake with as much vigor as they exhibit toward further probing the properties of matter or molecular basis of life.

It seems to me the type of natural area approach, for example, which Dr. Cole mentioned is an example of what I have in mind. The problem of the urban environment Dr. Cantlon mentioned is another aspect of this. We have tended in the universities to slide the responsibility for investigating these problems to institutes, to systems development corporations of one kind or another, and have said that our job is to train the student in basic science. I think the definition that we have here of basic science must be judged in its historical context.

We institutionalized science about 100 years ago and said anything that was done in the university was basic, and that which was done outside of the university in the real world was applied. Since man created this definition of basic science, I think we can change it. The universities have a major responsibility, their faculties must leave the insular laboratories and move into the field, into the real environments, and to train their students to handle the serious problems facing man.

Now is any university doing anything about this? Well, I am happy to say that this is exactly the program that we are attempting to develop at the University of Wisconsin, at Green Bay. This institution was established on March 10, 1967, when the board of regents approved the preliminary plan for its educational program. Just last week the Committee on Programs and Policies of the Coordinating Council on Higher Education of the State of Wisconsin approved our academic plan. I have a copy of this plan if you would like to see it. We hope that Thursday of this week the full council will approve the program visualized in this document.

(Note: the plan was approved on March 14.)

The objective of this new institution is to deal with these types of problems, to train our students in a problem-oriented way so that they will be more ecologically qualified and more ecologically sensitive to the very urgent matters that we have been discussing this morning. Now insofar as education is concerned, I feel that the decisions we make in the next three or four decades are the most important decisions that we as humans will make. It is a question of priorities here whether we should focus our attention on educating children or educating adults.The adults are the people who are really going to have

to deal with the problems that we now face. These environmental problems are sufficiently urgent so that they have to be grappled with effectively by the present adults. By such actions the children that we are bringing along will have an environment that is fit to live in.

I do not think, however, that we should neglect by any means the education of the children. I think John Cantlon's ideas are very exciting ones. I have been working with the Green Bay school system during the past few months. The staff has developed a title III grant application to establish what they call a wilderness laboratory in the vicinity of Green Bay to educate children from kindergarten through grade 12 in ecology and conservation. One of the difficult educational problems I have had is to broaden the perspective of the teachers who are manning this program.

They take the position, just as John said most do, that if you take the kids out and show them a nice woods, they will understand about ecology. I said: "Look, you have Green Bay and that is a good example of misuse of an environment resource. Let's understand something about how Green Bay got into its present condition." The proposal they have put forward I think is closer to what John has in mind than the original proposal that they submitted.

Dr. A. D. Hasler, of University of Wisconsin, has proposed that we develop ecological clinics in order to educate the public. These clinics could be sponsored by churches, service clubs, and resort owners. By this device we could make the public more ecologically perceptive. The community could then participate more intelligently and more willingly in the social decisions that must be taken to achieve the necessary environmental quality control.

I agree with you, sir, that the public is going to play a very important role in the policy decisions which you have to make and implement. Therefore it behooves us as educators to see that not only do we educate our children, but that we educate the public so that they can understand the type of legislation that is going to be required to solve these environmental quality problems.

Mr. DADDARIO. Thank you, Dr. Sargent.

Dr. Deevey, we are going to keep going and will try to give you as much time as we can.

Dr. DEEVEY. Thank you, Mr. Chairman.

(Biographical sketch of Dr. Edward S. Deevey is as follows:)

DR. EDWARD S. DEWEY

Professor of Biology; Born Albany, N.Y., 3 December 1914; B.A., Yale, 1934; Ph. D. (Zoology), Yale, 1938. Instructor in biology, Rice Institute, 1939–43. Research Associate, Woods Hole Oceanographic Institution, 1943–46. Assistant Professor, Associate Professor, Yale, 1946–; Professor, 1957–. Director, Geochronometric Laboratory, 1951–62. Guggenheim Fellow and Fulbright research scholar, Denmark, 1953–54; NSF Senior Postdoctoral Fellow, New Zealand, 1964–65. Zoological editor, Ecology, 1950–57. Co-editor, Radiocarbon, 1958–.

Publications: about 80 papers, in pollen stratigraphy, limnology, paleolimnology, biogeography, biogeochemistry, and general ecology.

## STATEMENT OF DR. EDWARD S. DEEVEY, SECTION HEAD, ENVIRONMENTAL SCIENCES AND BIOLOGY, NATIONAL SCIENCE FOUNDATION

Dr. DEEVEY. The statement I prepared covers a number of things and will take too long to read it; so, with your permission, I will touch a few of the high spots.

It describes in some detail the situation of research support for ecology as we in the National Science Foundation are in a position to see it.

I will preface this by pointing out that, although I am temporarily on official duty, I have been an ecologist for over 35 years and expect soon to return to academic life. To establish what kind of an ecologist I am, I have practiced limnology and paleolimnology, the study of lakes and the history of environment as recorded in lake mud, and I believe the term that best describes my long-term interest is historical ecology.

I indicated, I must confess, chiefly for Congressman Fulton's benefit, were he to be here, that I knew about eutrophication in 1938 and may have been possibly the first to introduce the word from the German language into English. I am mentioning these things because ecology is very hard to define and a forest ecologist or population biologist or environmental physiologist would probably give you a slightly different perspective. Those descriptions were not intended to apply specifically to Dr. Cantlon and Dr. Cole and Dr. Sargent, but in point of fact they come reasonably close. So I am a limnologist and will give you a slightly different perspective, but I think only slightly different, because ecology is concerned with complex living systems and all of these things are complex living systems.

I will first define ecology as the study of life in environment.

So much that is specifically human—sociology, social psychology, urban ecology, et cetera—is included in that definition, and so much that is also called environmental science could be included, that one rapidly draws more narrowly the limits of competence that ecologists draw for themselves. They are biologists and members of teaching departments of biology.

In that context they say they deal with the mutual relations between animals, plants, and their environment. They are concerned with physical properties of environment because they affect physiologies, but they usually place the emphasis on other animals and plants as the most relevant components of an organism's environment; but they also say at once that that subject as so defined is not the whole of ecology, it is environmental biology. Man has an ecology too, but ecologists do not always place man in the center of the picture. They don't claim to be expert in everything under the sun.

Skipping them a little bit about whether there is or is not a department of ecology on an American campus, I learned from Dr. Cole, this morning, that there is indeed one department of environmental biology. I was going to describe in some detail the research support program in the National Science Foundation especially within my program which is called environmental biology. We think we are in close touch with most of the leading practitioners and graduate teachers in the field because we support much of their research, but the de-

tails of this support—how many millions for this and that—I will rapidly pass over, unless you want to ask questions.

Mr. DADDARIO. Without going into the amounts spent, would it be helpful to, considering the growing importance of the subject, bring it together under a division of ecology? Do you believe that we are doing the right thing the way we are now by giving support in all of the related areas?

Dr. DEEVEY. I think some greater degree of centralization would be helpful, but I would not for a moment, sitting in the chair where I now do, advocate the consolidation of research support for all basic ecology into one central division, because too many genuinely important scientific problems would be created by doing that.

The present way is pretty good. It is not perfect. Some of us think that a section of environmental biology is, in fact, in operation now, although for various reasons including civil service constraints we don't quite call it that. The alternative you suggest, of taking this whole piece of environmental biology and incorporating it, for example, within the division of environmental science, which includes meteorology and oceanography, atmospheric science and Antarctic programs, et cetera, though it might help ecology, would remove its contact or potentially could remove its fundamental contact with other kinds of biology. The subject is so multidisciplinary that one has to think very carefully before launching an institutional reorganization of that sort because what you gain in one direction you may lose in another.

Mr. DADDARIO. It is because of this multidisciplinary characteristic that perhaps it ought to be in this institute that Dr. Cole is talking about.

Dr. DEEVEY. The National Institute of Ecology, as I conceive it, is quite a different affair from a National Science Foundation and basic research support. A national institute of ecology is large, but not so unmanageable that it fragments again the moment you try to pull it together. It focuses on environmental biology. It recognizes that you can not define the whole of the field that way, but it focuses on this and is intended as a step in several directions at once.

To enlarge the activity or the responsibility of environmental biology, by trying overnight to create some gigantic affair that includes the sociologists, the social psychologists and all the earth scientists too, this would seem—well, it may come in 25 years' time—it is hard to predict—but at the moment the cumbersomeness of such an organization would defeat its purpose, I would say.

One wants to start with what seems to be manageable, what seems to be "doable" and, what desperately needs doing.

Mr. DADDARIO. Well, it is something that needs to be analyzed. We are certainly not going to make a determination about it here and now.

Dr. CANTLON. I serve on the Advisory Committee of the Division of Environmental Sciences in the National Science Foundation, and if I might, I would request a clarification here, please?

Are you suggesting the NSF's Division of Environmental Sciences serve as the main ecological unit, or were you asking Dr. Deevey to react to a hypothetical model of a division of environmental sciences in which environmental biology is one of the components?

Mr. DADDARIO. I am not suggesting anything. I am trying to find out where it all fits in in order to come to some judgment about your recommendations. It seems to me that it does run counter to advice we have been given in the past about the creation of new institutions. When we made recommendations last year that the National Science Foundation ought to have the ability to do some work in the applied area, there was a hullabaloo about that as though these things should never get mixed together.

It seems that this is one of the problems. We always try to separate things, and because they seem to be unmanageable, not manage them.

Nothing is unmanageable providing we know what we want to do, how we want to do it and what resources we are willing to use to accomplish the task.

Dr. SARGENT. I am dean of the College of Environmental Sciences. Ecology in our academic plan is one of the environmental sciences. We have just gotten started. How it will work I do not yet know.

Mr. DADDARIO. I was just going to ask you, how is it doing?

Dr. SARGENT. I don't know yet. You can see in the document I have for you how our plan has developed. There is a tremendous national interest in what we are trying to do at Green Bay. Ecologists are very interested. The people I have interviewed for appointments at UWBG are not unhappy at this innovative context for ecology. Because of close intercollege relations, the ecologists will not be isolated from the biologists.

Mr. DADDARIO. We are extremely anxious to have an opportunity to look at the entire curriculum and discuss it. We weren't trying to get Dr. Deevey to spell this all out and put it in precise terms.

Dr. DEEVEY. If I might say so, sir, the kind of gigantic or, rather, total responsibility that I think you are trying to construct, and we all want very much to help you on, is a responsibility of the Federal Government at the topmost level. It is a superagency responsible for ecological and environmentally important programs and there are, I think, no action programs that are not environmentally important. But the instrumentalities by which we conduct research or support research in parts of this area need not, and I suspect probably should not ever be amalgamated to the extent that everybody, both the social scientist and the biologist and all are one. The working scientists don't do this. The Federal Government and the President's Office clearly must be able to process all of those kinds of information and many more in order to conduct this work.

We think scientists know pretty well what their limitations are. And ecologists have as many as other kinds. They have a certain view of the total system and it makes their advice exceptionally useful, but they are not to be charged with the responsibility for placing in operation all of the programs that follow from their advice.

Mr. DADDARIO. Not at all, Dr. Deevey. One of you four said this morning that it is our responsibility, as well as the Executive, to develop policy, but the fact still remains that we have to know in what kind of an atmosphere you can best accomplish your work. We do know that you can't put it in one compact ball. On the other hand, we know too that if you allow it to be proliferated you are not going to accomplish what you ought to do.

There is a need to get things done earlier rather than later. We certainly can't allow the scientists to go along as they have in the past and say, what difference does it make when it comes about.

This can come about 25 or 30 years from now.

In this area the answer needs to be developed sooner. We cannot wait before we at least begin putting things in motion to prevent the negative aspects from becoming more pronounced than they presently are. This is one of the reasons why organization is necessary. The problem is ours. But we need some guidance from you as to what tools you best need to do this particular job.

Dr. CANTLON. One comment in this vein:

It is conceivable that the model developed in the IGY and IQSY and is beginning to emerge in the IBP may actually be a more prudent model for certain of these kinds of operations. One would assume that if a concerted attack on a pollution question were successful, then that particular group ought not to live after it solved its problem. Indeed it should be restructured to solve the next priority problem.

Mr. DADDARIO. Should not be or should not be structured after it solves the problem.

Dr. CANTLON. The group should break up and a new one be restructured with different scientists around a different problem. You see my point is that it is conceivable that our existing model of government agencies may not be the best model for the kind of crash program that I think really is warranted in areas of environmental stress problems.

It is conceivable that what you need is a coordinating group that gets separate line item funding to address itself to one sort of phrasing of the problem. It could have a definite lifespan, the unit breaking up and dying automatically without ossifying and burdening the taxpayers in perpetuity. A new array might then be developed such that scarce talent continually reforms in a kaleidoscopic way around the particular problem to be solved. The universities, the national laboratories, and the pertinent Federal agency laboratories could be the talent reservoir. In a sense we have done this in wartime.

Maybe the sort of flicker we are seeing in these international cooperative scientific ventures is a suggestion of another way of doing it nationally without creating a new monstrous Federal agency to do it. Rather for any particular problem one or more of the Federal agencies might have some significant talent, which could be augmented from the body of talent that exists in the educational institutions and national laboratories. You should not remove too many scientists from their educational institutions or you dry up the source of the next generation of scientists in these areas. What we may want is a short lifetime problem-solving array that disappears when its problem reaches the level where it can be partitioned out to the pertinent action agencies for administering the selected courses of action.

Mr. DADDARIO. Dr. Deevey, you have been in this for a while. Do you go along with that?

Dr. DEEVEY. I think I do.

Mr. DADDARIO. Isn't that what we presently are doing? You don't see all of the development where programs are created and then almost before they get started they are just completely washed out. Mission-oriented laboratories, as an example, are presumed to end at the time

when they finish their mission objective, and some of them, in fact, do, but how about talents that we are developing?

I believe we develop a talent in our laboratories which is scarce in this country. This is the ability to take knowledge and apply it. These people learn certain things as they go along. They learn things not related to their mission objective which sometimes allows us to accomplish other programs and which sometimes is not even used as it ought to be because this is not their particular mission.

In many areas, this particular talent of taking different sets of facts, if they were given flexibility, might be a helpful asset.

Dr. CANTLON. I agree thoroughly with that. I couldn't endorse it more strongly.

Dr. DEEVEY. I was going to say there was one point I would disagree with Dr. Cantlon on, and that is the notion that the groups must automatically dissolve when the problems are solved.

Environmental problems won't go away, because slightly different, but related problems, will always exist, and the idea of the national institute is surely a permanent one.

Dr. COLE. Is the Rand Corp. the sort of model you are referring to?

Mr. DADDARIO. I am not thinking so much of the Rand Corp. I am thinking about how we can better utilize our great applied capabilities which have been developed in our national laboratories.

Dr. CANTLON. I would strongly endorse that. I was thinking of a place like Oak Ridge National Laboratory, which is now, in fact, developing a fair competence in pollution problems, and have, I believe, a major proposal before AEC.

No, my remarks were not intended to suggest we dispense with existing national laboratories. Rather, I feel that we shouldn't create a "pollution NASA," that is, one monstrous overriding new Federal agency for monitoring, for researching, for developing, and for enforcing in the area of environment.

Mr. DADDARIO. I look askance at the idea of developing new institutions. I do think that we have too much of a tendency to do this. Somewhere there might exist something which we can utilize better. One of the reasons we are holding these hearings is to get your view of how you are going to accomplish these programs. We are looking to the management of things.

Even though it isn't your job, you are working in them, especially you, Dr. Deevey. Therefore, we would like to ask you about it, because we can then come to a judgment as to whether or not we are in fact managing things as well as we ought.

Dr. DEEVEY. The National Center for Atmospheric Research has been described by one of my colleagues as NSF's outstanding creation, and I tend to subscribe to that. Several other programs have been sponsored by NSF, and one, at least, where there was major operating rather than research supporting activity was not, let us say, the most successful of the NSF's operations by a long shot.

Mr. DADDARIO. And you need not name it.

Dr. DEEVEY. The National Center is a good thing and it will be useful and instructive to study the relation between NSF and the National Center when it was first thought up, and to look at it now as it now exists. It is not NSF's operating arm in atmospheric science,

not at all. It is the universities', the science community's operating arm in atmospheric research. Nevertheless, there will be $12 million next year of NSF funds devoted to its program; that is, to supporting its research and providing much of its personnel.

Mr. DADDARIO. Do you include industrial participation in research activities because problems of pollution have their origin in industry? You don't mean to limit this Research Center to just the academic community, I would hope?

Dr. DEEVEY. No.

Mr. DADDARIO. I would hope that you in fact have strong participation by the industrial community because they are not only tremendously concerned, but consumer goods can be produced which can then motivate a great deal of other activity.

Then this is again a management question. How do you feel about it?

