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**REPORT TO THE CHAIRMAN,  
SUBCOMMITTEE ON  
THE ENVIRONMENT,  
COMMITTEE ON COMMERCE  
UNITED STATES SENATE**



**BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES**

**Federal Programs  
For Research On The Effects Of  
Air Pollutants**

**Environmental Protection Agency**

Much more research is needed on the health and ecological effects of air pollutants to adequately support and/or modify present national air standards and motor vehicle emission standards and to identify and set standards for other pollutants.

EPA needs to

- periodically prepare estimates of resources needed for an adequate research program,
- establish criteria or guidance for setting research priorities,
- develop an air pollution control strategy to facilitate better research planning, and
- better coordinate air pollution research done by other Federal agencies.



COMPTROLLER GENERAL OF THE UNITED STATES  
WASHINGTON, D.C. 20548

B-166506

Q + R Senator Philip A. Hart, Chairman  
Subcommittee on the Environment S 2304  
Committee on Commerce  
United States Senate

Dear Mr. Chairman:

Pursuant to your request, this is our report assessing Federal programs for research on the effects of air pollutants.

We invite your attention to the fact that this report contains recommendations to the Administrator of the Environmental Protection Agency. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions he has taken on our recommendations to the House and Senate Committees on Government Operations not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the Agency's first request for appropriations made more than 60 days after the date of the report. We shall be in touch with your office in the near future to arrange for the release of the report so that the requirements of section 236 can be set in motion.

Sincerely yours,

*Thomas P. Steats*

Comptroller General  
of the United States

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ABBREVIATIONS

CHESS	Community Health Effects Surveillance Studies
EPA	Environmental Protection Agency
EROS	Environmental Research Objective Statement
GAO	General Accounting Office
HEW	Department of Health, Education, and Welfare
NERC	National Environmental Research Center
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute of Occupational Safety and Health
NTIS	National Technical Information Service
OR&D	Office of Research and Development
RAPS	Regional Air Pollution Study
ROAP	Research Objective Achievement Plan
RTP	Research Triangle Park
SIE	Science Information Exchange

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#### ABBREVIATIONS

CHES	Community Health Effects Surveillance Studies
EPA	Environmental Protection Agency
EROS	Environmental Research Objective Statement
GAO	General Accounting Office
HEW	Department of Health, Education, and Welfare
NERC	National Environmental Research Center
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute of Occupational Safety and Health
NTIS	National Technical Information Service
OR&D	Office of Research and Development
RAPS	Regional Air Pollution Study
ROAP	Research Objective Achievement Plan
RTP	Research Triangle Park
SIE	Science Information Exchange

COMPTROLLER GENERAL'S  
REPORT TO THE CHAIRMAN  
SUBCOMMITTEE ON THE  
ENVIRONMENT  
COMMITTEE ON COMMERCE  
UNITED STATES SENATE

FEDERAL PROGRAMS FOR RESEARCH  
ON THE EFFECTS OF AIR POLLUTANTS  
Environmental Protection Agency

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D I G E S T

The Environmental Protection Agency does not have enough manpower, funds, or facilities to do the research needed to develop a sound information base for air quality standards established to protect public health and the environment.

Much more research is needed on the health and ecological effects of air pollutants to support adequately and/or modify present national air quality standards and motor vehicle emission standards and to identify and set standards for other pollutants.

In fiscal year 1974 the Agency obligated \$25 million for research on the effects of air pollutants. Preliminary estimates for an adequate research program ranged from \$45 million to \$70 million a year. (See pp. 4 to 12.)

In contrast, the Agency estimated that by 1979 capital investment in air pollution control abatement to meet these standards would total \$47 billion and annual costs would be \$17 billion.

The Environmental Protection Agency should periodically prepare estimates of the resources needed for an adequate air pollution effects research program, even though all its needs may not be ultimately funded. Only in this way can the Congress, the Office of Management and Budget, and the Public have a perspective of total air pollution research needs and of that portion not funded.

The Agency's research planning was highly complex, overly structured, and generated a great deal of dissatisfaction among its officials. The system can best be described as a "blizzard of paper." (See ch. 3.)

The Agency should establish criteria or guidance for setting research priorities, should develop an air pollution control strategy which would facilitate better research planning, and should prepare better financial reports for research managers planning research and allocating resources.

The research program was reorganized on June 1, 1975. According to the Agency, administrative issues raised by GAO were problems that the reorganization attempted to solve. The Agency is taking a number of steps in line with GAO's recommendations. (See pp. 47 and 48.)

GAO identified six other agencies in three Federal Departments conducting or supporting research on the effects of air pollutants.

The Clean Air Act directs the Environmental Protection Agency to promote research coordination, but it has taken little positive action and has no written policies, procedures, or regulations for coordination. Some coordination occurred on a scientist-to-scientist basis.

GAO also found that Agency scientists were unaware of research similar to their own being funded by other Federal agencies. A certain amount of planned redundancy might be beneficial. However, when redundancy is not planned, unnecessary duplication and inefficiency can occur. This is an important problem because needed research exceeds available resources. (See ch. 4.)

The Environmental Protection Agency cited a number of its coordinating activities. However, more research coordination, including a more systematic method to disseminate research information among all Federal agencies, would improve the information base for regulatory actions. GAO has so recommended. (See p. 47.)