Dr. DEEVEY. The instrumentalities for managing large research schemes of this sort are still being developed, just as the idea of the consortium as a managerial device is undergoing rapid evolution. We, at this table, I am sure, do not pretend to be expert in managerial science. That is the kind of "ecology of ecologists" that goes well beyond our competence, but we are willing to help. We simply have some germ of an idea that an adequate managerial science can be developed pari passu with the breathtakingly large-scale, high-quality research on environment, because it must.

Dr. DARRARIO. Gentleman, we have to go to answer a quorum call.

I certainly appreciate your coming here and your cooperation. We have learned a great deal this morning.

(The prepared statement of Dr. Edward S. Deevey follows:)

(PREPARED STATEMENT OF DR. EDWARD S. DEEVEY, HEAD, ENVIRONMENTAL AND SYSTEMATIC BIOLOGY SECTION, DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES, NATIONAL SCIENCE FOUNDATION:)

Mr. Chairman and Members of the Subcommittee. I am Edward Deevey, Head of Environmental and Systematic Biology Section, National Science Foundation and am on leave of absence as Professor of Biology, Yale University. I am deeply honored by the invitation to speak to this subcommittee on the status of ecology as a science and as a profession. Although I am temporarily on official duty, I have been an ecologist for over thirty-five years and expect soon to return to academic life.

To establish what kind of ecologist I am, I have practiced limnology and paleolimnology—the study of lakes and the history of environment as recorded in lake mud—and I believe the term *historical ecology* best describes my long-term interests. Although I have not checked the history of the word, I suspect that I was the first to use the word *eutrophication* in English. I did not invent it. My science was mainly written in German when I was a student, in my doctoral thesis I simply translated *Eutrophierung*, something that seemed very academic at the time. I mention these points of reference, because ecology is rather hard to define, and a forest ecologist or a population biologist or an environmental physiologist would probably give you a slightly different perspective on his kind of ecology. But only slightly different, for ecology is concerned with complex living systems, and forests, populations, and lakes can all be thought of as living systems. Having mentioned *eutrophication*, however, I trust I shall not have occasion again this morning to use a word longer than four syllables.

Let me first try to define ecology. It is the study of life in environment. So much that is specifically human—sociology, social psychology, urban ecology, etc.—is included within this definition, and so much that is also called "environmental science" might also be included, that I hasten to draw more narrowly the limits of competence usually drawn by those who call themselves ecologists. As biologists

and members of teaching departments of biology, ecologists say that they deal with "the mutual relations between animals, plants, and their environment." That is, in studying environment, they are concerned with physical properties because they affect physiologies, but they usually place the emphasis on other animals and plants as the most *relevant* components of an organism's environment. But they also say that the subject as so defined is "environmental biology", and is not the whole of ecology. Man has an ecology too, but ecologists do not always place man in the center of the picture, and do not claim to be experts in everything under the sun.

I regret having to use so many words to define my subject, but any non-scientist who has heard of ecology and knows its importance is bound to ask, "Who are the ecologists? How may departments of ecology are there? How many students are being trained in ecology?" etc. And if I reply that so far as I know there is not a single "Department of Ecology" on any American campus, this non-scientist will suppose that professors are made, as usual. In fact a great deal of ecology is taught in most colleges and universities, but under so many names that it is almost impossible to describe the field for the university administrator or the Congress. A device that is being used on more and more campuses is an interdepartmental Institute of Environmental Studies, or some such coordinating program, and we know of at least 45 universities in which such institutes or faculty committees exist. At one university, where I spent last Saturday, an Institute of Ecological Planning is being created, with faculty positions for eight ecologists, who will be attached to the Department of Landscape Architecture.

Our program in the National Science Foundation is not called *ecology*, but *Environmental Biology*. We believe we are in close touch with most of the leading practitioners and graduate teachers in the field, because we support much of their research.

Our program will have awarded grants for Fiscal Year 1968 totaling about 6.4 million dollars to about 175 investigators, nearly all of whom are college teachers and many of whom have graduate research assistants—student trainees, that is—whose stipends and research expenses are carried on their research grants. The total number of active grants of this sort in our program is currently about 600. Our program is only one of ten in the Biological and Medical Sciences Division, which granted 54 million dollars in Fiscal Year 1967. Of this, Environmental Biology granted about 5.9 million for 170 projects, about a third of it for biological oceanography and limnology and about a tenth for studies of energy flow through ecosystems. Another 5.6 million was awarded to 220 projects in Systematic Biology, a different but related program which is of extreme importance to ecology as it is to all other kinds of biology. Another 4.6 million went to Facilities and Special Programs, which supports some ship operations, some museums, some marine and inland biological laboratories, and other relatively large centers or programs, a number of which are mainly devoted to environmental biology.

Outside the Division of Biological and Medical Sciences, much of what we can call ecology (which may include but does not emphasize the *biological* aspects of environment) is supported by the various programs in the Division of Environmental Sciences. We have particularly close relations, often involving joint funding of projects, with Programs in Meteorology, Geochemistry, Geology, Weather Modification, Oceanography, and with the Office of Antarctic Programs. Thus, when NSF was asked to describe its activities in pollution research by the Research Subcommittee of the FCST Committee on Environmental Quality (Dr. Buckley's subcommittee, of which I am a member), we were able to identify about 4 million dollars worth of research support (Fiscal Year 1967) as contributing more or less directly to understanding pollution, but of this amount less than half, or 1.9 million dollars, were provided within the BMS Division, nearly all the rest being from the Division of Environmental Sciences. The Foundation's contribution of basic research support was a part of that identified by Dr. Buckley's committee as "contributing to understanding of pollution but not deliberately undertaken because of pollution." Circulation studies in estuaries provide a good example.

Our 600 or so grantees in Environmental Biology are by no means the only people doing ecology. We of course think they are among the ablest of ecologists, but we have funds for only a fraction of the good proposals that we receive, and there are many other ecologists who do not come to our Program or to NSF for support. In fact our research support is only a fraction of that which we can identify elsewhere among granting agencies.

I might begin again to describe the size of the profession by noticing that there are approximately 3,500 members of the Ecological Society of America. Remember, though, that those ecologists who are not primarily trained in *biology* are in general not members of the Society. So we can start in still a different place. The Committee on Research in the Life Sciences, set up by the NAS–NRC, and responsible to COSPUP, has been investigating the state of biology, and although the results of their survey are still being analyzed, we have some preliminary figures given us by Dr. Herbert Pahl, Executive Secretary of the Committee. At one stage in the analysis, out of 10,657 biologists who took doctoral degrees, 737 or 6.9% took their most recent degree in ecology. However, when asked what research materials they had used in their most recent doctoral training, 553 of the same ten thousand biologists said they had made "ecosystem studies," but 2,004 or 18.8% of the total said they had studied "populations of organisms." This larger group would include population geneticists and evolutionists, but these too are at least "ecologically oriented." It is interesting to notice that out of about 8,000 biologists who answered a different question, one about their current and future interests, 800 intend to change their research field. Of these 800, 74 will direct their future interests into ecology, ecology being one of the 5 major fields receiving changes of this sort. When this and much other information about ecologists and their work has been tabulated, a panel headed by Dr. Arthur Hasler will study and report on it to the Academy's Committee on Science and Public Policy (COSPUP).

Now, because we in NSF have about 600 and the Academy knows of 700, it might seem that our program is supporting most of the 700-odd ecologists who identified themselves to the NAS–NRC Committee. That this is certainly *not* the case is shown by a different survey, conducted by a group of biometeorologists representing the American Meteorological Society and assisted by a small grant from our Program. This group first queried the Smithsonian Science Information Exchange for current (late 1966) research projects in ecology. A preliminary run shook out some 14,000 projects, which were then carefully scrutinized by a group of professional ecologists and reduced to about 2,800 that were clearly ecological. Nearly every one of these, in other words, might have been proposed to NSF, and if of very high quality would have competed for the 5.6 million dollars allocated by our Program that year. Dollar amounts for all of these projects were not available, but in the attached table, summarizing these projects by agency, we see that a large number of agencies are supporting ecology. Though Interior seems to be in the lead, Agriculture and AEC are probably the real leaders; most of the projects they are supporting had not yet had dollar amounts attached to them in SIE's system. Collectively, those with known dollar amounts attached, accounted for three times as much ecology that year as NSF did. Somewhat vaguely but not surprisingly, we end up with the conclusion that there are thousands of ecologists working at thousands of projects, but it is very difficult to know precisely how many there are because the number depends on how one definies an ecologist.

As we turn to the vitally important question of training and recruitment, we must notice first that "professional ecology", if represented by a PhD. degree in ecology, would not include a large number of true professionals in agricultural science, forestry, wildlife management, or earth science, who work for a variety of agencies, local, state, and federal as well as industrial, without having needed the PhD. degree. Let us also emphasize what should by now be very evident, that ecology is a highly multidisciplinary science, so that it is often an arbitrary matter whether one calls biometeorologists, limnologists, or geochemists "professional ecologists" or not. Society affiliation helps a little, but not much. If I may cite my own case as typical, I am a member of 15 professional societies; and if society affiliation were any criterion, I could describe myself as a "professional" anything from anthropologist to zoologist. I believe my own case is typical if a little extreme; that is the way ecology is, and its practitioners *must* keep contact with several different disciplines.

In trying to answer this subcommittee's questions, therefore, it seemed essential to probe a little into the multidisciplinary nature of ecologists' training. The Study Committee of the Ecological Society had already made a survey of the 20 leading universities that train most of the PhD. ecologists in the U.S., and had come up with the pitifully small number of 112 PhD. ecologists as an average annual production. The Committee then had second thoughts and recently issued another questionnaire, this time more an opinion survey than a fact-finding operation, but this time also asking the questions about training in a different way.

A copy of the questionnaire and its covering letter are attached, with a preliminary tabulation of the first 123 responses (out of the total of 168 inquiries). Though it is preliminary and though it is only an opinion survey, the results give a very different impression of the state of ecology as a subject in our universities. They indicate that the production rate is nearer to 3,000 than to 100 PhD. ecologists (and perhaps as many as 10,000 undergraduates) *if* one counts ecologists in the ways they themselves do. They also indicate that the numbers could be at least doubled, perhaps tripled, with no major reorganizations on campuses, if facilities, stipends, and administrative support were available.

Here I want to stress that these 168 campuses are *all in the United States.* Canadian universities were deliberately omitted, but I can assure you that ecology as a profession does not forget them. In any list of, say, 50 really distinguished ecologists in North America, about half will turn out to be Canadians, most of whom had their training in Canada. Several extremely strong Canadian universities draw not only many students but many faculty members from the U.S.

To summarize what I have said so far, ecology is represented by many more professional people than is sometimes thought, a relatively large body of recruits is being trained right now, and the teachers of ecology on our campuses believe that the number of recruits could be expanded by an average of 2½ times with no substantial organization changes. In addition, there is now clear evidence that intellectual talent can rather readily be recruited when ecological projects of scope and imagination require mobilization of such talent. In other words, ecology seems to us to be in a reasonably healthy state, and ready to respond to society's needs for understanding environments in depth and detail.

To say this, however, is not to say that nothing more needs to be done. A number of new organizations and institutional relations must be develped, and a great deal of hard ecological research must be done, before we can say, as Mr. Daddario would like us to say, that ecology has an adequately strong voice in public affairs or that ecological ideas are sufficiently diffused to decision makers at all levels. In speaking briefly to some of these new plans and institutional relations, I should make it clear that I am speaking mainly as an academic ecologist, not primarily as a representative of the National Science Foundation.

I should say first that ecological research, though very good, will not be truly excellent or adequately supported until substantially increased support is available for graduate students. "My field needs more money", as I am sure I am the first to say before Congressmen, but as the "project grant system" continues and expands support to match the increasing quality of projects in science, it is on graduate research training that I place my top priorities. Present ways of providing this training through the universities are not completely satisfactory, and ecological students are tending to get the short end of such support as is available.

The time has long since passed when the "ecologically oriented" graduate student was the cheapest kind to have, because all you had to do was give him a bicycle and bench in the museum, and great results would flow from his intensive study of the "biology" of two closely related sets of museum specimens. Three kinds of new technologies have been developed in the last few years, in geophysics (such as multispectral remote sensing), geochemistry (such as isotopic tracing), and computer science, that have transformed field ecology just as biochemistry has transformed laboratory biology. One result is that ecological graduate students are the most expensive rather than the least expensive kind. Not only does their training demand very expensive instruments, but the geographic dispersedness of the subject makes it in many cases essential to send them repeatedly and for long periods to the tropics, the arctic, and many other places beyond the reach of a bicycle. Hence, for adequate research training at the graduate level sharply increased support, much of it in the form of research traineeships, is essential. There is little reason to believe that NIH will consider this kind of biology sufficiently health-related to extend its magnificent training programs to include the whole of ecology.

As to the need for ecological research, I should make it clear that no thoughtful ecologist takes the position that society can do nothing about using its environment until 25 years' more research results have accumulated and "we really know what it is we are doing." Society can not wait that long, and will not. Ecology knows a great deal right now that is not being applied intelligently, and many of the answers decision makers seek are already available if mechanisms can be found for communicating them. In fact, if the basic ideas of ecology were as completely internalized by educated persons as are the basic ideas of economics (like "the market" and "benefit-cost ratios"), much of the

environmental deterioration we are all so concerned about might have been avoided before it started.

Nevertheless, ecology is only at the beginning of a new phase of discovery. An enormous amount of high-grade research needs to be done, and done quickly, before some of society's major questions about environment can be answered. What is coming to the fore is a concept of the ecosystem, and a wholly new set of procedures for studying ecosystems on a regional scale, so that the requisite research in many field projects must now be multidisciplinary in practice as well as in the library.

Much is now known about ecosystems, which range in scale from drops of water to 10-acre corn fields, and some extremely ingenious theories are available to account for the behavior of complex systems and to help model them so that their variations under experimental manipulation can be tested by the computer. These computer-simulation techniques are particularly helpful when dealing with forest stands, small lakes, estuaries, and so on which are too large to be experimentally manipulated in the usual ways. But the results of all such studies, however informative, cannot be extrapolated upward to larger patches of nature, containing more environmental and biological diversity (and especially those *containing* man and his artifacts), without loss of rigor and predictability. Ecology therefore needs to deal with systems on a large enough scale to be both meaningful and helpful, and it is for this kind of research that new modes of team work and multidisciplinary collaboration are being developed.

Some of the reasons for conducting team research on ecosystems have been spelled out in the Study Committee's plan for a national institute of ecology, on the pattern of the National Center of Atmospheric Research (NCAR). Personally I subscribe wholeheartedly to this idea. It seems to me the first really workable idea for bringing ecology to bear on major environmental problems that has appeared during my career. I recognize that it is not a panacea. "A *research* institute is not the only mechanism, or necessarily the best mechanism" for fulfilling *all* the responsibilities of ecology to public information, education and advice. Nevertheless, having talked a good deal with atmospheric scientists over many years and also during this year's term with the National Science Foundation, I am profoundly impressed by the appropriateness of the NCAR model and intend to do all I can to demonstrate its application to ecology. It seems to me there are very many points of similarity—procedural, educational, organizational, and motivational—between ecology as we see it now and atmospheric science as it was seen by a number of farsighted scientists 15 or so years ago. More than that I will not say just now, because I know that Dr. Cole will be discussing the Study Committee's plan with you this morning.

In urging the need for this new mechanism for conducting largescale team research on ecosystems, I do not want to be heard as insisting that ecology must abandon its older ways of doing things. Ecological research as conducted in hundreds of independent institutions by thousands of able scientists and their students is very good and getting better all the time. Scientists prize their intellectual independence, and that independence of inquiry must be preserved. There must always be room for the cantankerous or even misanthropic genius who will vigorously reject the idea that this research and teaching should be "programmed" by "those bureaucrats running that National Institute," or in fact programmed by any mind but his own. I say only that *some* kinds of ecology can *only* be done by well organized teams, that those kinds are among the most important as well as the most exciting kinds, and that some portion of the profession is ready and eager to conduct these kinds of ecology in the field.

Not being partial to being programmed myself, I have come rather slowly to this way of thinking. One of the main sources of my present conviction is the emerging U.S. portion of the International Biological Program, the portion that is now regarded as central and is called *Analysis of Ecosystems*. As this Subcommitee knows very well, the IBP has not sold itself equally vigorously in all quarters, and "friendly critics" have not been lacking who fear that the entire enterprise may be a gigantic boondoggle. Speaking now as an old Eagle Scout who knew what a boondoggle was before 1933, I assure you that IBP is not a boondoggle, that it is in many ways the most exciting program in natural science to appear since the IGY (International Geophysical Year), and that a very great deal of shaping, organization, scrutiny for high quality, etc., has taken place during the last few months within and around the U.S. IBP Committee.

To show where my own priorities lie within the framework of this program, and to stress the points that I think need stressing if the program is to appeal widely on its merits, I have drawn up a little statement about the IBP which is

attached to this testimony. Actually, it was prepared at the suggestion of Freeman Quimby of the Library of Congress staff, and as he has now seen it for the first time this morning and as almost no one else involved has yet seen it, I ask the indulgence of the Subcommittee in placing this preliminary draft on record.

Finally, let me comment briefly on some other ideas that are circulating that are intended to increase the effectiveness of ecology in public affairs. I have tried to make it clear that I believe that ecology will acquire an appropriate voice in public affairs when it deserves one as a consequence of being better science. Much of the talk we hear—and I have probably talked as much as anyone on such matters, is simply not effective because, as L. B. Slobodkin says, it "tends to substitute purpose for action". Slobodkin warns us about "the satisfying sense of being unable to take specific action because of a malicious, or at least uninformed, opponent or class of opponents".

I believe most ecologists would like very much to see such and advisory group as the proposed Council of Ecological Advisors or Council on Environmental Quality attached to the Executive Office of the President, providing genuinely informed advice on environmental programs in parallel to that given by the Council of Economic Advisors. Several bills providing such councils are now being considered by this Congress and this Subcommittee, and I think I should say very little about any one of them because I tend to favor them all rather indiscriminately but do not feel professionally qualified to argue the finer points of managerial science with advocates of one or another council.

In other words, ecologists, who are citizens first, are natural scientists second, and political scientists a very poor third, so that their role in advice-giving councils needs to be carefully delimited to the areas of their professional competence. By no means do I say that ecologists should not worry about such matters, for they must and will, but I suggest they will meet their political objectives faster if they get on with their own job of doing better ecology.

THE ECOLOGICAL SOCIETY OF AMERICA.

*To a Selected Group of U.S. Ecologists:*

We are sorry to inflict another questionnaire on you, but we think this one is important to you as an ecologist, and it won't take much of your time. Please read these questions with care, discuss your answers with others on your campus if you feel you need to, but return the questionnaire promptly, i.e. within a week. We will collect most answers by telephone, as we want 100 percent response, but if you take a little time to consider your answers first the telephone inquiry can be efficient as well as thorough.

The immediate purpose is to prepare ourselves for a congressional inquiry into the state of ecology as a profession. Representative Daddario's Subcommittee on Science, Research and Development is conducting a new series of hearings on environmental problems, and E. S. Deevey and I are invited to testify for ecologists. In a letter written during the last session, Mr. Daddario doubted that ecology is yet able "to become an umbrella science for greatly expanded research effort", but praised the Ecological Society's activities that "involve ecology in public affairs as well as the education of ecologists and the infusion of ecology in general education at all levels."

We find our own information about research training, is very deficient. The general surveys available (including the one now being assembled by the NAS/NRC Committee on the Life Sciences) do not adequately identify *ecology* as a separate subdivision of biology, owing to admixture with systematic, evolutionary, and physiological biology. Moreover, an outstanding property of ecological education is its interconvertibility; under certain circumstances—especially assuming the enlarged responsibilities Mr. Daddario is concerned about—meteorologists, geochemists, oceanographers, and behavioral biologists are all, or can easily become, ecologists, and economists, anthropoligists, and other kinds of social scientists should also be considered. Our questions are designed to probe into this interconvertibility. We hope that a quick survey will produce more meaningful estimates of the numbers of ecologists than a more highly organized and costly survey that fails to ask the right questions of the right people.

You have been selected, probably somewhat arbitrarily, to speak for ecology *on your campus.* Some of you are departmental chairmen, but our idea is to ask ecologists, not administrators. As a professional, you yourself exemplify the multidisciplinary aspect of the subject that we want to emphasize, and we cannot be sure that that is true of chairmen, deans, and registrars.

It will not be possible for you to be accurate in your assessment of which students are potential ecologists and which are not; the best approximation you can make is the one we want. Obviously, you will have most trouble when you look outside your own department. The best guideline we can think of to help you is *potential research collaboration and orientation.* If this student, with this kind of training is a potential collaborator with you and other ecologists, not necessarily in what you are doing now, but in any ecological project in which you might join, count him as an "ecologist".

We are interested in *current* numbers students being trained, and suggest the last five years as giving appropriate averages; but if dramatic reorganizations in your campus make the future training capacity look very different, use the next three years as the time-period for your average estimates.

Please give the matter some thought, return the questionnaire in the enclosed envelope, and be prepared for a telephone call in the next week or so.

Cordially,

LaMont Cole,
*Chairman, Study Committee.*

INSTITUTIONS WITH GRADUATE PROGRAMS

STUDY COMMITTEE, ECOLOGICAL SOCIETY OF AMERICA QUESTIONNAIRE: TRAINING OF ECOLOGISTS

[Numbers are estimates only. Your replies will de tabulated but not identified as yours]

| | Your department | Other biological departments [1] (how many?) | Earth science departments | Social science departments | Others if any [2] | Total |
|---|---|---|---|---|---|---|
| How many students are currently receiving training as ecologists on your campus? | | | | | | |
| Ph. D. level (not counting attrition; estimate average number of Ph. D.'s per year) | 743 (82) | 1,288 (50) | 201 (36) | 230 (20) | 110 (23) | 2,572 |
| Terminal MS level (average number of MS candidates who enter professional status without further academic training) | 636 (90) | 848 (54) | 160 (43) | 287 (26) | 134 (22) | 2,065 |
| Undergraduate majors (those who enter graduate or professional status in ecology on award of B.A. or B.S. degree) | 1,852 (79) | 2,374 (42) | 411 (37) | 1,408 (25) | 176 (20) | 6,221 |

[1] E.g., wildlife, fisheries, forestry, agriculture, botany, zoology, microbiology, physiology, biochemistry, biophysics, entomology, and oceanography.

[2] You may want to consider architecture, city planning, of even engineering.

Note: 105 institutions responded to this questionnaire.

*Check if applicable*

This institution has no graduate programs.

There are graduate programs but not in ecology.

Assuming no major reorganization or expansion, and assuming an adequate supply of eligible students, by what factor could these numbers be increased in the next five years? 1.0, 1.5, 2.0, etc.) *2.5 (14)*

Which *one* of the following is the major factor that may prevent such an increase?

1. Inadequate direct (stipend) support for ecology students, 9.
2. Inadequate facilities, including space, laboratories, and libraries, 14.
3. Inadequate or unbalanced faculty positions in ecology, 7.
4. Lack of vision or ecological orientation or part of administration, 7.
5. Supply of eligible students, contrary to assumption above, is not expansible on this campus, 6. (We're scraping the bottom of the intellectual barrel right now").

Is there on your campus a cross-departmental organization 'Institute or Center for Environmental Studies, degree program in ecology, oceanography, conservation, etc.) that coordinates ecological research and/or training?

1. No. 17.
2. No, and we won't have one if I can prevent it. 1.
3. No, but we are working on one. 10.
4. Yes, but it is largely on paper; i.e. a committee. 2.
5. Yes, but it is too new to appraise. 3.
6. Yes, and it is working reasonably well. 7.

INSTITUTIONS WITH NO GRADUATE PROGRAMS

STUDY COMMITTEE, ECOLOGICAL SOCIETY OF AMERICA QUESTIONNAIRE: TRAINING OF ECOLOGISTS

[Numbers are estimates only: Your replies will be tabulated but not identified as yours]

| | Your department | Other biological departments [1] (how many?) | Earth science departments | Social science departments | Others if any [2] | Total |
|---|---|---|---|---|---|---|
| How many students are currently receiving training as ecologists on your campus? | | | | | | |
| Ph. D. level (not counting attrition; estimate average number of Ph. D.'s per year) | | | | | | |
| Terminal MS level (average number of MS candidates who enter professional status without further academic training) | | | | | | |
| Undergraduate majors (those who enter graduate or professional status in ecology on award of BA or BS degree) | 209 (24) | 154 (15) | 22 (9) | 78 (7) | 3 (1) | 466 |

[1] E.g., wildlife, fisheries, forestry, agriculture, botany, zoology, microbiology, physiology, biochemistry, biophysics, entomology, and oceanography.

[2] You may want to consider architecture, city planning, or even engineering.

Note.—18 institutions responded to this questionnaire.

*Check if applicable*

This institution has no graduate programs. ☐

There are graduate programs but not in ecology. ☐

Assuming no major reorganization or expansion, and assuming an adequate supply of eligible students, by what factors could these numbers be increased in the next five years? (1.0, 1.5, 2.0, etc.) *2.74 (98)*

Which one of the following is the major factor that may prevent such an increase?

1. Inadequate direct (stipend) support for ecology students—42
2. Inadequate facilities, including space, laboratories, and libraries—43
3. Inadequate or unbalanced faculty positions in ecology—30
4. Lack of vision or ecological orientation on part of administration—14
5. Supply of eligible students, contrary to asumption above, is not expansible on this campus—15 ("we're scraping the bottom of the intellectual barrel right now")

Is there on your campus a cross-department organization (Institute or Center for Environmental Studies, degree program in ecology, oceanography, conservation, etc.) that coordinates ecological research and/or training?

1. No—14
2. No, and we won't have one if I can prevent it.
3. No, but we are working on one.—30
4. Yes, but it is largely on paper; i.e. a committee.—18
5. Yes, but it is too new to appraise.—20
6. Yes, and it is working reasonably well.—15

CURRENT SUPPORT FOR ECOLOGY (DECEMBER 1966)

SCIENCE INFORMATION EXCHANGE

[Prepared for American Meteorological Society Study Group on Bioclimatology]

| Supporting agencies | Number of grants without funds | Number of grants with funds | Amount of grants with funds |
|---|---|---|---|
| Agriculture, Department of | 868 | 92 | $1,065,586 |
| Alabama, State of | 7 | | |
| Alaska, State of | 1 | | |
| American Association for Advanced Science | | 2 | 203 |
| American Cancer Society | | 1 | 6,500 |
| American Philosophical Society | 1 | 1 | 1,000 |
| Airzona, University of | 3 | 2 | 7,000 |
| Arizona, State of | 5 | | |
| Arkansas, State of | 11 | | |
| Atomic Energy Commission | 72 | 28 | 1,007,561 |
| California, University of | 2 | 2 | 25,500 |

CURRENT SUPPORT FOR ECOLOGY (DECEMBER 1966)—Continued

| Supporting agencies | Number of grants without funds | Number of grants with funds | Amount of grants with funds |
|---|---|---|---|
| California, State of | 96 | 1 | $33,000 |
| Canada, Government of | 1 | | |
| Colorado, University of | 6 | | |
| Colorado, State of | 6 | | |
| Commerce, Department of | | 2 | 7,752 |
| Connecticut, State of | 1 | | |
| Delaware, State of | 1 | | |
| Florida, State of | 21 | | |
| Ford Foundation | 1 | | |
| Georgia Institute of Technology | 1 | | |
| Georgia, State of | 22 | | |
| Guggenheim, J. S., Memorial Foundation | 1 | | |
| Hawaii, State of | 10 | | |
| HEW PHS Bureau of Disease Prevention and Environmental Control | 1 | 25 | 674,992 |
| National Institutes of Health | | 67 | 1,682,433 |
| Idaho, State of | 9 | | |
| Illinois, State of | 6 | | |
| Indiana University | 1 | | |
| Indiana, State of | 22 | 1 | 18,000 |
| Interior, Department of | 109 | 704 | 4,324,028 |
| Iowa State University | 2 | | |
| Iowa, State of | 4 | | |
| Kansas, State of | 7 | | |
| Kent State University | 2 | | |
| Kentucky, State of | 5 | | |
| Louisiana, State of | 14 | 8 | 11,500 |
| Maine, State of | 1 | | |
| Maryland, University of | 1 | | |
| Maryland, State of | 3 | | |
| Minnesota, State of | 25 | | |
| Mississippi, State of | 7 | | |
| Missouri, University of | 2 | | |
| Missouri, State of | | 4 | 19,400 |
| Montana, State of | 6 | | |
| Montana, University of | 1 | | |
| National Audubon Society | | 1 | 5,000 |
| National Science Foundation | 1 | 202 | 3,237,188 |
| Nebraska, University of | 1 | | |
| Nebraska, State of | 5 | | |
| Nevada, State of | 1 | | |
| New Hampshire, State of | 2 | | |
| New Jersey, State of | 7 | | |
| New Mexico, State of | 8 | | |
| New York, State University of | 5 | | |
| New York, State of | 44 | | |
| No formal support | 1 | | |
| North Carolina, State of | 14 | | |
| North Dakota, State of | 2 | | |
| Ohio, State of | 10 | | |
| Oklahoma, State University | 2 | | |
| Oregon, State of | 46 | 6 | 69,000 |
| Pacific Northwest Power Co | | 1 | 24,000 |
| Pennsylvania, State of | 10 | | |
| Portland General Electric Co | | 2 | 31,500 |
| Puerto Rico, Commonwealth of | 3 | | |
| Purdue University | 1 | 1 | 1,500 |
| Research Corp | | 1 | 8,000 |
| Rhode Island, State of | 2 | | |
| Rockefeller Foundation | | 5 | 122,643 |
| Sigma Xi, Society of | | 10 | 3,850 |
| Smithsonian Institution | 6 | | |
| Social Science Research Council | 1 | | |
| South Carolina, State of | 6 | | |
| South Dakota, State of | 9 | 1 | 16,000 |
| Southern Illinois University | 1 | | |
| Tennessee Valley Authority | 1 | 3 | 25,000 |
| Texas A & M University | 1 | | |
| Texas, State of | 31 | | |
| Utah State University | 13 | 1 | 1,100 |
| Utah, State of | 7 | | |
| Veterans' Administration | 1 | | |
| Virginia Polytechnic Institute | 3 | | |
| Virginia, State of | 16 | | |
| Washington, State of | 8 | | |
| Wisconsin, State of | 13 | 2 | 13,568 |
| Wyoming, State of | 3 | | |
| **Total** | 1,650 | 1,176 | 12,442,804 |

## Why an International Biological Program?

For all animals and for man, today's material resources are tomorrow's garbage, and vice versa. Waste, therefore, does not exist. Living systems move matter around, into and out of many sources and sinks, but they do not create matter, or destroy it. Eventually, plants remake what we call resources out of what we call garbage. The energy they need to do this is captured from sunlight.

Most resources used by man are chemically reduced. Food, iron, and gasoline are examples. When they are used, oxygen is added to their molecules, and they gain weight. Therefore, the more resources are used, the faster the total weight of garbage increases. Fortunately, in turning oxidixed compounds that were garbage into reduced compounds that are resources, plants restore the oxygen to the atmosphere.

Human societies are now so large, so complex, and use resources so rapidly, that they are in danger of drowning in their garbage. The problem is inescapable; there is no rug under which it can be swept. All sinks are temporary; like cesspools, they have a way of becoming septic when overloaded. "Waste resources" have seriously polluted the Great Lakes, and even the ocean cannot process all the garbage it now receives.

Most men understand these matters in principle, to detail, nobody understands them well enough. Partly, this is because living systems are amazingly complex, and are turning out to be interlocked in unexpected ways. In addition, the pace of technological progress has intensified the need for understanding. Human ingenuity creates so many "new" resources, and they become garbage so quickly, that old ways of handling garbage can no longer be counted on. Meanwhile, the old familiar pollutants—silt in our reservoirs, manure on our farms, carbon and sulfur compounds in our air—pile up on an unprecedented scale, and overflow the sinks that used to contain them.

When garbage is smoothly converted to resources, we speak of a system's "output" as "production". When interruptions occur in the same systems, we call the pileups "pollution", and notice that "production" is declining. Pollution, then, is deflected production. It can be channelled or controlled, but as every material pollutant is a potential resource, none can be eliminated entirely. Pollution is the internal friction of productive systems, part of the cost of maintaining output.

The International Biological Program is devoted to understanding the biological basis of human welfare. Because it is an international research program operated in more than 60 countries, it emphasizes those kinds of biology that demand information from a global "field." These include human genetics and nutrition, human responses to stressful environments, transport of airborne spores and pathogens, colonization of islands and of disturbed environments, and other not yet fully formulated. None is more important than the one the US–IBP Committee has chosen as central: Analysis of Ecosystems. It is central because it focuses on man's central problem, as a dweller in environments: the relations, in depth and detail, between pollution and production.

Analysis of Ecosystems is not less international than other components of IBP. In the United States, however, it differs both in scope and in emphasis from its counterparts in other countries. In much of the world, where more food is man's paramount need, the emphasis logically falls on production. In the United States, as in other developed countries, production has been reasonably adequate, at least up to now, and the emphasis falls instead on pollution. In the ecological view, however, these problems are inseparable. Today's productive systems are always polluted in some sense; it is *intensified* pollution that short-circuits production, behaving exactly as a cancer in the system. The objective of Analysis of Ecosystems is to understand living systems well enough to recognize such cancers before they start.

Edward S. Deevey.

## Additional Views Submitted By Dr. John E. Cantlon

I should like to take as a point of departure a recent remark made in a body of scientific consultants. This group was examining a series of possible avenues that might yield useful approaches for meeting our burgeoning environmental problems. One scientist's remark brought the discussions to a climax.