## CHAPTER 1

### INTRODUCTION

In a letter dated October 16, 1973 (see app. I), the Chairman, Subcommittee on the Environment, Senate Committee on Commerce, requested us to examine the Environmental Protection Agency's (EPA's) research activities for the effects of environmental contaminants, with special emphasis on air pollution. The Chairman asked that our assessment include

- the adequacy of EPA manpower, funds, and facilities used for research,
- research needs established by EPA and the priorities assigned to them,
- the extent to which research needs have been met, and
- EPA's coordination with other Federal agencies conducting similar research.

The Chairman stated that EPA scientists have questioned whether the agency has the necessary resources to properly determine the public health and environmental effects of pollutants, especially air pollutants.

In a subsequent meeting with the Chairman's office we agreed to concentrate our review on research activities for the effects of air pollutants, the research area of prime interest to the Chairman. We pointed out that many findings resulting from our review of EPA's system for establishing air pollution needs and for assigning them priorities would be applicable to other research areas which are subject to the same system. The scope of our review is in Chapter 6.

### ENVIRONMENTAL PROTECTION AGENCY

EPA was established on December 2, 1970, in accordance with Reorganization Plan No. 3 of 1970. Before that date the air pollution control program was administered by the Department of Health, Education, and Welfare. Under the Clean Air Act, (42 U.S.C. 1857)(1970), EPA sets two types of national ambient air quality standards: (1) primary standards for protection against the effects of air pollutants on the public health and (2) secondary standards for protection against the effects of air pollutants on soil, water, vegetation, materials, animals, weather, visibility, and personal comfort and well being. The act requires States to adopt plans for implementing, maintaining, and enforcing



national ambient air quality standards in air quality control regions. Also, the act provides for a program to reduce air pollution from motor vehicles by prohibiting the sale of vehicles that do not conform to Federal emission standards.

The Clean Air Act provides that EPA establish a national research and development program for the prevention and control of air pollution and that it consult with other appropriate Federal agencies to coordinate its research with them. EPA's Office of Research and Development (OR&D) is responsible for developing, directing, and conducting a national research program principally to support EPA standards by obtaining sound data on the impact of pollutants on human health and ecological stability and to develop control technology. In-house research is conducted at OR&D'S National Environmental Research Centers (NERCs) in Research Triangle Park (RTP), North Carolina; Cincinnati, Ohio; Corvallis, Oregon; and Las Vegas, Nevada; and at other laboratories associated with NERCs. Extramural research is carried out under research contracts and grants with public and private organizations and under agreements with other Federal agencies.

Most of EPA's in-house research and monitoring of extramural research on the effects of air pollutants is performed by NERC-RTP. In addition, research on air pollution health effects is done at the Cincinnati NERC's Environmental Toxicology Research Laboratory and on air pollution ecological effects at the Corvallis NERC's National Ecological Research Laboratory.

## CHAPTER 2

### ASSESSMENT OF EPA'S

#### AIR POLLUTION EFFECTS RESEARCH PROGRAM

Various studies and knowledgeable officials, within and outside of EPA, have concluded that EPA does not have adequate resources--manpower, funds, or facilities--to conduct the research needed to develop a sound information base for air quality standards required by the Clean Air Act.

The need for air pollution research has become more apparent in recent years since the Clean Air Act required national standards of ambient air quality to protect public health and the environment. Research provides scientific information for determining the point to which pollution levels must be reduced to protect the public health and environment. EPA's research is directed toward establishing adequately protective air quality standards which are also technologically and economically feasible.

Benefits of improved air quality are measured by reduced pollution costs which include the cost of damages to human health, man-made materials, and vegetation. In a report released in October 1974, EPA estimated that the annual cost of air pollution damages in 1970 ranged from \$6.1 billion to \$18.5 billion, with the best estimate being \$12.3 billion. EPA also estimated that by 1979 capital investment in air pollution control abatement under the Clean Air Act would total about \$47 billion and that the annual cost of curbing air pollution would be about \$17 billion. EPA noted that its estimates did not provide an adequate basis for accurately comparing the cost and benefits of abating air pollution. One major problem is that not all the benefits have been measured.

Through its research programs, EPA has:

- Obtained scientific data on some pollutants' safe levels and established air quality standards for the six most common air pollutants.
- Obtained data that demonstrates the benefits of improved air quality for people with respiratory diseases.
- Provided evidence that indicates the adverse health effects associated with exposure to suspended sulfates.

--Initiated studies to evaluate the potential health effects of fuel emissions from internal combustion engines.

Air quality standards have fostered establishing State and local air pollution control regulations which have resulted in air quality improvements. In addition, through the research performed in preparation for establishing the standards, EPA has increased its knowledge of the effects of these pollutants.

EPA scientists and the National Academy of Sciences agree that much more research is needed on the health and ecological effects of air pollutants to adequately support and/or modify present national ambient air quality standards and motor vehicle emission standards and to identify and set standards for other pollutants for which standards have not yet been set by EPA. EPA has identified major gaps in research knowledge.

In his comments on the uncertainties of the scientific information base for the standards, an EPA NERC Director stated in October 1973 at a conference on health effects sponsored by the National Academy of Sciences that:

"\* \* \*uncertainties about a standard which itself requires the stringent control of emissions will inevitably result in major uncertainties in the justification of control costs. The uncertainties inherent in the present standards are without a doubt billion dollar uncertainties. \* \* \*Clearly, it is wise to clear up major uncertainties as rapidly as possible to avoid wasteful expenditures and to assure the development of needed new control technology." (Underscoring supplied.)