"I keep hearing strong pleas for encouraging the investigation of natural purification phenomena, and of the need for more and better ways to halt increasing pollution. Why aren't we concentrating our scientific efforts on increasing tolerance to pollution?"

In a quick assessment of the matter this does indeed appear to be an oversight. Yet with some thoughtful reflection we can see that this rather widely held question is symptomatic of our past aimless drift of accelerating environmental degradation. It starts from two false premises: a) that the forms of pollution we now suffer under are essential and inescapable byproducts of modern industrial living, and b) that man and a very few domestic plants and animals are the only creatures on earth we need worry about.

Setting aside my strong moral and ethical reservations over the latter, let us consider the logic of these two premises.

It has been stated many times that pollution is really one or more resources out of place. Sewage-contaminated water is not only degraded water, it also represents potentially usable inorganic nutrients. Further the heat pollution from our power plants might with a bit of creative engineering be usable in one or more other phases of the water pollution problem. A systems look at the overall pollution mix could well yield real technological breakthroughs intrinsically useful quite apart from their improvements in environmental quality. We need to reach free of the narrow technological strait-jackets in which our current crop of problem solvers was trained. We need not tolerate existing pollution—we clearly should not expend scarce public funds to increase tolerances to today's stupidities.

Generating even more trauma in ecologically aware persons, however, is the widely-held nonsense that man and a veritable handful of domesticated plants and animals are all that are essential to the ecosystems that sustain man. If this were true *we* might learn to love pollution, breed our domesticants to resist it and evade forever the responsibility and expense of halting the accelleration in the fouling of our nest.

A moment's reflection suggests clearly that we cannot have the option of permitting the demise of large numbers of the earth's essential but poorly known organisms. A rather spine-chilling observation is that no man, no group of men, can tell us this moment how many of the earth's species constitute the irreducible minimum biota to keep our biosphere functioning and healthy. To think we could breed resistance to any list of pollutants in any significant number of these species—even if we knew which ones to select—is patently absurd.

How is it possible for otherwise knowledgeable scientists to be unaware of any hazard stemming from a pollution-stressed and pollution-reduced earth biota? Why are they so confident that no damage can be incurred to essential organisms such as N-fixing microbes? Largely, I suppose, it's the appearance of having gotten away with it up to now. They need to be cautioned, however of the rapidly shifting balance between man-generated systems of less than 30 years old, and ecological systems that have survived a valid test of time. There is a great deal of difference in the potential danger to the overall system of farms separated by fence rows and woodlots as opposed to blocks of hundreds of square miles containing a single variety of wheat and sustained by an ever-lengthening list of pesticides, the latter of which may escape to damage organisms at some distance from their point of application. Also, a lonely camper urinating behind a tree is a far cry from the chain of urban complexes utilizing the same river for sewage disposal, generator cooling, drinking water and allowing their urban pest control chemicals to move down the storm drains into the same river. We now approach a scale of operation that does indeed endanger other species. If we know they aren't now essential, and if we are certain we will *never* profit from the genetic information' they contain, we might justifiably swap our freedom to pollute against their loss. To permit extinctions unmonitored and in complete ignorance of the creature's genetic assets borders on lunacy.

How have we learned so much only to become so ignorant? Scientists and engineers are often more coldly willing to take the risks in such trades than an uneducated person. Something is drastically wrong with our priorities in education.

Many of us have noted with dismay that while our public schools *require* courses in how our governments function, in how our economy functions, and even in how the student's own body functions—none (to my knowledge) require courses focused on how the ecosystems that sustain society function. Couple this with the ever-increasing number of lifelong urbanites in our society and we get a hint of the educational displacement.

In my own opinion we ought to require elementary training in systems ecology for all of our high school graduates. We surely need it for our engineers, for all high school teachers, home economists, and the scientists in agriculture, industry and medicine.

However, let me emphasize that the ecologists don't have all the answers. They happened to have been the present custodians of what was left in the classical field of natural history after the taxonomists, geologists, engineers, chemists and physicists departed for their own reductionist worlds. By taking apart into smaller and smaller pieces their particular slice of old "Ma Nature", they have given us the glories of the scientific age, atomic energy, the DNA code, how to convert fossil plant debris into magic white fluid that propels a couple of tons of steel and rubber and one man across the landscape at a mile a minute—and the solid state electronics that led to modern computers. Meanwhile back in nature, the ecologists have profited from their reductionist brethren and began using isotopes to get at the transport systems showing how resources are transferred between species. They learned to utilize the computer to handle the vast scales and noisy world deliberately left behind by the ever more narrowly trained other scientists. They adopted the systems approaches developed by engineers, some of whom were learning the complex art of putting a man in a sealed life support system for interplanetary travel.

Now the ecologists—who a short 20 years ago nearly drummed out of their society those colleagues interested in man's problems—have come to realize that their left-over science is a pivoted science for man. Not all ecologists are happy about this. Many wish the engineer would learn enough ecology to stop making fools out of themselves and costing future generations untold misery from bad ecological judgment in unnecessary drainage projects, faulty waste disposal systems, air polluting combustion and processing systems etc. These ecologists like their fellow-scientists in other fields ask only to be left alone to do better ecology. If the lately discovered worth of their science leads more of the brighter young men to adopt it for a career, or leads congress in its wisdom to view with favor agency proposals for ecological training for the general public, they would be content.

Many of us, however, feel that the time is short, the number of adequately trained ecologists too small, the avenues likely to benefit from ecological contributions are too many to leave matters stand as they are now.

If sputnik jarred the United States into realizing Russia had slipped unheralded and unnoticed into first-rate scientific stature, perhaps our impending environmental flap could be the ecological equivalent. Crash programs are always wasteful, but unfortunately in our Madison Avenue conditioned society, they are more likely to derive public support than a calm steady growth. I trust this committee in its wisdom will find a suitable route. I would like to suggest the following:

1. Fundamental research on natural purification processes be encouraged to the extent that these fields will be in as favorable a position to draw scientific engineering talent as say the space program or internal medicine; e.g., (*a*) atmospheric particle scrubbing; (*b*) biological uptake of inorganic nutrients from aquatic systems; and (*c*) inorganic nutrient retention by terrestrial systems.

2. That modelling and computer simulation of natural and man-made systems be encouraged so that we may anticipate which components in such systems are apt to be most sensitive to pollution stresses and which most important to the natural purification processes.

3. Perfect micro-cosms of high complexity and reproducability for use in meaningful bioassay in pollution studies.

4. Initiate a program designed to examine the genetic and ecological information contained in the earth's ecosystems for potential uses in pollution control, a counterpart to the USDA's plant introduction program.

5. Consider the possibility of assisting in the birth of a national unit that could assemble problem solving arrays that do not live on after their problem is solved. One in which talent moves from problem to problem and back to the higher educational system both for helping keep the education systems tuned to current problems and for the renewal of talent. I think of the I.G.Y., and possibly the I.B.P. models, but the Weather Modification Commission and the NSF's participation it might also work. If the NSF had a separate major unit comparable to its present semi-separation of the Education Divisions from its Research Divisions, perhaps called Engineering and Applied Sciences, it might successfully undertake such a role. This unit, like the current Education Divisions, would use criteria beyond scientific merit in its decisions. Further, it should be given a charge to ellicit proposals from the best talent that can be interested in a problem the division chooses to pursue. Existing national laboratories and Industrial laboratories from the private sector should not be passed

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over if the academic science community lacks comparable problem-solving potential. Problems and approaches not yielding rewarding results after a reasonable time should be discontinued but certain long range research should be encouraged. The unit should not become the national monitoring agency for any environmental condition but might perfect techniques or engage in research necessary to establish whether such monitoring might be prudent. My personal view is that in most cases it should not create new national facilities except where a reasonable case is made that other agency goals preclude effective management of the necessary unit.

6. An inter-agency committee alone is quite sure not to perform a lead role in finding imaginative new aproaches to environmental problems, and is unlikely to be very effective even in controlling its member agencies' current bad practices.

7. Consider seriously the wisdom of setting up a council of ecological advisors for the executive branch of government, as has been proposed by several bills over the past year or so. A word of caution here. Advisory boards are only as good as the people on them. Several bodies concerned about the environment have appointed panels of prestigious scientists, engineers and administrators, none of whom had a clue as to how an ecosystem functioned—some were even unaware of the term. One would hope that ecologists would have an opportunity to make an input to such a potentially important function.

## EXECUTIVE OFFICE STUDY

(THE FOLLOWING STUDY WAS FURNISHED TO THE SUBCOMMITTEE SUBSEQUENT TO ITS HEARINGS ON ENVIRONMENTAL QUALITY)

### EXECUTIVE OFFICE OF THE PRESIDENT, OFFICE OF SCIENCE AND TECHNOLOGY

MARCH 1968.

The attached report was prepared in response to a request by the President to the Directors of the Office of Science and Technology and the Bureau of the Budget to recommend how the Federal Government may best direct its efforts toward advancing scientific understanding of natural plant and animal communities and the ways in which they are influenced by man and his activities.

This report emphasizes the need to conserve and to increase our understanding of our unspoiled wildlands—forests, grasslands, deserts, streams, and lakes.

The report proposes

setting aside on Federal lands additional natural preserves for scientific purposes, and

conducting surveys and research so that we will understand better the impact of environmental changes.

Additional information is available from Dr. Donald R. King, Executive Office of the President, Office of Science and Technology, Executive Office Building, Washington, D.C. 20506; 395–3516.

DONALD F. HORNIG, *Director.*

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF SCIENCE AND TECHNOLOGY,
*Washington, D.C., January 24, 1968.*

Memorandum for the President.

Subject: Advancing scientific understanding of natural plant and animal communities.

At the time of your February 1965 Message to Congress on Natural Beauty, you instructed the Directors of the Office of Science and Technology and the Bureau of the Budget to recommend how the Federal Government may best direct its efforts toward advancing scientific understanding of natural plant and animal communities and their interactions with man and his activities.

Our review indicates that no one agency now has or should have exclusive jurisdiction in this area. Ten agencies are now carrying on activities—as an essential part of their respective missions—that are related to scentific understanding of natural plant and animal communities or "wild lands" which include forests, grass lands, deserts, swamp lands, alpine regions, lakes and streams,

marine systems, and small semiwild areas within cultivated lands. Understanding of these areas is an integral part of the *total* effort to understand the complex interrelationship among living things and the interactions between them and their physical environment. This is the science of "ecology."

Coordination and communication among agencies and with the general scientific community is needed to assure that essential work is carried on, and undesirable duplication is avoided.

*We recommend* that

the Office of Science and Technology assume responsibility for maintaining overview of this area and

assure necessary coordination among agencies and with the science community.

The Office of Science and Technology staff can call on such groups as committees of the Federal Council for Science and Technology, panels of the President's Science Advisory Committee, professional societies, and the academic community—for advice and assistance.

The above conclusions are based in part on the recommendations of a panel of experts from Federal agencies assembled by the Office of Science and Technology. The panel made recommendations dealing substantively with areas of potential action and with the question of how the Federal Government may best direct its efforts related to the understanding of natural communities. A report based on the panel's findings is attached. The report recommends:

designation of additional protected natural areas for scientific purposes;

expansion of research, including cooperative studies of a limited number of large ecological systems;

expansion of monitoring and survey programs to measure the impact of environmental changes; and

improvement of ecologically-oriented training and education programs.

We believe the recommendations require close attention by the concerned agencies. We plan to make the report available so that agencies may review their programs in light of the recommendations, and consider how they might emphasize and reorient activities that contribute to advancing our understanding of natural plant and animal communities and their interactions with man and his activities.

The Bureau of the Budget makes no recommendations for the commitment of funds for new programs. Such decisions can be made only after careful consideration of agency proposals within the context of fiscal policy prevailing at the time.

CHARLES L. SCHULTZE,
*Director, Bureau of the Budget.*
DONALD F. HORNIG,
*Director, Office of Science and Technology.*

## ADVANCING SCIENTIFIC UNDERSTANDING OF NATURAL COMMUNITIES

In his message to Congress on Natural Beauty on February 8, 1965, President Johnson asked the Directors of the Office of Science and Technology and the Bureau of the Budget to recommend *how the Federal Government may best direct its efforts toward advancing scientific understanding of natural plant and animal communities and their interactions with man and his activities.*

Natural plant and animal communities are important in rendering material services indispensable to the welfare of man as well as in satisfying aesthetic and recreational needs. They are the least modified ecological[1] systems. They constitute the so-called "wildlands," and include forest, grasslands, marine systems and small semi-wild areas within cultivated lands. The condition and productivity of these natural systems are highly relevant to all segments of human society. The production of food from the sea, food and other products from livestock on natural grasslands, timber from forests, and wildlife for recreation; the regulation of water run-off and maintenance of domestic water supplies; and

[1] Ecology is the science concerned with the interrelationships among living things and the interactions between them and their physical environment. Thus, ecology involves the interrelationships of biology and the environmental sciences such as meteorology, geology, and hydrology. Applied ecology includes practices of forestry, agriculture, the conservation of desirable nondomestic plants and animals and the control of undesirable life forms.

the cleansing of air are examples of direct benefits of human society. On a larger scale, natural communities play an important role in removing carbon dioxide and releasing oxygen on land, in freshwaters and in the oceans.

Natural communities are part of the very complex environment in which man lives—one in which so many factors are interrelated and inter-dependent that it is often difficult to determine what is cause and what is effect. The problem man faces is how to cope with this tangled web and extract the resources needed for his welfare without impairing the system that sustains him.

It is difficult, if not impossible, to divorce the need for programs pertaining to natural communities from the total effort in ecology. Accordingly, this report treats natural communities in the context of a broader ecological effort.

The first section of the report describes activities that are needed to advance scientific understanding of natural plant and animal communities and their interactions with man. It also describes needs for protected natural areas for continuing study; and national needs for research, surveys, and education. Current activities of federal agencies are discussed in the second section. A third section includes specific recommendations for action by the Federal Government.

## I. FINDINGS AND NATIONAL CENTER NEEDS

Recent increases in the human population and advances in technology have resulted in an increasing number of environmental changes. A considerable body of knowledge of ecological relationships has been developed and constructively brought to bear on optimizing these changes. Too often, however, there is inadequate information about them to develop comprehensive judgments regarding the full extent and manner in which they are advantageous or detrimental and some of the changes are clearly unfavorable. Also, conflicts frequently arise among man's multitude of purposes. These conflicts demand an increasing amount of knowledge to provide the basis for sound decisions; e.g., decisions to whether areas of land should best be used for economic or aesthetic purposes, the extent and form in which pollutants may be introduced into the environment, and the extent and procedures by which the weather may be modified without unfavorably influencing the environment.

Much is already known, of course, about natural communities; some of it learned in studies of other environments, some in response to urgent practical needs and a goodly share gathered in response to purely scientific curiosity. But there remains a need to more fully understand the contributions these areas can and do make to the national welfare.

The following discussions outline the specific national needs for improving our scientific understanding of natural communities.

### *Protected Research Natural Areas*

In ecological studies of natural plant and animal communities, field areas are needed as outdoor laboratories. A series of land and water research reserves—established in such a fashion as to provide protection for extended periods of time—is essential. The series should include examples of all important natural ecosystems, some available only for observation; others for manipulation. A joint effort by the Department of Agriculture and the Department of Interior (with AEC and Department of Defense cooperation) has already resulted in designation on Federal Lands of 336 areas that are available for observational studies. Additional locations will be needed to obtain representation of all ecological types.

### *Research*

More research on environmental matters is needed. In the United States this is not primarily because new problems have arisen, though there are many, but because of the new, enlarged scale on which the old problems—subsistence, health, and the adjustment of population to resources—must now be faced. For example, sulfur bacteria and other decomposers play a role in the economy of nature that is now only dimly sensed; interference with it was inconceivable a generation ago. The oxygen content of the atmosphere, on which all human and animal life depends, is probably regulated by the combined activities of sulfur bacteria and green plants, neither being more important than the other. But the bacterial fraction, being less understood, is more open to disastrous interference by some environmental pollutant.

As previously indicated, we need to improve our understanding of the processes by which natural plant and animal communities survive and change and interact with man. Not only does optimum management of natural communities depend upon such knowledge, but also management of cultivated lands and fisheries can be improved by such understanding. Scientific team efforts are required to answer many of the important ecological questions. Research by biologists, physical and social scientists, and engineers at many locations is needed to develop improved methods and practices which will assure protection and proper utilization of natural communities.

Research principally in universities, the Federal Government and private foundations has contributed much to current understanding of natural systems, but in terms of foreseeable needs our knowledge must be greatly increased.

Studies conducted or sponsored by many government agencies are mainly directly at "economic species"—those most directly useful or harmful to man. These studies fall short of telling us what happens to the innumerable other species involved in biologically indispensable functions.

Understanding of biological processes at the individual, species, population, community, and ecosystem levels of integration is basic to their manipulation in man's best interests. Federal agencies should consider (1) increasing their ecologically oriented research activities along the lines of their specialties; (2) developing a concerted integration of effort among the agencies; and (3) lending their strong support, professional talent, and other resources in interorganizational efforts with universities, private corporations, and state agencies in the advancement of scientific understanding of natural communities. The general objectives of a needed research effort are described by four general headings.

*Fundamental processes operating in and affecting plant and animal communities.*—There is need for an improved understanding of the fundamental structure and the processes of natural communities which govern the development, size and fluctuations of their plant and animal populations. Additional information is needed about the mechanisms that control energy flow and organic matter production in plant and animal communities. There is also need for studies on the effects of natural and man caused influences on the condition and functions of these communities.

The information obtained would be useful in (a) maintaining the diversity and stability of natural communities; (b) predicting the influence of environmental alterations; (c) deriving principles useful in crop, domestic animal and fish production, and (d) arriving at optimum management techniques for most effective utilization of our wildlands.

*Impact of plant and animal communities on man.*—Additional information is needed about the role of natural areas in maintaining the equilibrium of the earth environment, and toward improving our understanding of the indispensable services rendered to man by the natural biota. Examples of such services are the uptake of carbon dioxide and the release of oxygen by plants, and the cycling of water and essential mineral nutrients.

There is also a need for studies of natural communities to determine their role in harboring organisms harmful to man and to identify plant and animal species which may have potential usefulness for him.

Natural areas are also major sources of recreational aesthetic enjoyment. Additional information is needed to determine how opportunities for public use of these areas can be enhanced, while their beauty and utility are retained.

*Impact of man on plant and animal communities.*—Improved understanding is needed of the purposeful and inadvertent modifications of natural communities caused by human activities. Our society is increasingly the source of major stresses on natural communities. It is imperative that we gain understanding which will enable us to protect, utilize and enjoy these areas.

Research is needed to find ways to alleviate or rectify any undesirable consequences of environmental alteration resulting from such things as weather modification, industrial and agricultural practices and waste disposal. Some innovations could be mutually beneficial to man and natural communities.

*Methodology, instrumentation, and taxonomy.*—Better techniques are needed to enable more accurate observation and sampling of organisms under various environmental conditions. Improved systems and instrumentation for sampling and analysis of biological, chemical, and physical processes in natural environments are also required.

Accurate taxonomy and descriptive ecology are essential foundations for ecological investigations, for other types of biological research, and for bioenviron-

mental surveillance. Detailed life histories are known for a relatively small proportion of the species of organisms even among those which are of direct importance to man. Several taxonomic specialists may be required for a single ecological study requiring identification of a large number of species.

*Surveys*

Comprehensive data are needed about the nature, frequency of occurrence and geographic distribution of living things and other environmental components comprising natural communities.

*Broad scale studies.*—Additional and more complete information is needed for national and regional inventories and descriptions of such things as soil, water, fish, wildlife, timber, range grasses and other vegetation. Several of these subjects for surveys are primarily found in natural areas or have their chief origins in them.

*Localized benchmark studies.*—Comprehensive documentation of the nature, abundance, distribution, diversity and condition of the components in a limited number of representative areas is needed to provide points of departure for measuring future changes in natural communities. Data from detailed benchmark studies provide a basis for further programs in research and monitoring and comprise an inventory of the related factors in a functioning natural system. From the standpoint of research they are points of departure for studies ranging from such basic aspects as measurement of energy flow within undisturbed natural systems, to providing a basis for assessing the long term effects of environmental manipulation e.g. existing weather modification programs. As an essential prerequisite for monitoring, benchmark information is the "ground truth" with which the impact of expected or unanticipated environmental changes can be compared.

*Monitoring.*—Monitoring of all relevant biological and environmental components of representative natural community areas is needed. Work should be conducted in both undisturbed and modified areas. Favorable and unfavorable changes should be noted over time and trends identified. Additional information is needed about the effects and duration of natural biologically—and environmentally—induced changes in plant and animal communities and man-induced changes resulting from management practices and other activities.

Information from monitoring has great utility in research to assess cause and effect relationships for changes in nautral communities.

*Education*

As we recognize new and growing environmental problems associated with our rapidly advancing technological society, it is clear that there is a shortage of "ecologically oriented" scientists concerned with understanding natural ecological systems.

Ecology, more than most fields, depends on people trained in a wide variety of sciences, but trained to be conscious of interfaces.

Well-educated scientists are urgently needed in vegetation science, the dynamics of animal populations (from insects to whales), and ecosystem oriented ecology. Highly trained technicians are required to support research scientists. Much emphasis in the biological sciences in recent years has been placed on the molecular level, but the higher levels of biological integration have been seriously neglected. It is now recognized by the scientific community and society that one of the significant needs of our time is for scientific understanding at these higher levels, including the organization of human societies and their total environment. The understanding of natural plant and animal communities is a part of the knowledge required.

The need for an increased educational effort extends from kindergarten to the graduate level. An appreciation of nature is highly important to successful careers dealing with natural communities, and this element is acquired largely through early experience in the development of an individual. While the major need is for higher education, the elementary and secondary levels cannot be neglected.

## II. ACTIVITIES OF FEDERAL AGENCIES

This report includes information about the types and levels of Federal activities contributing to understanding natural plant and animal communities. Most government agencies are concerned in some sense with man-in-environment, and there are few if any aspects of society and culture that cannot be described as ecological by someone. A rigorous attempt was made to confine the inquiry to wildlands, to biological and closely related physical science, to native or indigenous species, and to natural rather than artificial systems. Environmental programs largely or solely concerned with the physical or the social environment were excluded at the outset. So were activities related only to intensively managed or man-created environments, such as cultivated fields and urban areas. But much work carried on in such areas is directed to fundamental ecological processes, and the results can be and are being extrapolated to natural communities.

It is likely that agencies, in responding to the inquiries, interpreted the "ecological" aspects of their missions rather generously. Some subjective judgments also are inherent in interpreting and categorizing the responses, implying that a general, rather than literal, assessment of the data is appropriate. At any rate, by almost anyone's definition, ten [2] agencies of the Federal Government support work that contributes to the understanding of natural plant and animal communities and their interactions with man. And, under their interpretation of what that understanding requires, the total expenditures in this area were about $162,422,000 during FY 1965 and $175,355,000 during 1966.

The major share of these expenditures was on research concentrated on individual species of plants or animals, or populations of these species, and on surveys which provide data about how much of what is where. The species studied were largely those that are pests of man or that he uses directly for food, or fiber, or recreation. Much of the knowledge gained from such studies is useful in understanding natural plant and animal communities, and some of it would in fact have to be gathered specifically for this purpose, were it not otherwise available. A relatively small amount of effort was devoted to plant and animal *communities* and even less to studies of whole *ecosystems*. Studies of ecosystem functioning, however, are central to understanding the iterrelationships of man and natural plant and animal communities. Such studies have received very little support.

Federal support for higher education related to the study of natural communities comprised a relatively small proportion of the expenditures reported.

The distribution of expenditures among topics and agencies is summarized in Table 1. About 74 percent of the total fund support was used for research and related activities. Surveys of soils, forests, range land, hydrologic conditions and animal populations accounted for an additional 23 percent. The remaining 3 percent was used for education and training. The distribution of expenditures was as follows:

| Fiscal year | Intramural | Extramural grants and contracts | Higher education |
|---|---|---|---|
| 1965 | $106,508,000 | $51,985,000 | $3,929,000 |
| 1966 | 115,649,000 | 55,269,000 | 4,437,000 |

[2] The Bureau of Public Roads which was under the Department of Commerce when agency activities were surveyed is now a part of the Department of Transportation.

TABLE 1. FEDERAL GOVERNMENT ACTIVITIES FOR THE ADVANCEMENT OF SCIENTIFIC UNDERSTANDING OF NATURAL COMMUNITIES AND THEIR INTERACTIONS WITH MAN—PROGRAM EXPENDITURES BY AGENCY IN FISCAL YEAR 1965

[In thousands of dollars]

| Agency[1] | Ecological research | | | | | Surveys education | | Total |
|---|---|---|---|---|---|---|---|---|
| | Health, pollution, and pest control | Production of food, fiber, lumber, and industrial products | Taxonomy and other support | Soil and water conservation | Non-domesticated plants and animals | | | |
| USDA | $4,660 | $11,770 | $2,859 | $17,143 | $3,223 | $28,735 | ---- | $68,390 |
| Int. | 2,954 | 15,478 | 735 | 745 | 4,262 | 8,680 | $197 | 33,051 |
| HEW[2] | 18,817 | ---- | 3,045 | 2,105 | 1,045 | 1,064 | 1,014 | 27,090 |
| NSF | 375 | 235 | 6,178 | 30 | 6,676 | 141 | 2,610 | 16,245 |
| AEC | 5,144 | ---- | 1,613 | 196 | 2,478 | 255 | 108 | 9,794 |
| Smithsonian | ---- | ---- | 4,302 | ---- | 362 | ---- | ---- | 4,664 |
| DOD | 1,188 | 25 | ---- | ---- | 572 | 60 | ---- | 1,845 |
| NASA | ---- | ---- | 1,100 | ---- | ---- | 90 | ---- | 1,190 |
| Comm. | 32 | 121 | ---- | ---- | ---- | ---- | ---- | 153 |
| Subtotal | 33,170 | 27,629 | 19,832 | 20,219 | 18,618 | ---- | ---- | ---- |
| Total | ---- | ---- | 119,468 | ---- | ---- | 39,025 | 3,929 | ---- |
| Grand total | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 162,420 |

[1] USDA equals Department of Agriculture; Int. equals Department of the Interior; HEW equals Department of Health, Education, and Welfare; Comm. equals Department of Commerce; NSF equals National Science Foundation; AEC equals Atomic Energy Commission; DOD equals Department of Defense; NASA equals National Aeronautics and Space Administration.

[2] Includes programs of the Federal Water Pollution Control Administration, which was transferred to the Department of the Interior on May 10, 1966.

Federally supported *research on or applicable to* natural plant and animal communities is briefly documented under five headings in this report. These efforts to increase scientific understanding of natural plant and animal communities were supported by a total of about $120,000,000 of Federal funds in FY 1965. This research was conducted or otherwise supported at many locations. It involved participation by scientists in many disciplines.

*Health, Pollution and Pest Control.*—Atomic Energy Commission; Department of Commerce; Department of Agriculture; Department of Defense; Department of Health, Education, and Welfare; Department of the Interior; National Science Foundation; Smithsonian Institution.

Studies of the effects of environmental factors on the natural history of diseases and their hosts and vectors are among activities under this heading. Others relate to studies of the effects of soil, water and air pollutants such as radionuclides and exotic chemicals; bionomics of pests and disease carrying organisms; and pesticidal, biological, and other means of control of pests, weeds and undesirable brush. About $32,000,000 was expended for such research in FY 1965.

*Production of Foods, Fiber, Lumber and Industrial Products.*—Department of Agriculture, Department of Defense, Department of Commerce, Department of the Interior, National Science Foundation.

Trees, shrubs, grasses, other ground flora, livestock, game, fish and shellfish found in natural communities are the sources of many products useful to man. Ecological aspects of research to understand and manipulate life processes, improve biological efficiency and quality of product, understand and control environment phenomona and develop more effective management and husbandry methods involved the expenditure of about $27,600,000 in FY 1965.

*Taxonomy and Other Support Activities.*—Atomic Energy Commission; Department of Agriculture; Department of Health, Education, and Welfare; Department of the Interior; National Aeronautics and Space Administration; National Science Foundation; Smithsonian Institution.

Biosystematic studies are conducted on animals, fish, insects, plants, and shellfish. These seek to define and catalogue species and genera and variations within and among them. In addition to identifying distinguishing morphologic characters, differences in reproduction, processes and compatibilities, life histories, physiologic responses, metabolic processes, feeding methods and geographic distribution are also recorded.

Studies of micrometeorology and remote sensing of biological and physical conditions and phenomona; the development and improvement of bioinstrumentation; and Antarctic experimentation are examples of other support activities related to advancing our understanding of natural plant and animal communities. About $19,800,000 was expended in this area in FY 1965.

*Soil and Water Conservation.*—Atomic Energy Commission, Department of Agriculture, Department of the Interior.

The soil and water components of natural communities are vital to plants and animals that live there. Information about ways to maintain and improve their quality and productivity are sought in field and laboratory research. Studies of soil composition, structure and texture; and water source, composition, distribution, and quantity are examples of research to better define and manage soil, water, plant, animal, and marine life relationships. These and other facets of soil and water research are a part of an overall effort to more efficiently use and more completely conserve these resources. About $20,200,000 was expended for such research in FY 1965.

*Non-domesticated Plants and Animals.*—Atomic Energy Commission; Department of Agriculture; Department of Defense; Department of Health, Education, and Welfare; Department of the Interior; National Science Foundation; Smithsonian Institution.

This category includes research most directly concerned with the interrelationships between plants and non-domestic animals in natural areas. Examples are studies of the interrelationships between plant communities and wildlife, animal ecology, plant ecology, and fish habitats, the effects of hurricanes on natural areas, and the causes of both short and long-term vegetational changes. Investigations of the ecological effects of water use projects on fish and wildlife and the effects of human use and beautification of wildlands are conducted to evaluate the influence of man's activities on natural communities. About $18,600,000 was expended in this area in FY 1965.

Surveys (Atomic Energy Commission; Department of Agriculture; Department of Defense; Department of Health, Education, and Welfare; Department of Interior; National Aeronautics and Space Administration; National Science Foundation; Smithsonian Institution).

This work involves identifying, measuring, classifying, and documenting existing bioenvironmental conditions; where appropriate, relating findings to preceding conditions and contributing factors; and identifying and measuring changes and trends, as well as the scope of variation and diversity.

Continuing, periodic, or one-time surveys are made. They range from national and regional efforts to activities in selected locales. Among the subjects studied were:

Biological productivity in waterways.
Exotic chemicals.
Forests.
Freshwater fish.
Land.
Marine benthonic organisms.
Marine fish.
Plant and animal pests—diseases, insects and parasites.
Poisonous or unwanted plants.
Poisonous marine animals.
Range.
Seals.
Soils.
Soil, water and air contaminants.
Whales.
Wildlife habitat.

About $39,000,000 was expanded for such work in FY 1965.

*Education.*—Atomic Energy Commission; Department of the Interior; Department of Health, Education, and Welfare; National Science Foundation.

Grants for higher education, including pre- and post-doctoral fellowships and traineeships; support for facilities for scientific training; the preparation and distribution of bibliographies; and scientific data centers are among activities included under this hearing. About $3,900,000 was expanded in this area in FY 1965.

## III. RECOMMENDATIONS

Although considerable effort is currently being directed to understanding natural communities and their interactions with man, much of it arises from special economic problems and particularistic aspects of agency missions. The comprehensive overview of man-in-nature, which is needed for harmonious adjustment of human populations to resources, is rarely attained. The following recommendations outline steps to be taken toward achieving this adjustment.

*Protected natural areas*

1. *A group, composed of representatives from concerned Federal agencies and the academic community, should prepare a definitive list of natural ecosystem types.*—The Department of the Interior, the Department of Agriculture, and the National Science Foundation, should jointly assume responsibility for this undertaking. Current efforts in this direction, including those in connection with the International Biological Program, should be recognized and integrated into the system.

2. *The same group should recommend, for designation by the agency controlling the land, specific areas representing these types for protection as a natural areas.*—These areas should be adequate in number and size to use for observational and experimental research and for monitoring. Priority should be given to areas presently under public control to assure their perpetuation.

3. *If areas containing ecosystem types recommended by the group are not represented on Federal or other preserves, the group should consider how such areas might be acquired or access to them obtained through means such as lease or easement.*

4. *Designated areas should be available to any bona fide researcher, subject to sufficient regulation by the land-holding agency to protect them and prevent interference of one program with another.*

*Research*

1. *Greater attention should be given to studies within natural plant and animal communities.*—In this general effort, increased emphasis should be given to an ecosystem approach in which these communities are considered in the context of the total environment in which they exist.

2. *Agencies with major research programs pertaining to natural plant and animal communities should establish focal points and take other actions to facilitate interagency coordination, planning, support and conduct of programs.*—No single agency has, or should have, exclusive jurisdiction in supporting research on this subject, since research related to natural areas is an essential part of the mission, responsibilities of several agencies. Communication among agencies and within the scientific community needs to be improved to prevent undesirable duplication and to insure complete coverage. OST should assume responsibility for assuring necessary coordination.

3. *A small number, perhaps six to ten, of major intensive ecosystem studies should be conducted. As no single agency has the total capability to perform the major ecosystem studies outlined above, the agencies concerned should undertake a coordinated program including sharing of funding and support.*—The ecosystem orientation of many small-scale studies, past and present, needs to be expanded and applied to very large and complex systems, such as forests, grasslands, large lakes, estuaries and rivers with emphasis on interrelationships within and between components. The competence of both Federal and non-federal scientists should be utilized. This activity may necessitate a reorientation of some current efforts.