#### INADEQUATE RESOURCES FOR RESEARCH ON THE EFFECTS OF AIR POLLUTION

Each year the Office of Management and Budget assigns EPA a total resource figure. EPA must then divide the total among all its programs. EPA cannot get all the resources needed for all its programs, so priorities must be set and the resources divided accordingly.

Various studies and knowledgeable officials, within and outside of EPA, have concluded that EPA does not have adequate resources--manpower, funds, or facilities--to conduct the research needed to develop a sound information base for air quality standards required by the Clean Air Act.

For fiscal years 1972, 1973, and 1974, obligations for air pollution health effects research totaled \$6.1 million, \$11.7 million, and \$11.6 million respectively. For the same fiscal years obligations for ecological processes-and-effects <sup>1/</sup> research totaled \$9.3 million, \$13.4 million, and \$13.7 million. If obligations during the fiscal year 1974 were continued at the same level in future years they would be less than one-quarter of one percent of the estimated national annual cost of \$17 billion.

We obtained numerous examples of research needed to fill gaps in the scientific information base for ambient air quality standards but which could be undertaken only if additional resources became available. For example, additional research could be done on the

--long-term (chronic) effects of pollutants at low levels and

--effects of air pollutants on vertebrates, insect-plant interactions, food chain processes, and water.

We obtained several estimates from various sources on the funds needed for a research program designed to insure a sound information base for regulatory actions under the Clean Air Act. For EPA air pollution health effects research the estimates ranged from \$25 million annually for a minimally adequate program to \$50 million annually for a comprehensive program; an EPA official estimated \$20 million would be needed annually for a national program for ecological effects research.

#### Manpower, funds, and facilities for EPA's research program

EPA's research on the health effects and ecological effects of air pollution is carried out (1) through work at several EPA NERCs (in-house research) and (2) through grants and contracts with public and private agencies, institutions, and individual and interagency agreements

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<sup>1/</sup>Research on the processes of pollution is concerned with the sources, fate, and effects of pollutants in the environment and with determining mechanisms by which they pass through the food chain and related ecosystems. Research on pollution effects is concerned with determining effects on man, animals, plants, materials, and the general environment. Throughout this report, we use the term "ecological effects" to include both research on the processes and the effects of pollution.

(extramural research). About 69 percent of the funds obligated in fiscal year 1974 was for extramural research. Most of the in-house research and monitoring of extramural research is performed by NERC-RTP. In addition, some biomedical research on health effects is done at NERC-Cincinnati and research on ecological effects is conducted at NERC-Corvallis.

Manpower

The following table shows the professional staff at the NERCs directly involved in air pollution effects research activities for fiscal years 1972, 1973, and 1974.

Professional Staff at the NERCs Directly Involved  
in Air Pollution Effects Research at the End of  
Fiscal Years 1972, 1973, and 1974

	<u>Number of staff</u>		
	<u>1972</u>	<u>1973</u>	<u>1974</u>
Health effects:			
Pollution characterization	6	7	9
Community Health Effects Surveillance Studies (CHESS)	38	70	71
Biomedical research	<u>76</u>	<u>42</u>	<u>40</u>
Total health effects	<u>120</u>	<u>119</u>	<u>120</u>
Ecological effects:			
Fuel and fuel additive registration	2	5	7
Regional Air Pollution Study (RAPS)	0	6	7
Ecological impact of air pollution	29	23	18
Formation and decay of pollutants	14	13	20
Meteorological research	<u>a/ 42</u>	<u>a/ 39</u>	<u>a/ 38</u>
Total ecological processes-and-effects	<u>87</u>	<u>86</u>	<u>90</u>
Total	<u>207</u>	<u>205</u>	<u>210</u>

a/Includes National Oceanic and Atmospheric Administration staff working under the direction of NERC-RTP through an interagency agreement as follows: 38 in 1972, 35 in 1973, and 35 in 1974.

NERC-RTP has the primary responsibility for health effects research. At the end of fiscal years 1972 and 1973 about 33 percent of the professional staff held doctorate degrees, 30 percent held master's degrees, and 37 percent held bachelor's degrees. At the end of fiscal year 1972, there were 30 medical doctors and 25 at the end of fiscal year 1973, a decrease of 17 percent.

The NERC-RTP Director estimated that an additional 95 staff members were needed to carry out the fiscal year 1974 air pollution effects research program. The Director said the greatest staff need was for scientists to administer extramural research. According to NERC officials, staff inadequacies result from (1) limitations by higher EPA authority on the total number of staff that can be hired and (2) average grade-level ceilings imposed by higher EPA authority. Obligations incurred for air pollution effects extramural research by NERC-RTP shows that obligations almost doubled from \$8.2 million in fiscal year 1972 to \$17.5 million in fiscal year 1974 while the number of staff increased by only 3. The Director also said that more physicians with specialties in epidemiology were needed for health effects studies.