4. *In research on intensively managed areas where the findings may have application to natural plant and animal communities, greater attention should be given to designing experiments and interpreting results from the standpoint of their ecological implications.*

5. *Increased research should be performed to provide a basis for making the best possible judgments on the benefits and losses which accrue from the interactions of man and natural communities.*

6. *In seeking to increase ecologically oriented research commensurate with their missions, agencies should emphasize*—(*a*) *Fundamental Processes Operating and Affecting Plant and Animal Communities*—

1. basic life and life-supporting processes.
2. how living things relate to and affect one another.

3. how living things relate to their physical environment.

4. how the above components interact to yield an observed condition at a given time and place.

(*b*) *Impact of Plant and Animal Communities on Man.*—

1. identifying and assessing the significance of specific ways in which natural communities affect man.

2. the ways the constituents of natural communities affect man directly, or indirectly by affecting each other.

3. ways in which the beneficial effects of natural communities on man can be perpetuated and enhanced.

(*c*) *Impact of Man on Plant and Animal Communities.*—

1. identifying and assessing the effects of specific and purposeful actions of man on natural communities.

2. identifying and assessing the significance of the anticipated or inadvertent side effects of man's activities on natural communities.

3. defining more and better ways for man to use and manage the resources provided by natural communities and their environment.

7. *Steps should be taken to bolster competence in taxonomy and systematics through expanded support for professional and subprofessional personnel and for such facilities as reference collections, field stations, mobile laboratories and data processing centers.*

8. *Research on methodology and instrumentation should be continued* to:

(*a*) improve sampling and analytical methods which lend themselves to statistical interpretation.

(*b*) increase utilization of remote sensing and other new sampling techniques.

(*c*) expand the use of computers for processing data.

(*d*) increase utilization of tools for systems analysis including simulations of ecosystem structure and functions.

*Surveys*

*Benchmark Studies*

*The departments and agencies responsible for specific natural areas should accept the obligation to conduct or support a limited number of localized benchmark studies in major ecosystem types.* Benchmark studies on non-Federal lands or on Federal lands where studies have not been funded by the controlling agency may be funded by Federal agencies as needed to support their missions.

2. *Federal agency "ownership" alone should not preclude benchmark studies on these areas by other agencies in support of their missions.*

3. *Whenever it is economical and practical, the responsible agency should, through contracts or agreements, utilize the competence of other agencies for appropriate portions of the benchmark surveys.*—For example, the Department of Health, Education, and Welfare with capabilities in air pollution surveys, the Department of Agriculture with similar capabilities in soil analysis and the Department of the Interior with competence in water inventories should be called upon by the responsible agency to perform these functions whenever it is more practical and economical to do so.

4. *The responsible agency should also maintain a record of the location of benchmark data to serve as a point of contact and to assure ready acessibility of information to the entire scientific community.*

*Monitoring*

1. *A monitoring program in natural areas should be a part of broader programs for monitoring the total environment.*—The FCST Committee on Environmental Quality is presently engaged in assessing current monitoring activities and developing proposals. A survey of the needs in natural areas should be included in this review.

2. *Insofar as it is practical and economical, agencies with competence and responsibility for programs dealing with specific environmental components should monitor these components in natural areas.*—For example, the Department of Health, Education, and Welfare should have responsibility for monitoring air; the Department of Agriculture for soil; and the Department of the Interior for water. In some cases, additional legislative authority for contracting portions of this effort may be required. Such authority would be useful in situations where it is more practical and economical to utilize competence outside the responsible agency.

3. *A committee on natural areas should serve as a point of contact within the Federal establishment for information on natural areas obtained in the monitoring program.*—An informal group composed of representatives from the Department of Agriculture and the Department of Interior is currently developing reference information on natural areas.

*Education*

1. *Additional emphasis should be given to ecologically-oriented training.*
2. *Federal agences with missions in ecologically-oriented research should support training of students in their fields.*
3. *Ecologically-oriented national research programs, including those at national laboratories, should contribute to university education through direct involvement of students in these programs.*—The Federal Government should facilitate the participation of its scientists in research training.

Mr. DADDARIO. This committee will adjourn until tomorrow morning at 10 a.m. at the same place.

(Whereupon, at 12:25 p.m. the subcommittee adjourned, to reconvene at 10 a.m., Wednesday, March 13, 1968.)

# ENVIRONMENTAL QUALITY

WEDNESDAY, MARCH 13, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
*Washington, D.C.*

The subcommittee met, pursuant to adjournment, at 10:08 a.m., in room 2325, Rayburn House Office Building, the Honorable Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our environmental quality hearings continue today with representatives from independent groups which have examined specific issues in this field.

This subcommittee recognizes the value of multiple and diverse sources of information, especially when the subject is so broad as to encompass all elements of our society.

Our first witnesses represent the American Chemical Society, Dr. Lloyd Cooke, Dr. Milton Harris, and Dr. Charles C. Price. Over the past few years we have developed a useful relationship with the ACS in a number of matters. The society is concerned with environmental quality, and I am pleased they are here today.

We will hear later from Mr. Ron Linton, representing the Task Force on Environmental Health which he directed for the Secretary of Health, Education, and Welfare. Mr. Linton is with the Urban Coalition where he will be soon joined by John Gardner in their important work in human environment.

If you gentlemen then, would come forward, and proceed in whichever order you have decided. As I understand it from Mr. Carpenter, Dr. Cooke will be giving the presentation.

Dr. COOKE. Right.

Mr. DADDARIO. Please proceed.

(The biographies of Drs. Cooke, Harris, and Price follow:)

DR. LLOYD M. COOKE

Food Products Division, Union Carbide Corp., 6733 W. 65th St., Chicago 38, Ill. Chemistry. La Salle, Ill. June 7, 16; m. 57. B.S., Wisconsin, 37; *Ph. D. (org. chem), McGill, 41. Phi Kappa Phi; Phi Lambda Upsilon; Sigma Xi. Mgr., Planning, Food Prods. Div., Union Carbide Corp., 1967 to date;* Mgr., Market Research, Food Prods. Div., 1965–67; Assoc. Dir. of Research, 1957–64; Mgr., Cellulose & Casing Research Dept., 1950–56. Mem. ACS since 1939. Chicago Section: Chm., 1955–56; Comm. on Pub., Prof. & Mem. Rel., 1968; Comm. on Pubs., 1968; Adv. Bd., C&EN, 1967–69; Comm. on Chem. & Public Affairs, 1965–68; CPC., 1964–67, V. Chm., 1964–67; Comm. on Patent Matters & Related Legis., 1963–67. Mem.: AIC; Trustee, Chicago Chem. Library Fund, Amer. Mktg. Assoc.; Chicago Chem. Club. Structure of lignin; starch modifications and derivatives; cellulose derivatives; viscose chemistry; carbohydrate and polymer chemistry.

DR. MILTON HARRIS

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## STATEMENT OF DR. LLOYD M. COOKE, ACCOMPANIED BY DR. MILTON HARRIS AND DR. CHARLES C. PRICE, AMERICAN CHEMICAL SOCIETY, SUBCOMMITTEE ON THE SCIENCE AND TECHNOLOGY OF ENVIRONMENTAL IMPROVEMENT

Dr. COOKE. Mr. Chairman and members of the subcommittee, my name is Lloyd M. Cooke. I am a member of the board of directors of the American Chemical Society and appear before you today in my capacity as chairman of the subcommittee on environmental improvement of the society's board committee on chemistry and public affairs.

I am also manager of planning for the food products division of the Union Carbide Corp.

Accompanying me are Dr. Milton Harris, chairman of the American Chemical Society's Board of Directors and retired vice president for research of the Gillette Co.; Dr. Charles C. Price, chairman of the American Chemical Society's Committee on Chemistry and Public Affairs and university professor of chemistry at the University of Pennsylvania; Dr. B. R. Stanerson, executive secretary of the ACS; and Dr. Stephen T. Quigley, director of the society's office of chemistry and public affairs.

Mr. DADDARIO. Dr. Cooke, the other gentlemen, who are here, should not feel inhibited in any way. They feel they have something to say. They should volunteer to do so.

Dr. COOKE. Thank you, we appreciate that opportunity. And also we appreciate very much the opportunity to discuss with your subcommittee the work of the American Chemical Society study project on the science and technology of environmental improvement.

I will begin by describing the origin of our committee on chemistry and public affairs. The basis of the committee lies in the charter of the American Chemical Society. The ACS charter was granted by your predecessors in Congress in 1937, and it says in part that one of the objectives of the society should be "by its meetings, professional contacts, reports, papers, discussions, and publications, to promote scientific interests and inquiry, thereby fostering public welfare and education, aiding the development of our country's industries, and adding to the material prosperity and happiness of our people."

The society, as you may know, has been doing things of this sort for many years through local, regional, and national meetings, publications, and other activities. However, with the steady growth of the American Chemical Society—we now have about 110,000 member chemists and chemical engineers—the society's responsibilities have increased.

In a technological world in which chemistry plays an exceedingly important part, the role which the society must play has been reevaluated. Thus in 1965 the ACS Board of Directors decided to form a new operating entity, the committee on chemistry and public affairs.

In support of the committee's main responsibility to help fulfill the obligations imposed on the society by the national charter, the committee was charged with the responsibility: "to initiate and conduct studies and prepare and publicize to the membership and the public reports on problems involving the role of chemistry in public affairs."

Now, having provided some background on the why and the when of the ACS Committee on Chemistry and Public Affairs, I will bypass the events which lead up to the purpose of our visit here today. Later, I will speak to some aspects of this bypassed experience. However, one of the first actions of the new Committee on Chemistry and Public Affairs was to respond to the so-called Tukey report "Restoring the Quality of Our Environment." Our response has been to question and to experiment in order to determine the need for ACS action, and after validating the need, determine the direction and the mechanism for a society effort in this critical problem area. This mechanism is perhaps best introduced by permitting it to speak for itself. I will read to you from the preface of the society's report on "The Science and Technology of Environmental Improvement" which report is now in preparation.

Our aim in this report has been to set down in one place an objective account of the bearing of chemical science and technology on the problems of environmental quality—what is known, how it is being used, what needs to be known, how it might be used.

We have not attempted to write an all-encompassing textbook or primer. We have stressed instead those problems that we believe to be at the same time important to environmental quality and accessible to

We have not dwelt overlong on the dimensions of the pollution prob- attack on the basis of current and prospective chemical knowledge.
lem, except where one or more of those dimensions is specifically germane to the point at hand, nor on the social, political, economic, or organizational questions that it raises. Others have covered these matters at length. Our intent rather has been to focus strongly and specifically on chemistry, chemical engineering, and the related sciences, and thereby, to stimulate the chemical awareness and the flow of chemical know-how that are essential to any long-term rational approach to understanding and managing our environment.

For officials at all levels and in all branches of government who must deal with the environment, we hope to have developed a coherent chemical picture that will refresh the expert and inform the nonexpert.

For the chemical world at large, we hope to have exposed the important chemical aspects of pollution and, by extensive documentation, to have made it possible for the working scientist or engineer to proceed without delay to the scientific or technological background of whichever of these questions happen to excite his interest or become his assignment.

Mr. DADDARIO. Dr. Cooke, when do you expect that this report will be released? To what type of audience will it be specifically directed?

Dr. COOKE. If all goes uncommonly well, by early fall. Midwinter might be more likely.

Mr. DADDARIO. Aimed at whom?

Dr. COOKE. As stated in the preface, the report is aimed at agencies who have assignments in the area of environmental control as they might relate to chemistry, and also to scientists (1) to excite their interests, and (2) to help provide background information so that they may start research projects more expeditiously.

Mr. DADDARIO. These are most commendable objectives. The aim to involve people with the role of chemistry in public affairs is extremely important.

The question I have, and one that bothers me somewhat. You have with you a tremendous competence. You are manager of planning for the food products division of Union Carbide. Dr. Harris has been vice president for research of Gillette. Dr. Price has had tremendous experience in public affairs. He has worked with this committee on many occasions in the past.

Why is it that any involvement in the social, political, and economic areas is avoided, especially the organizational questions. These are, in my opinion, real difficult roles.

How do you view the way agencies in government are established to handle this problem? What are the problems of management? How do industry, the universities, and government play their part? What do you think of the laws pertaining to clean air and water? The way Congress is structured to handle these problems.

Don't these subjects deserve some attention? Aren't you gentlemen of the society the type of people who have been involved in the management of affairs of this kind?

Dr. COOKE. May I start to try to answer that question? And I would hope, after a brief statement, that Doctors Harris and Price will speak, too.

The segregation, shall we say, of objectives, and apparent negative statement with regard to organization, social and economic factors, was by no means meant to denegate their importance, nor the capacity of individual members of the society, to speak constructively to those factors.

As we view the situation thus far, we feel that the solution of economic and organizational problems require (1) the definite, positive statements of the problem, (2) a compilation of what knowledge there is to work with, (3) and what needs knowing in some relationship to importance (establish priorities). This is not to suggest that others do nothing now, while waiting until such are available, but rather for us to concentrate our skills, expertise, and participation of knowledgeable chemists in industry, government, and universities to help provide a basic story of what we know, and what we need to know.

After accomplishing this, I am certain that many of us will then recommend ways to organize to achieve the ultimate aims. However, we feel it is imperative that our first priority job be to pull together, as well as we can, in one place, the chemistry and chemical engineering related to these problems. Define them, and define the need. By no means do we mean to delimit or denegate the importance of the social and political aspects. But, in order of priority, we have chosen the technical approach, we think, intelligently.

Mr. DADDARIO. Well, it is not in the nature of my question to be critical. I would quite agree that we ought not to wait until we can prove out what we need to do, before we get about doing it. But I would hazard the guess that as you gentlemen review what is being done, you could come to these conclusions: some of it is being badly managed. Some things are being done we ought not to be doing, and some things are not being done which we have a great competence to do and ought to be done. This fits into the pattern of organizational, political, economic, and social questions, if we are doing things which are economically unsound and if you had some suggestion as to what needed to be done in order to develop a greater competence in programs presently in existence. How might these be replaced to accomplish certain end objectives which would give us leadtime for learning more about things that ought to be done? Not just chemistry is involved here, but the management part of this is extremely important.

Dr. COOKE. Then, sir, I think, appraised this way, that we are expecting and hope to come up with many such specific recommendations and commentaries with regard to the relative economics of certain processes. Further in my testimony I will make specific reference to one or two such cases as examples of what we hope to achieve.

Perhaps we have overemphasized the fact that we are approaching the problem from the scientific knowledge basis, rather than from the standpoint of economics and organization. This is not meant to deny the importance of scientific knowledge in recommending courses of political and economic action and possible mechanisms by which action might be taken.

Mr. DADDARIO. While we are on the subject, does Dr. Harris, Dr. Price or any other gentleman want to say something about this?

Dr. HARRIS. I don't have to tell anyone in this room that this is one

of the important problems in our society. It is also a problem loaded with emotion. The spectrum includes those who feel that there is no problem to those who feel that the minute we put our heads outside, we are not going to live more than 2 or 3 years.

In order to develop a meaningful way to tackle a problem as complex as this, we felt that we ought to know more about the technical aspects of the problem. One should not develop an advertising or sales campaign for a product that doesn't exist. It is really not a very easy thing to do. Rather, we should find the meaningful technical aspects of the problem, especially in our areas of expertise. Here we have an advantage, since the ACS comprises 110,000 members including leaders in the academic, industrial, and government communities.

Many among this group feel that this is one of our important social problems. However, they really don't know what to do about it nor their fields of expertise can contribute to solutions. Thus, if we can come up with much more meaningful technical definitions in our areas of expertise, I feel we can contribute much.

Mr. DADDARIO. Dr. Harris, we would rather not, too. But I think this is a time when, recognizing the reasons why this is being avoided in this case, there are high emotions. There are people who are at each end of the spectrum. In my opinion, we don't have the time to work this out over a long period of time. We need an answer, not necessarily an ultimate solution in each instance, but we need to develop some way to get hold of these great problems earlier, rather than later. Somehow these conflicts within your society have to be reconciled—not reconciled so that you have a unanimous approach to things, but it would seem to me it would be even better if your society were to participate in giving us advice with minority points of view, if necessary, so that at least the nature of the conflict could be understood. I am not being critical because I recognize the problems of the society. At the same time there ought to be developed a mechanism of getting these opinions in public where they could then be refined somewhat. People do have a tendency, when they have taken a position, and have been criticized, to perhaps adjust themselves somewhat.

Dr. Price.

Dr. PRICE. I find this discussion extremely helpful, and in fact it is one of the reasons we wanted to come today when our report was still in an incomplete stage so that we could find out the ways we could be most useful. I am sure that if we can see ways we can make recommendations in this area we will be willing to do so.

I think there were several reasons for reluctance to aim at that direction, one of which is we are only one aspect of the problem. The chemists have a competence to deal with only one aspect of the problem. The chemists have a competence to deal with only one facet. For example, the biological problems, ecology, are extremely important parts of evaluating the social and economic aspects. We didn't want to presume to undertake this from only the limited base of chemistry. But I do believe that we ought to try to find ways to make recommendations, and I think when they are clear, we will. But I think it would have been a mistake for us to presume to speak from just the basis of chemistry to make a broad recommendation in these very important areas.

Dr. HARRIS. Early in this undertaking, we met with Don Horning and his staff. We wanted to make a contribution in this area but did

not want to be in the position of the society which forms a committee and then says "We would like to be helpful, give us something to do." What we proposed was to really find out what the technical aspects of the problem were and then make suggestions. There are too many "do-gooders." We recognized the need for more meaningful approaches and I think we hope to near that stage very quickly.

Mr. DADDARIO. I recognize that this is one of the problems and that what you say is so. In this instance, you have come forward to be helpful, and it becomes a matter of coming to some determination of a formula.

I don't know, Dr. Price, whether I can go along with you when you say because you are in the chemical end that you have no view of how the other parts of this little world live. I am sure Dr. Cooke and Dr. Harris, in their day-to-day work, have had to come to determinations about how to manage other things beyond chemistry. The ability that you people have to look at these things from the eyes of managers transcends by far your expertise in the chemical area, where your fundamental capabilities lie.

You really have a better capability and that is the reason we asked for advice in this area from people precisely of your kind. It is not a narrow view you can give, but a wider one. You may be right in what you have done for some of the reasons you have all given. On the other hand, it would appear to me at first blush that it is a narrower point of view that you give us than the broader one that you are in fact capable of giving us.

Dr. HARRIS. We are prepared to help in every way possible. But as I said before, I hope that when we come forth with recommendations and suggestions, which I am sure we will be able to do, based on our capabilities, they will be something more than just idle suggestions.

Mr. DADDARIO. Were you going to say something, Dr. Cooke?

Dr. COOKE. I would perhaps state my viewpoint somewhat differently.

I think our field of chemistry provides an excellent base from which to build knowledge and understanding which, in turn, would permit a better opportunity to impinge concepts of management and control and organization. It is, I think, his conviction too that——

Mr. DADDARIO. When you say "his," you mean Dr. Price?

Dr. COOKE. Yes, I mean Dr. Price—that, of the disciplines which may be directly involved in the technical aspects of the problem, perhaps chemistry is most pervasive, most general. Of the possible organizations which could start from some solid basis and expand, as you suggest, we feel that the ACS, by representing a unique cross section of industrial, academic, and agency people, is particularly well suited for this purpose. Thus, for example, at a meeting called by a division of the ACS 2 years ago, a group of experts in environmental science proposed to provide public service by broadening the scope of national meeting seminars to include scientists from other disciplines—biologists, mathematicians, sanitary engineers, etc. This has been done for 2 years. During this time we have succeeded in bringing in many people from other disciplines. Thus, although we appear to be starting from a limited base in chemistry, in fact, we find that we are able to bring in other scientific knowledge effectively.

So I would suggest that we proceed further into a discussion of what we propose to do and bring in a couple of examples. I think you

may find that we will cover some of the points which you have raised. Perhaps we have not planned to go as far as you would encourage us to go, but perhaps when we examine those examples, we might be able to speak more specifically to your suggestions.

Mr. DADDARIO. Yes. We ought to get along. I am pleased, of course, that these other points will be raised, but it seems to me that the report you are putting out ought to be discussed.

Dr. COOKE. This we intend to do.

The content of this quoted preface delineates the boundary conditions of our study.

The society is convinced that there is a real need for this kind of report and we believe that we are in a favored position to do the job within the limits of our resources.

Let me establish the qualifications of the American Chemical Society to do an analysis of this kind. The 900 members of the ACS Division of Water, Air, and Waste Chemistry include many of the people trained in chemistry and closely related sciences who are working on the problems of environmental quality in the United States. Many other society members are knowledgeable in the problems that need to be solved.

We have taken advantage of this expertise in our effort to develop a dispassionate and specific analysis of the chemical problems involved in managing our environment and how they have been—the problems—have been or might be solved.

The first draft, representing only a part of the planned content, will be the subject of critical review this afternoon and evening in New York City by our subcommittee consisting of Dr. William O. Baker, vice president for research, Bell Telephone Laboratories; Dr. Arthur M. Bueche, vice president, General Electric Co.; and Dr. Frank A. Long, vice president for research and advanced studies, Cornell University.

Also present for the review will be Dr. Melvin Josephs, managing editor of the American Chemical Society Journal, Environmental Science and Technology, and Dr. Stephen T. Quigley, director of the American Chemical Society's office of chemistry and public affairs.

Dr. Thurston Larson, head of the chemistry section, Illinois State Water Survey, who leads the American Chemical Society task force of scientists who are actively engaged in research in water, air, and waste chemistry, will also participate.

Since our effort began, two major documents on the environment have been published. One is "Waste Management and Control," the so-called Spilhaus report, published in March 1966 by the Committee on Pollution of the National Academy of Sciences—National Research Council. The other is "A Strategy for a Livable Environment," which was prepared for the Secretary of Health, Education, and Welfare by his task force on environmental health and related problems and published in June 1967.

I will use one or two points from the Tukey and Spilhaus reports to illustrate the kind of thing we hope to be able to do in the completed ACS report.

The Tukey report, for example, mentions at a number of points the importance to antiknock rating of the lead that reaches the atmosphere through the use of lead alkilis in automotive gasoline. We think that

we can add some chemical perspective to a discussion of lead. We would do this by putting in one place all of the relationships among the chemical phenomena involved: The effect of lead on the development of currently known catalytic converters to burn the hydrocarbons and carbon monoxide in exhaust gas; the effect of lead on currently known catalytic converters designed to eliminate oxides of nitrogen from exhaust gas; the chemical nature of gasoline and the consequences, both technical and economic, of removing the lead from gasoline; the effects on the prices of certain petrochemical based plastics at the consumer level if lead were removed from gasoline and the antiknock rating maintained by chemically altering the molecular structures in the fuel.

We can also raise and suggest answers to other pertinent questions: What are the real chances of cleaning up automobile exhaust without using catalysis? Is it thermodynamically possible to remove oxides of nitrogen from exhaust gas without using a catalytic approach? What is the mechanism by which lead poisons catalysts?

Once we understand the mechanism, will it be possible to design catalysts that function in the presence of lead?

What kind of research would be required to find out if lead actually does interfere with the operation of certain enzyme systems in the body, thus producing subclinical effects of an unknown nature?

In short, the technical question of lead is a controversial one and we hope that by using our committee approach we can set down an objective appraisal of the situation in specific chemical terms.

The Spilhaus report comments that "More technology is needed in the areas of low-cost source control devices, especially for sulfur dioxide."

To a discussion of that kind we would add specific descriptions of the major processes now available for removing sulfur from stack gases at the concentrations in which it is found there. We would point out the apparent costs of such processes. We would point out that no process of that kind is yet operating on the scale required at a modern powerplant, although two or three are in the process of being installed.

We would point out that, for some of the reactions involved in these processes, what actually happens, chemically, is not entirely clear, and we would ask whether knowing what actually happens would have any substantial effect on the efficiency and cost of operation of the process.

We would assess the technical likelihood of being able to remove sulfur from oil at substantially less than the present cost. We would point out that particulates created by burning low-sulfur coal are more difficult to collect in any electrostatic precipitator than are particulates from a coal that contains more sulfur.

In New York City this means that Consolidated Edison's precipitators go from 99 percent efficiency to 98 percent when the company switches from coal at 2 percent sulfur to coal at 1 percent sulfur. The 99 percent efficiency level will be required by law for all coal-burning equipment by next year, coal of not more than 1 percent sulfur content will be required by law by 1971.

Consolidated Edison can counteract the effect on its precipitators in several ways, although at somewhat greater cost. There are numerous instances of effects of this kind—effects that are based on the scientific facts of the case at hand—that rarely are spelled out in more

general discussions of what degree of pollution abatement can be achieved in specific cases and at what cost.

Sometimes the effect is important, sometimes it isn't. But at any rate, we believe that we will be performing a service by exposing this kind of technical detail in the context of the more general discussion.

Mr. DADDARIO. Dr. Cooke, is there any relevance to the lead health problem? You do not mention it here.

How does it fit in?

Dr. COOKE. I refer, as an example, to the phrase:

**What kind of research would be required to find out if lead actually does interfere with the operation of certain enzymes systems in the body, thus producing subclinical effects of an unknown nature.**

We would emphasize those areas in which there is known data with regard to effects of lead, and those in which there are not. In the latter case we would indicate which data might be collected and provide suggestions as to how.

Mr. DADDARIO. I see. Then you have not——

Dr. COOKE. We have not ignored that possibility. We have not crossed it off. This sentence was meant to fit within the narrow confines of this morning's testimony. It was meant to point out the need for additional information. In the second example, concerning sulfur in coal and precipitator efficiencies, we point out the purposefulness of bringing technological data alongside economic data to help provide more realistic forecasts of the technological and economic merits of course A versus course B.

As I said earlier, it is with these examples that we hope to point out how we will use technical knowledge to point out the areas where economic and health problems pertain. Also, to the extent we can, we will relate the technological facts to the economic and the health problems.

Studies of environmental quality generally conclude that analytical chemistry is vital to developing new knowledge of the processes involved.

Our study would illustrate the problems and achievements in specific terms. We would point out, for example, that until the past year or so, there has been no means of making standard samples of many air pollutants, at the concentrations at which they actually occur, that could be used to calibrate the methods and instruments that we use to measure such pollutants.

There are things that can be done to make progress in the face of such problems, but they are problems nevertheless that must be solved sooner or later and the existence of such problems means that we must always be certain what kind of information we are dealing with.

For example, the national air surveillance network in the past couple of years has improved its analytical techniques for nitrogen dioxide. One result is that the nationwide readings for 1966 are recorded at values of 50 percent higher than they were in previous years for the same actual concentration of nitrogen dioxide in the air.

This, then, is the kind of perspective that we hope that we, as a scientific society, will be able to provide.

In retrospect, let me now describe briefly some of the problems that a society such as ours encounters in organizing for such a venture. In fact, we still have to validate the efficacy of our present approach. The

value of our testimony may lie in submitting some of our probing experiments for your review.

As I stated earlier, the formation of the Committee on Chemistry and Public Affairs coincided with the publication of the President's Science Advisory Committee document commonly called the Tukey report. The first reaction of the committee to possibilities of constructive participation in areas of pollution control was that PSAC and other bodies were charting reasonable courses which appropriate agencies could follow directly or amend with experience.

Subsequently, the committee realized that the membership of the American Chemical Society might provide a unique cross sectional representation of experts in the field of environmental quality. If this were true, perhaps a group of such experts, as represented by membership in the Division of Water, Air, and Waste Chemistry, and the American Chemical Society's Board Committee on Air Pollution, might welcome an opportunity to explore areas wherein the society might serve chemistry and the Nation purposefully.

That expert members of the society were interested and willing to participate in such an exploration was quickly affirmed, and from a meeting of such members in March 1966 came the following recommendations:

1. Members of the American Chemical Society experienced in environmental chemistry and technology could provide a valuable service by analyzing the recommendations of the Tukey report, as related to chemistry.

2. The American Chemical Society should determine those areas where basic chemical knowledge related to environmental control is lacking and encourage and/or sponsor appropriate research.

3. All chemists must be informed of the scientific problems encountered in environmental control.

4. The ACS Division of Water, Air and Waste Chemistry should arrange broad spectrum symposia on environmental control, and, by broad spectrum, we meant their bringing in other related disciplines, the sanitary engineers, the biologists.

5. A scientific journal concerned with the chemistry of water, air and waste materials should be established. In January 1967 the ACS began publication of Environmental Science and Technology, a professional journal that now has a circulation of more than 12,000. This journal covers the news of environmental science—not just chemistry—and also serves as the American Chemical Society's publishing outlet for reports of original scientific research in the field.

6. There is need for a documentation center for toxicological information. A similar recommendation was made by PSAC and these recommendations were implemented by the establishment of a toxicological information center in the Department of Health, Education, and Welfare.

The American Chemical Society decided to help implement most of these recommendations with special emphasis on underwriting an analysis of the recommendations of the Tukey report from the standpoint of chemistry. At that time, as Dr. Harris has indicated, these plans were described to Dr. Donald F. Hornig, Director of the Office of Science and Technology, for purposes of communication and to obtain whatever counsel and suggestions his office might provide.

Dr. Hornig encouraged the American Chemical Society to pursue the proposed program, placing special emphasis on items 1 and 3 above; that is, preparing an analysis of the recommendations of the Tukey report and informing the scientific community of problems faced in improving our environment.

Recruiting of scientists to participate in our task force proceeded smoothly because all were convinced that the program provided a valid opportunity to fill a real need.

The high level of enthusiasm and dedication continued throughout all stages of planning, group study, decisions with regard to assignment of people and topics, and finally providing well-written segments of what was then planned to be the ACS report.

However, at this stage it became apparent that the documents provided had, on the one hand, somewhat exceeded the original limits of the analysis of the recommendations of the Tukey report. On the other hand, that which was provided was not extensive enough to show "what is known and what is needed" to solve environmental problems.

Your subcommittee experienced a somewhat similar situation at about the same time. You were faced with bringing intelligent order out of the wide variety of information contained in the massive 2-volume collection of your hearings in 1966 on environmental pollution. We were much impressed by the monumental task performed by the team headed by Mr. Richard Carpenter of the Library of Congress. We took heart from your success.

We do not believe that science and technology make up a panacea for environmental improvement and control. We do believe that the technical facts should be made fully available in an unprejudiced fashion to those who must make the decisions. We are not yet certain that we have found the best way to do this, which is to say that we regard our current effort as experimental. But without experiment we will learn nothing and the one thing that we are convinced of is that we must search out the proper role of a modern scientific and educational society in the context of public affairs. Until we know what that role is, we may be wasting a valuable resource.

We think we are now on the way to meet part of a criticism your report leveled at the scientific community. Your subcommittee has said:

> Finally, the hearings indicated that environment quality, with its deep roots in the natural sciences, has not yet attracted sufficient attention from the scientific and engineering community. This is a problem worthy of the very best thinking we can muster.
>
> It should receive a more generous allocation of the scientific resources at our disposal.
>
> Corrective activities involve long-term commitments and high costs which provide clear motivation for additional research, development, and demonstration projects. Technology is available to accomplish some urgent objectives and should be used without delay.
>
> In many other instances, the knowledge is lacking to define objectives and to deal with pollution on a cost-effective basis.

It is our aim to help answer this call.

Thank you.

Mr. DADDARIO. Dr. Cooke, I am pleased that you made note of Mr. Carpenter's tremendous contribution to the work of this subcommittee, and to all, actually, in this field.

I think it is a tribute not only to him but to the fact that the chairman of the full committee, Mr. George P. Miller, has given support to the establishment of a scientific and technical competence in the Library of Congress, which over the years has been of tremendous assistance to us. The recognition you give to Mr. Carpenter, and he is deserving personally of it, is an indication of the scientific and technical community's recognition of this competence which the Congress leans heavily on.

This is an important development in the building up of confidence generally as to our ability to handle these matters.

You mentioned your report which you plan to release in midwinter of 1968.

I wonder what concern might have been shown from time to time as to problems such as this? For example, HEW is already setting criteria and certain States are being required to establish standards for ambient air.

Does it concern you? Should these standards be established? What problems arise by the HEW forcing on certain States, which really do not have the competence to establish such standards?

Once these are fixed, the problems of readjustment always come up.

Since you have said you have so many bits and pieces of this report to put together, if certain parts of it are critical at this moment perhaps it could be released earlier. It might stem off some of these problems which might otherwise arise.

Dr. COOKE. We are well aware of the fact that there is a nutcracker effect here. As you said earlier, we must act as well as we can within the framework of the limited knowledge—too limited knowledge—which is there to be brought forth in a document such as ours.

We have faced up to the fact that actions, recommendations and directions will go on (even before the facts are available). This is true of the example I gave earlier with regard to sulfur dioxide and precipitator defects when one uses lower sulfur fuels. These kinds of things are happening daily. Had we been faster, doubtless we could have been of more help.

We are unhappy with the delay that has occurred, that we didn't seem to get on the present track as soon as we liked. We have learned much from this experience, and hope it will be helpful to others.

We have not ignored the problem of the need for action before all the facts are in. We are aware of the report from Health, Education, and Welfare and the recommendations therein. As a result of your questioning we will perhaps look more acutely at data as it unfolds while preparing the report. We will attempt to judge our timing in terms of other events.