The Director, Environmental Toxicology Research Laboratory, NERC-Cincinnati, said 17 additional staff members were needed for the fiscal year 1974 research program including a pathologist, pulmonary physiologist, biological chemist, organic chemist, inhalation toxicologist, aerosol physiologist, behavioral toxicologist, and some technicians. He also needed contract monitors and a technical science writer. According to an EPA official, several additional staff had been requested in fiscal year 1974 but only a few were added.

The Director said that because of a lack of adequate resources, important research on the effects of such air pollutants as manganese, cadmium, mercury, lead, and fuel additives had to be terminated in fiscal year 1974 when the laboratory was directed by OR&D to undertake studies on the catalytic converter, a pollution control device used on many 1975 cars. He said that the data developed under the terminated studies was not adequate to serve as a basis for setting standards.

He agreed that EPA needed to have data on catalytic converters, but he added that these studies required about 90 percent of the laboratory's research activities in fiscal year 1974 and was expected to total about 90 percent in fiscal year 1975. As a result, important research--useful in setting air pollution standards--on the effects of such hazardous pollutants as mercury and lead had to be delayed at least 2 years.

The professional staff at the National Ecological Research Laboratory at NERC-Corvallis increased from 18 at the end of fiscal year 1973 to 19 in fiscal year 1974. NERC-Corvallis officials said that a ceiling has been imposed by EPA headquarters because of the ceiling approved by the Office of Management and Budget which has prevented any major changes

in the number or composition of the laboratory's professional staff. Laboratory officials stated that, because of the ceiling, they are attempting to obtain key researchers for 1- to 3-year periods in a way that would not affect their personnel ceiling. In November 1974 officials said three researchers had been hired under the Intergovernmental Personnel Act. In fiscal year 1975 one researcher was hired under the National Science Foundation's Post-Doctoral Program. Two more researchers have been assigned by the National Science Foundation for fiscal year 1976 under the same program and have accepted the positions. NERC also was able to increase its use of temporary technical personnel.

The need for more manpower at the NERCs is contrasted with indications that OR&D headquarters is overstaffed. An internal study by the Director of EPA's Management and Organization Division during July and August 1972 concluded, among other things, that OR&D was overstaffed by about 65 of a total of 169 positions. In August 1974 the Director said that there had not yet been any action to reduce the OR&D headquarters staff.

According to an October 3, 1974, EPA task force report which studied the OR&D planning process, the EPA Deputy Administrator informed the task force of his desire to reduce the number of headquarter's OR&D personnel. Also, in February 1975, the Administrator informed several Members of Congress of his intent to reorganize OR&D. The reorganization was announced in an EPA Order dated April 24, 1975, and indicated that some staff realignment would be necessary.

### Funds

Obligations for air pollution effects research for fiscal years 1972, 1973, and 1974 were \$15.4 million, \$25.1 million, and \$25.3 million respectively. Health effects research obligations comprised \$6.1 million in fiscal year 1972, \$11.7 million in fiscal year 1973, and \$11.6 million in fiscal year 1974, while ecological effects research obligations for fiscal years 1972, 1973, and 1974 were \$9.3 million, \$13.4 million, and \$13.7 million respectively.

Obligations for Air Pollution  
Effects Research For  
Fiscal Years 1972, 1973, and 1974

	<u>Obligations--fiscal years</u>		
	<u>1972</u>	<u>1973</u>	<u>1974</u>
	----- (000 omitted) -----		
Health effects research:			
Pollutant characterization	\$ 734	\$ 966	\$ 723
Community Health Effects Sur- veillance Studies (CHESS)	1,874	6,542	6,949
Biomedical research	<u>3,537</u>	<u>4,149</u>	<u>3,943</u>
Total health effects	<u>6,145</u>	<u>11,657</u>	<u>11,615</u>
Ecological effects research:			
Fuel and fuel additive regis- tration	1,391	1,066	2,048
Regional Air Pollution Study (RAPS)	-	4,668	3,905
Ecological impact of air pol- lution	1,675	1,707	1,989
Formation and decay of pol- lutants	2,596	3,007	2,826
Meteorological research	<u>3,591</u>	<u>2,989</u>	<u>2,963</u>
Total ecological effects research	<u>9,253</u>	<u>13,437</u>	<u>13,731</u>
Total	<u>\$15,398</u>	<u>\$25,094</u>	<u>\$25,346</u>
Net change over prior fiscal year		+9,696	+252

The RAPS program began in fiscal year 1973, and during that year the CHESS program was expanded from one to several locations. These two programs accounted for \$9,336,000 of the net increase in research funds of \$9,696,000 in fiscal year 1973. A NERC-RTP official said part of the fiscal year 1973 funds originally planned for the meteorological research program were transferred to the RAPS program. If obligations totaling \$25.3 million for fiscal year 1974 air pollution effects research are continued at the same level in future years, they would be less than one-quarter of one percent of the 1979 estimated annual cost of \$17 billion to control air pollution. In contrast, the national average for industry is about 4 percent of net sales for research



## Facilities and equipment

EPA conducts air pollution processes-and-effects research at three NERCs. As shown below, the majority of this research is conducted at NERC-RTP.

At NERC-RTP eight buildings were used to conduct air pollution effects research as of June 1974. Two buildings were Government-owned and six were leased. The research staff utilized 40,586 square feet for health effects research and 48,440 square feet for ecological effects research, which together represent 24 percent of NERC-RTP's total net usable space. An additional 21,424 square feet of warehouse space was used to store equipment for the research indicated above. As of February 1974 NERC-RTP had approximately \$4.6 million in research equipment used for air pollution processes-and-effects research.

At NERC-Cincinnati the Environmental Toxicology Research Laboratory building is leased by the General Services Administration for \$212,600 a year and contains about 62,700 square feet of space, of which 48,800 square feet is usable space. As of February 1, 1974, about 11,800 square feet, or 24 percent of the usable space, was unoccupied. The unoccupied space is primarily office space which we were told was vacated in October 1973 when two NERC administrative offices were moved to another EPA facility in Cincinnati. In July 1975 the new EPA Environmental Research Center building was dedicated in Cincinnati. The laboratory was to be moved into the new building in September 1975. The December 31, 1973, laboratory inventory records showed 653 pieces of equipment costing about \$1,078,000. As of July 1975, a laboratory official estimated equipment to be about 600 pieces and to cost about \$1 million.

As of July 1975, the NERC-Corvallis National Ecological Research Laboratory occupied about 4,000 square feet of the laboratory and office space in the main building at NERC-Corvallis and about 5,000 square feet in new office trailers. Additional laboratory and office space (1,218, square feet) and a small greenhouse (1,800 square feet) were leased from the Agricultural Research Service. The laboratory had effects research equipment which cost about \$666,400.

Inadequate facilities hinder research.--A June 1971 EPA report stated that the research center at NERC-RTP, where most of laboratory space used for air pollution effects research is located, has safety problems. The report identified the major problems as

--uninsulated steel columns and girders,

- lack of a fire sprinkler system,
- lack of spark-proof fume hoods in laboratories,
- inadequate ventilation and air conditioning, and
- inadequate fire walls between laboratories.

The NERC-RTP Acting Director suspended all research classified as hazardous in 71 laboratory units at the research center in October 1972 for as long as 6 months until laboratory changes could be made to decrease the amount of risk involved. As of February 1974, the research center still did not meet the Occupational Safety and Health Administration and EPA safety standards for hazardous laboratory operations despite the changes made to the laboratory units. According to one laboratory official, his work has been delayed at least 3 months and restricted because of safety problems.

Also, in June 1974 the NERC-RTP officials said that the greenhouse at NERC-RTP, where about 2,500 square feet was used to shelter test animals for air pollution effects research, was grossly inadequate because the space for housing and maintaining the research animals was not large enough.

EPA used leased space in 15 buildings; most of them in RTP and several others in Durham and Chapel Hill, North Carolina. According to a February 1974 laboratory plan, EPA is to consolidate all EPA personnel from the 15 buildings into 5 leased buildings within the next 2 years. Four of the buildings are in RTP. The plan further stated that none of the 15 leased buildings meet Occupational Safety and Health Administration and EPA safety standards for hazardous laboratory operations. However, five buildings in which the most hazardous operations are to be conducted on an interim basis are considered safer than the main technical center building of NERC.

The NERC-RTP Director said that the best solution to the need for adequate facilities was to build a new research laboratory at RTP. He estimated that the laboratory would cost \$50 million, excluding the cost of land already owned by the Government, and that about one-half the laboratory space would be used for air pollution effects research.

The Director of the Environmental Toxicology Research Laboratory at NERC-Cincinnati stated that the research facilities were adequate but the equipment was not. He said that up to 50 percent of the equipment was either outdated because it was the electronic tube type which did not work

properly or was inoperable due to the lack of replacement parts.

In January 1973 the Division of Ecological Research was transferred from NERC-RTP to NERC-Corvallis where no formal plans had been made to meet facility needs of the division. (See GAO report on the "Circumstances Surrounding the Transfer of the Division of Ecological Research from Research Triangle Park, North Carolina, To Corvallis, Oregon," January 5, 1973, B-177222.)

Overall, the unavailability of facilities and the time required to reestablish the research effort after moving between facilities reduced the level of in-house research activities during fiscal years 1971 through 1973. A laboratory official estimated that the program suffered a 10-percent reduction in research output during those years compared to what could have been accomplished with adequate facilities. In addition, the mix of research projects was modified in that some long-term experiments were postponed and replaced by short-term activities (e.g., problem analysis, state-of-the-art, reviews, etc.) after the move to NERC-Corvallis was announced. A laboratory official said that by fiscal year 1975, the work had resumed a normal tempo.

During fiscal years 1974-75, according to a laboratory official, the laboratory space was increased thereby making the research facilities more adequate than they had been. A laboratory official said, however, that construction delays of planned greenhouses could hinder their research efforts. They said that although the lack of facilities had been the major problem in the past, manpower and funding limitations would be the overriding concern in the future.

#### MORE RESEARCH REMAINS TO BE DONE

We were told on many occasions, and many reports confirmed, that there is a need for much more research on health and ecological effects of air pollutants. The following quotes are examples of the comments that we received.

#### Health effects

The summary of the National Academy of Sciences' Conference on Health Effects of Air Pollutants in October 1973 stated:

"The present standards rest upon the best judgments which could be made of effects observed under far from ideal observing or experimental

conditions. The impressions gained from the collective presentations and attitudes of those who participated in the conference is that, from the standpoint of health considerations, it would be prudent to retain the present standards until a substantial body of research provides much better evidence than any currently available to indicate that the primary air quality standards should be either relaxed or made more stringent."