May I then conclude by stating that your point is valid. I mean that in the sense that we recognize it. We are caught in a balancing act while attempting to get the whole thing done rapidly. We will definitely bear in mind your expression of the need to provide data or information early as it may be uncovered. We are not just waiting until we have a neatly bound volume. Rather, we are waiting until the individual sections are validated and tested as well as we can—not forever, but tested well enough to be meaningful and purposeful.

Mr. DADDARIO. I certainly would not want to push you into doing something earlier because precipitous actions and recommendations

could, if wrongly placed, do great harm to what follows. We also set our goals for certain times and then find ourselves putting reports out later on. But we have on occasion found that we had to, in fact, put out a report earlier, rather than later.

Dr. COOKE. We have considered that point very seriously with regard to the pesticide portion of the original submission. We decided, in terms of the depth and reliability of the information then available versus the apparent lack of immediate pressure and need in that area, that we would be more serving, better serving, by waiting until other sections were completed.

The point is, we actually seriously considered publishing a part of the report before completing all of the report.

Mr. DADDARIO. But the fact still remains, while you gentlemen who have such competence in this area have great concern about certain of these problems, standards are in fact being set.

Dr. COOKE. We get the message. I agree.

Mr. DADDARIO. Now, your work, in the preparation of this report, involved people from universities, industry, and the agencies. Has the opportunity come up within that framework to come to some judgment about inadequacy of information available to you or what the government agencies find inhibiting them from doing an efficient job?

Has this been part of the discussions?

This gets back again to the management question which I raised earlier.

Dr. COOKE. Yes, it will be part of the report.

Mr. DADDARIO. And will be part?

Mr. COOKE. Yes.

Mr. DADDARIO. Dr. Harris, do you have any comment on the point I raised with reference to standards being set at this time, when you gentlemen are still wrestling with what ought to be done?

Dr. HARRIS. We are always aware of the need for standards but are concerned about standards based on poor data. It is always easier to put in standards than to get them revised later.

I, for one, have taken very much to heart your suggestions, and will see what we can do by way of testing any of our knowledge in order to speed up developments.

Mr. DADDARIO. One point that seems to follow here: Do you have any suggestion about what States ought to be doing that are under the gun with certain time limits? If they do not establish the standards, conflicts then arise as to what ought to be done. Taking into consideration the problems we have in establishing the criteria, should it, in fact, be held in abeyance or would it be better to go ahead with the information we presently have on hand and then wrestle with the problem of readjusting standards at a later time?

Dr. HARRIS. That is a very broad order. We are in the position of making the decision as to whether you freeze a model and build a DC–3, or do you wait until you are ready to build a jetplane.

Technically you are better off building the DC–3, gaining experience, continuing R. & D., go on to the DC–4, and eventually to the jetplane or SST.

Mr. DADDARIO. I don't know whether I go along with the analogy.

Dr. HARRIS. But the DC–3 was valid.

Mr. DADDARIO. The criteria that went into the DC–3 was known. We knew what it would do.

Do we know what is going into this criteria and will it, in fact, fly?

Dr. HARRIS. Well, my answer to that, as stated in my original statement is the need for more valid information, not only in terms of technology but also in terms of economics and social relationships. For example, one would not want to put industries out of business and destroy our economy. These are all interrelated in a very complicated way.

But most of all, I think what we need is meaningful technical information on which to base standards.

Mr. DADDARIO. I would agree with you.

I am not placing obstacles in the path of getting these things done because it seems to me we ought to get people thinking about them. If they aren't prepared, they will begin establishing governmental agencies as they develop a competence of one kind or another.

I feel because this is a problem we ought to get your advice about it.

For example, in New York City, Commissioner Heller has already begun to back off from the 3 percent sulfur in coal for 1969 and 1970.

Once you say to an industry, this is what we expect, they begin preparing plans, and in some case even construction, to meet those requirements. You run into a tremendous economic disruption. This can be extremely harmful to the financial structure of a whole industry.

Dr. COOKE. Mr. Chairman, may I speak rather bluntly to the point you are raising, to tell you what travail we have experienced in attempting to pick a course between these two points.

To provide a purely scientific document may take 3, 4, or 5 years, to issue as firmed up a possible, versus replying or responding to situations that might arise before the report issues.

Let us go back to the meeting with Dr. Hornig and an admonition from him that is quite pertinent. Dr. Hornig said that, one of the worst things that could happen would be for this report to appear to issue from chemical industry.

Now you just mentioned the problem with regard to 3 percent sulfur. We have felt under a gun here. If our first reply, or statement in the area of environmental quality, is negative, that is, critical of an agency recommendation, we would really pull the rug from under the effectiveness of our future contributions, unless we really have an overwhelming mass of data to support our criticism.

This is not to say we are not aware of the problem and the potential, but we feel strongly that what we finally provide you, the agencies, and the scientific community, must be of a caliber immediately recognizable as of high caliber and usefulness, and that it has no taint of vested interest. This report must represent a scientific response to the problem so clearly and so credibly that we can then be of maximum use to you and to other agencies as new situations arise in the future. After that has occurred we may then be able to make recommendations earlier, with less data, and with indications of data still to come.

This has been the major constraint, you might say, under which we felt we must operate. I think we are saying that, we may have tied ourselves down too much. But that is a tricky question to answer, too.

Mr. DADDARIO. Your explanation is certainly valid. You have a dilemma. You may have worked out a wise solution to it. But nonetheless, there are problems.

Dr. COOKE. There are many problems there.

Dr. HARRIS. Correct.

Mr. DADDARIO. Dr. Price, you seem to have something to say.

Dr. PRICE. I am just agreeing with that. The problem that we have had to face, and as chairman of this committee, I felt particularly this way, that since this will perhaps be the first major report that we will issue, it is especially important to establish the value and credibility of our efforts to have it carefully documented. We may have been a little too conservative.

I think maybe you understand, since this will be perhaps the first major effort this new committee has made, we have taken a fairly conservative position.

Mr. DADDARIO. Despite questions I raised, I am extremely heartened by what has been done. I raised the questions, because it is my responsibility to come to some kind of an understanding about this.

Do any of you, or your colleagues, have any further remarks?

Dr. PRICE. In closing, all I would like to say is that we appreciate the opportunity that this gives us to be made aware of the major needs that you people are facing up with, and I hope it will also help inspire us to make sure that we do all we can. We need inspiration to see what we can do to help solve these problems. I think these hearings are a little bit of a needle for us to make sure we accept our responsibilities in this area.

We appreciate the needle.

Mr. DADDARIO. The meetings weren't put together for that purpose, however.

Dr. PRICE. But that is a purpose they will serve.

Dr. COOKE. We understand you.

Dr. PRICE. We made notes of many of the important questions.

Mr. DADDARIO. We certainly appreciate your coming and your cooperation.

Thank you.

Dr. PRICE. Thank you very much.

Dr. COOKE. Thank you.

Mr. DADDARIO. Our next witness is Mr. Ron M. Linton. Would you please come forward?

He is with the Task Force on Environmental Health and Related Problems, of HEW.

We are pleased to have you here, Mr. Linton.

Mr. LINTON. It is a pleasure to be with you.

I prepared a statement which I submit to you for the record, Mr. Chairman. At your pleasure, I could either read it or proceed to discuss it.

Mr. DADDARIO. Why don't you use your own judgment and handle it any way you like?

Mr. LINTON. All right.

(The biography of Ron M. Linton follows:)

RON M. LINTON

Ron M. Linton, a native of Detroit, Michigan, is National Coordinator of the Urban Coalition, a post he assumed last fall when the organization was formed. He had been director of special projects for Urban America Inc., but went on leave to serve the Coalition. Linton became assoicated with Urban America in November, 1966, at almost exactly the same time that the Secretary of Health, Education and Welfare appointed him Chairman of a Task Force on Environmental Health and Related Problems which completed its task in June, 1967.

Before joining Urban America, Mr. Linton was for more than three years chief Clerk and Staff Director of the U.S. Senate Committee on Public Works. In that post he had major responsibility for the development and enactment of Federal legislation in a broad range of fields, including air and water pollution control, solid waste disposal, highway construction and mass transit programs, civil works projects, Appalachian development, and regional economic development programs.

Linton's experience in Washington began in November 1959 as a Congressional Fellow of the American Political Science Association.

This assignment in Washington interrupted a journalism career which began while Linton was a student at Michigan State University. Majoring in political science, Linton was editor of the newspaper at Michigan State until a year before his graduation in 1951, when he joined the United Press. After service as an officer with the First Armored Division during the Korean War, Linton re-joined United Press International, working first in Des Moines, Iowa and later in Grand Rapids, Michigan, and finally in Lansing, Michigan. In 1954 he was Press Secretary to the late U.S. Senator Blair Moody.

After Moody's death, Linton served as Assistant Press Secretary to then Governor of Michigan, G. Menner Williams. He was assigned by the Governor to work with the Michigan State Department of Economic Development and was later appointed Secretary of the Department of Workmen's Compensation with responsibility as the chief administrative officer of that Department.

In 1956, Linton joined the Louisville COURIER-JOURNAL, where he was Labor Editor until his assignment to Washington under the American Political Science Association Congressional Fellowship Program.

From March through November 1960, Linton was a member of the personal campaign staff of then Senator John F. Kennedy.

After the election of 1960, the late Senator Pat. McNamara of Michigan, who was Chairman of the Senate Special Committee on Aging, asked Linton to join the Committee staff. In that assignment Linton produced the first national survey of the implementation of the Kerr-Mills Act to provide medical care for the aged through Federal grants to States.

In May 1961, President Kennedy sent Linton on a special assignment to the Defense Department to head a task force project to develop a program to relate Defense spending to the Nation's economic needs. In the course of his work at the Defense Department, where he was ultimately named Director of Economic Utilization Policy, Linton devised policies and a program which improved the techniques of relating unused skilled labor and production facilities to defense needs.

It was at the conclusion of his work at the Department of Defense in 1963 that Senator McNamara called on Linton to return to Capitol Hill in a key Committee assignment.

As Chairman of Secretary Gardner's Task Force on Environmental Health and Related Problems, Linton headed a six-member group of persons from outside the Federal government whom the Secretary has asked to recommend Departmental goals in the area of environmental quality and health protection.

Linton was born May 7, 1929. He is married to the former Nancy Cox Gualt and has two children. He has strong interests in conservation, and is a member of the Shenandoah Natural History Association. He is also a prominent layman in the Unitarian Universalist Denomination.

## STATEMENT OF RON M. LINTON, ENVIRONMENTAL MANAGEMENT CONSULTANT

Mr. LINTON. When I used to sit on the other side of the dais, it always meant a long statement, if they didn't read it, and a shorter

one, if they did. So I think in the interest of time, I will just proceed to read my statement and then offer myself to questioning from you and Mr. Miller.

A little over a year ago, former Secretary John Gardner, concerned with the extent to which the Department of Health, Education, and Welfare was meeting its responsibilities in providing Americans with environmental protection, created a six-member task force on environmental health.

I had the good fortune of being designated by the Secretary to chair that task force.

The six members represented a variety of disciplines. Our charge was to recommend to the Secretary the goals, priorities and strategy to cope with environmental threats to man's health and welfare.

From beginning to end of our work, the single, most constant theme we heard and understood was the urgency for action. We are in an emergency to prevent the destruction of our physical environment, yet we are not even appropriating authorized dollars.

We undertook our assignment from the view of how the Secretary could best direct the Department's resources so as to most effectively discharge its responsibility as assigned by congressional legislation.

Thus our work was essentially to recommend what needed to be done so that the Secretary could make the necessary decisions.

We attempted to make recommendations which could be implemented within the authority of existing statute. I believe about half of our recommendations would require no additional congressional authorization, albeit it would require some additional appropriation.

The remaining 50 percent, requiring congressional authority, are to a great degree responsive to implied congressional desire but lacking specific statute.

Only the metals and consumer protection goals represented a substantially new area of legislative activity. Subsequently, of course, consumer protection has come in for considerable interest by the Congress.

The task force decided initially that it would not spend its time reproving that environmental problems existed or even testing the validity of the tehcnical aspects of the problems. We felt there had been many experts preceding us who had made reports on the nature of the problem, and who evaluated much of the technical aspects related to the problem. We viewed our charge as recommending what should or could be done on the assumption that the problem was real and existing technical solutions valid.

What can be done takes two forms—today or now, and tomorrow or in the future. There is much less difference between these two time elements than most people realize. What we do now will determine what we have to do in the future. Our concern was to recommend action to be taken now that would bear upon Government's ability to deal with the future.

We also proceeded from the standpoint of what the Department of Health, Education, and Welfare should do in relation to State and local government, and the private sector.

Then we viewed all of our approaches from the context of what action the Secretary needed to take.

We knew the Secretary wanted a strategy for action. He had, and still has, the job of determining resource allocation. As you know, there is only so much time, so much money, so much personnel, and many more problems than can be handled with the amount of time, money, manpower resources available. Thus the resources have to be divided or allocated on some basis of priority need.

We found that the goals which were being set were being done so at the lower levels of the Department. They didn't seem to relate to any overall policy.

The first thing we had to do was to identify the enemy. The enemy was the environmental insults which occurred in the air, water, on or in the soil, and in the space that humans occupy.

The second thing we decided was where the action should take place. We decided that the direct operations to prevent environmental decay or restore environmental quality ought to be done by the city or in high density urban areas by a metropolitan regional body. Where State lines cut through an urban area, regional bodies should be established to do the job.

The task force did not deal with a State role. But I would say it should be to supplement funding local action programs and to prevent budding urban areas from falling into the same traps existing ones are in.

The State does not need to play a direct role in local action programs, nor should it. The State does not need to be an intermediary between Federal support and local action, and it should not be.

I have long heard the plaintive word that the State must be involved in the planning of environmental improvement in urban areas because of the effect on the rest of the State. All I can say is that the effect on the rest of the State can only be positive. Let the State enter the battle for environmental improvement with its money and its support.

The Federal role we suggested should be to provide the resources which no local or State agency can provide itself. This is essentially research, establishment of criteria, manpower development, and compliance leadership. The Federal Government's direct action role should be limited to those things which are clearly beyond local reach, such as automotive exhaust emission control or consumer protection. But its role should be extended to include authority to take action if local units can't or won't.

Mr. DADDARIO. Mr. Linton, in talking about establishment of criteria, you have gone into problems that the States have and that some of these problems do cut across the State-city lines, as of course they do. Are you talking about the establishment of criteria on a basis of various standards, or do you have this capability? Can you, in fact, meet the criteria requirements of one area without coming to a judgment that will perhaps place you in the position where criteria for the setting of regulations in other places should be higher or lower?

Mr. LINTON. It may be—and I am speaking in terms of standards rather than criteria—that a standard in one area may have a deleterious effect on another area because the standard is either too high or too low. Therefore, I think it is correct to establish a range of criteria, that relates to every conceivable, and possible development that can be evaluated in terms of standards.

My position on the State role does not eliminate a coordinator responsibility. All too often I think we find, that the approach now is to attempt to balance out the allocation of resources, rather than apply the resources that are available to the areas of most severe need.

Mr. DADDARIO. You believe that the agency involved ought to have flexible approach to this.

Mr. LINTON. Absolutely.

The task force believed that the private sector must play a coopera tive role with the Federal Government.

Having identified the enemy and what the roles of the Government were in dealing with this enemy, it became a great temptation to deal from there on in generalities. How easy it would have been to set as the goal "defeat the enemy" and then go home, or to make recommendations like so many reports such as "we need better Federal-State relations."

The task force felt that there were plenty of others who could rapidly set out general philosophical goals.

We decided someone had to start with quantitative goals, and so we did. We set out 10 of them. We did it because we felt a strategy recommendation was meaningless unless it were pointed at some specifics.

There is nothing sacred about these goals stated in the report. They were thought to be most appropriate at the time we enumerated them as base points to test the effects of allocating resources. We expected they would give way to changing circumstances; and, if left to stand long enough unacted upon, would become outdated.

But goals of this nature are needed if the Department is to apply a strategy.

Outside of appropriations, only four of the goals required legislative approval; and two of those, water supply and waste management, called for a modification of existing authority.

The only new legislative authority would be for control of materials, trace metals and chemicals and consumer protection against health and safety hazards of appliances, clothing, food, and hazardous substances.

To undertake this responsibility would not, in my opinion, be as difficult as it seems at first glance, providing two ground rules are accepted.

One, the first standards set will not be the only standards set. Standards for these materials will have to be changed as new data and information on their effect on health is developed. The statute authorizing such a program will face the Congress with a basic public policy decision, to err on the side of caution or err on the side of economic expansion. I do not suggest it is an easy decision to make. But we need to make it, and to start the learning experience necessary to protect humanity from itself.

I believe that many of our environmental problems will be solved only by trial and error. The sooner we get started, the more experience we will havein trials and errors.

The second ground rule will be the establishment of a number of independent nonprofit testing organizations jointly underwritten by government and industry. These will have to adhere to rigid controls on its objectivity. But they are essential if many medium-size and small firms are to survive under the legal requirements of a consumer protection goal.