During the same National Academy of Sciences' conference, the NERC-RTP Director said:

"Realistic assessment of our current information base shows that major gaps exist for each of the pollutants covered by the primary ambient air quality standards."

His assessment of existing information and the gaps in research data is presented in appendix III.

In this regard, the Acting Director of EPA's Experimental Biology Laboratory stated in a June 1974 memorandum to the NERC-RTP Director that:

"If our Agency is to assure that its regulatory programs adequately protect public health, we must better understand the interactive effects of environmental pollutants. \* \* \*Frankly, we have as an Agency, failed to meet this clear scientific and regulatory challenge."

### Ecological effects

An EPA document entitled "Ecological Effects of Air Pollution" which defined specific research objectives for fiscal year 1974 stated:

"National Secondary Air Quality Standards were based upon the generally sparse state of knowledge of earlier work. \* \* \*Because several states have based their air pollution control programs on National Secondary Standards, it is of utmost importance that the validity of these standards, some of which were founded on questionable effects research data, be examined."

In a February 1974 memorandum to EPA headquarters, the Director of the Office of Air Quality Planning and Standards stated, with regard to the ecological effects (also referred to as "welfare" effects), that:

"The purpose of the memorandum is to express some of our concerns and thoughts for an expanded and structured EPA 'welfare' effects research program. We are especially concerned that the basis for secondary standards be improved. Current air pollution standards for SO<sub>2</sub> [sulfur dioxide] and TSP [total suspended particulates] are based on incomplete welfare effects data. The SO<sub>2</sub> standard, for example, is based upon vegetation damage in a three-hour period. The TSP standard is based on the calculation of visibility reduction over a five-mile range. Because of lack of data, the standards do not consider chronic effects on, plants, synergism, acid rain, effects on materials, esthetics such as odors, meaningful visibility effects, and property values. These factors may provide the economic justification for many types of air pollution control and will probably form the basis for a future 'round' of control programs."

We discussed research needs with various EPA officials and scientists and reviewed many EPA and other reports to identify specific areas where additional research is needed to increase the research knowledge base for primary and secondary ambient air quality standards. The following section of this report discusses some of these areas.

#### Research that could be undertaken with more resources

An August 1973 EPA draft strategy study on air pollution health effects research stated that existing studies were adequate to define a risk to health but did not define the true impact on health of pollutants covered by the six primary standards. The study also said that the present body of knowledge was insufficient to precisely determine where standards should be set. The study further stated that a reasonably complete scientific assessment concerning human health effects of air pollution required blending three health disciplines: epidemiology, clinical studies, and toxicology. The table below, obtained from the draft strategy study, summarized EPA's state of knowledge for those disciplines.

<u>Standard</u>	<u>Research</u>		
	<u>Epi- miology</u>	<u>Clinical studies</u>	<u>Toxicology</u>
Sulfur oxides	Adequate	Inadequate	Minimally adequate
Particulate matter	Adequate	Inadequate	Minimally adequate
Carbon monoxide	Inadequate	Adequate	Inadequate
Nitrogen oxides	Inadequate	Inadequate	Minimally adequate
Photochemical oxidants	Inadequate	Inadequate	Adequate
Hydorc carbons (note a)	-	-	-

a/The standard for hydorc carbons is based on the formation of photochemical oxidants. These oxidants are formed by the action of sunlight on the oxides of nitrogen and hydrocarbons on the air.

During our review, EPA officials stated that EPA still did not have adequate data for any of the six primary air pollutants covered by the standards. EPA laboratory officials identified four pollutants where additional research was needed: sulfur oxides, nitrogen oxides, ozone, and aerosols. They and headquarters officials identified the following specific research areas, which had not been pursued due to a lack of adequate funds and manpower. 1/

- Long-range transport and transformations of sulfur oxides and nitrogen oxides in power plant plumes and urban plumes.
- Oxidant formation in plumes from hydrocarbon sources and other organics, such as petroleum refineries and petrochemical and chemical manufacturing facilities.
- Transport of a pungent, colorless, toxic gas called ozone in urban plumes.
- Identification of new pollutant species formed by atmospheric reactions.

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1/In a letter dated October 24, 1975, EPA supplied us with a partial list of studies for fiscal years 1975-76. (See app. II.) The research was started after our review was completed.

--Research on pollutants for which EPA has not yet set standards

--Effects of long-term exposure to air pollutants.

The National Academy of Sciences supported EPA's contention that more research was needed. A September 1974 report to the Senate Committee on Public Works discussed air quality and automobile emission control. It stated that more Federal funds appear to be warranted for evaluative research and identified four broad areas which deserve high priority for allocating such funds, as follows.

--Epidemiological studies of the human health effects of air pollutants.

--Studies for improving the data for measuring ambient air quality.

--Modeling, using known techniques, the interactions and chemical transformations of pollutants in the atmosphere.

--Laboratory studies aimed especially at establishing the effects of pollutants on animal health and relating these to their effects on man.

With regard to ecological effects research, officials of EPA's National Ecological Research Laboratory in NERC-Corvallis pointed out that EPA's research has been primarily to observe and describe the more apparent, short-term effects of air pollutants on a limited variety of plants (mostly crops). The Clean Air Act however, required EPA to conduct research on the short- and long-term effects of air pollutants on "soils, crops, vegetation, animals, wildlife," not just on plants.

Officials said that there was an overall need for research on long-term (chronic) effects of pollutants at low levels to show whether secondary air quality standards are sufficient to prevent long-term degradation of ecosystems. They said that more resources were needed to do the following research.

--The effects of air pollutants on birds, vertebrates, insect-plant interactions, food chain processes, and water.

--Development mathematical models to predict the impact of air pollutants on rate of growth succession, and species diversity in agriculture, forest, and other vegetative regimes.

## Resources needed for an adequate research program

EPA does not prepare on an annual basis estimates of resources needed to carry out an adequate air pollution effects research program. Such information would provide the Congress, the Office of Management and Budget, and the public with a perspective of total air pollution needs. An EPA task force of scientists prepared a draft report stating that an optimal health effects research program for fiscal year 1973 would have cost in excess of \$100 million, of which over \$40 million would have been needed for air pollution research alone. The report stated that a minimally adequate plan would have cost in excess of \$65 million, of which over \$25 million should have been designated for air pollution health effects research, as compared to EPA obligations of \$11.7 million for such research in fiscal year 1973.

We obtained preliminary estimates of what resources were needed from the research laboratory officials. A NERC-RTP official in the Human Studies Laboratory stated that a comprehensive health program would require a funding level of \$50 million annually and a professional, support, and clerical staff of 300. EPA's professional staff totaled only 119 in fiscal year 1973 and 120 in fiscal year 1974.

The NERC-Cincinnati Environmental Toxicology Research Laboratory Director said that if the EPA research program is to be most effective it should be increased fourfold. He expressed the belief that his in-house program could be most effective if it were funded at \$2.5 million annually and had about 100 people, or double the current program resources.

Officials of the National Ecological Research Laboratory at NERC-Corvallis estimated that the laboratory needed about \$5 million to \$6 million annually and a permanent research staff of 50. In fiscal year 1973 EPA obligated \$1.5 million for laboratory research activities and the laboratory had a professional staff of 18. Laboratory officials stated that the permanent staff have predominantly plant-oriented backgrounds and that additional expertise is needed in zoology, meteorology, soils, microbiology, ecosystems, and mathematical modeling to do broad ecosystem research.

We discussed the above estimates made by NERC officials with the then Assistant Administrator for Research and Development in May 1974, shortly before he left EPA, who said that he considered the estimates reasonable. He said that the funding level for research to set air pollution standards for the six major pollutants has not been adequate and that three hazardous air pollutants (asbestos, beryllium, and mercury)



and twenty-six other pollutants also needed research. He cautioned, however, that one should consider the needs of the entire EPA organization, not just certain components, to most accurately estimate the level of funds and manpower needed.

In addition to our discussion with NERC officials and the Assistant Administrator, we also asked the Director, NERC-RTP, to provide us with rough estimates of the resources and time needed for a research program to insure a sound health and ecological effects information base for regulatory action under the Clean Air Act. We also stated that his estimate could include research that might be undertaken by other Federal agencies.

In May 1974, he estimated that the needed research would require between 5 to 10 years but that significant advances would be apparent within 2 years. The needed research would involve roughly \$80 million to \$90 million annually and about 600 full-time positions. In addition to the \$50 million for adequate facilities previously mentioned (see p. 11), of which about one-half would be used for air pollution effects research, \$20 million would be needed for research facilities. The following table shows the estimates prepared by the Director.

Estimated Resources Needed to Meet  
Clean Air Act Requirements

<u>Research area</u>	<u>Health effects</u>	<u>Atmospheric and ecological effects</u>	<u>Pollutant characterization (note b)</u>	<u>Total</u>
----(000 omitted/SY) (note a)----				
Ambient air quality standards	\$ 7,645/47	\$ 7,200/54	\$1,990/27	\$16,835/128
Stationary source control	12,100/73	1,350/17	500/7	13,950/97
Unregulated mobile source emissions	11,655/79	2,900/15	2,580/19	17,135/113
Fine particulate	9,005/53	3,950/24	290/4	13,245/81
Non-deterioration of air quality	-	1,540/13	200/3	1,740/16
Interactions of pollutants	10,230/66	1,900/17	590/8	12,720/91
New problem definition	<u>6,500/38</u>	<u>850/7</u>	<u>885/15</u>	<u>8,235/60</u>
	<u>\$57,135/356</u>	<u>\$19,690/147</u>	<u>\$7,035/83</u>	<u>\$83,860/586</u>

a/SY = staff years

b/GAO note: EPA's research planning system classified pollutant characterization as health effects research.

We recognize that the above estimates are rough, but they do indicate key EPA research officials' belief that a substantial increase in resources is necessary to develop a sound information base for air pollution standards and enforcement of those standards.

The National Academy of Sciences, in its September 1974 report on air quality and automotive emission control to the Senate Committee on Public Works, agreed that more resources were needed for research on effects of air pollutants.

"The committees engaged in this investigation have \*\*\* become painfully aware of the inadequacy of the existing information base for the decisions that have to be made. The costs that will be incurred by our society in controlling automotive emissions are of the order of \$5 to \$10 billion per year. In comparison, the annual expenditures by the Federal government in recent years for evaluative research have been relatively small: to study the health effects of air pollution, perhaps \$10 million; to study the costs and benefits of controlling automotive emissions, less than \$1 million; to study the relation of emissions to air quality, less than \$10 million. The significant reduction of the uncertainties in decision making for these topics depends on the generation of new knowledge. Much large commitments of Federal funds to these tasks appear to be warranted."

## CHAPTER 3

### ADMINISTRATIVE PROBLEMS IN EPA'S RESEARCH PROGRAM

There are numerous administrative problems in EPA's research program. EPA's research planning is highly complex, overly structured, and has generated a great deal of dissatisfaction among EPA officials. We believe that EPA needs an air pollution control strategy to better plan its research activities to support that strategy and better financial information on its research activities. We also found that EPA research program may have been somewhat hampered by the high turnover of key EPA scientists responsible for research on the effects of air pollutants.

#### EPA'S RESEARCH PROGRAM PLANNING AND REPORTING SYSTEM IS HIGHLY COMPLEX AND OVERLY STRUCTURED

In March 1972 EPA formally established the research Program Planning and Reporting System to assist OR&D in meeting the research requirements of the agency through a formal process of identifying research needs, defining specific research objectives, developing detailed plans to accomplish these objectives, establishing priorities, and assigning resources and responsibilities for executing approved plans. A report on an internal study during July and August 1972 by the Director of EPA's Management and Organization Division concluded that OR&D's program planning and development activities were overly structured, difficult to comprehend and operate, and did not appear to significantly support top management in its decisionmaking responsibilities.

Merely to describe the system is in itself a difficult task. Under the system EPA's research and development program is divided into 16 program areas (health effects research is one such program area) established to bring related research activities under the common management and control of a program area manager. The program area manager is an OR&D headquarters division director responsible for defining research objectives and priorities, allocating resources, and reviewing and monitoring work conducted within his area.

Each program area is made up of program elements. They were established to bring the activities in a specific subject area under the common direction of a program element director who, in most cases, is a laboratory director within one of the NERCs. His responsibility is to provide the detailed planning and estimates of resource requirements for all tasks necessary to accomplish the specific research objectives identified by the program area manager and to direct the implementation of approved plans.

## The OR&D Needs System

The OR&D Needs System, which is part of the Program Planning and Reporting System, is the formal mechanism for identifying research needs. Environmental research need statements are prepared to define environmental problems which cannot be solved satisfactorily with existing technology or scientific knowledge. Anyone can submit need statements, but OR&D actively solicits them from EPA regional and headquarters program office personnel and from State and local environmental regulatory offices.

Initially need statements are submitted to the appropriate EPA need sponsors who are the ten regional office administrators, five program office assistant administrators, and the Administrator. Need statements are reviewed, approved, and ranked in priority by need sponsors and then forwarded to OR&D for review by the program area manager and for consideration along with others for incorporation into OR&D's proposed research program. Program area managers review and select the needs to be considered for inclusion in the program.

Need statements were first used by EPA to develop the fiscal year 1973 research program.

### Research objectives and plans

After the decision has been made on which needs will be included in the program, the detailed research planning cycle begins. The program area manager prepares Environmental Research Objective Statements (EROSs) which define specific research objectives and prescribe the criteria for assessing the research output. EROSs are sent to the appropriate program element directors who develop detailed plans for various tasks to achieve the specific objectives. The plans, called Research Objective Achievement Plans (ROAPs) are the basis for all research, development, and demonstration activities conducted by OR&D. In essence, an EROS defines what the objective is and when it needs to be achieved. A ROAP defines how it is to be achieved and what resources are required.

ROAPs and plans for other OR&D activities such as support management, overhead, and technical assistance are submitted to the Program Assessment Group, a group of senior OR&D officials who develop the annual OR&D program plan.

Program areas and elements for  
air pollution effects research

Our work dealt primarily with eight program elements within the health effects and the ecological effects program areas as follows.

<u>Program area</u>	<u>Program element</u>
Health effects	Pollutant characterization
	Community Health Effects Surveillance Studies (CHESS)
	Biomedical research
Ecological effects	Fuel and fuel additive registra- tion
	Regional Air Pollution Study (RAPS)
	Ecological impact of air pollution
	Formation and decay of pollutants
	Meteorological research

A description of each EROS and ROAP funded in the two program areas for fiscal year 1973 is presented in appendix V.

Problems with the program planning  
and reporting system

During our review we sent questionnaires to key EPA scientists in the field and at headquarters and held discussions with EPA regional officials and officials of the EPA Office of Air Quality Planning and Standards--a major user of OR&D research--to obtain their opinions of the OR&D planning system. These scientists and officials expressed a great deal of dissatisfaction with the system.

The following are examples of the many comments we received.

--"Insufficient preliminary review and input by the NERC to Headquarters Management. Research objectives should be jointly determined, so a clear objective would be available and understood by everyone."

- "\* \* \*Extending the system, by subdividing program elements into ROAP's requiring extensive headquarters review has been counterproductive in terms of outputs.\* \* \*"
- "The present NEEDS system should be modified or replaced with a simpler system which utilizes the scientific, rather than clerical, skill of the research staff.\* \* \*"
- "\* \* \*There are far too many ROAPs for the headquarters and field people to keep track of, consequently they tend to be approximately useless except for a means of requesting money and manpower. \* \* \*"
- "\* \* \*There is no specific system established for the setting of priorities in research; what exists is a system of assigning responsibilities for carrying out types of work to specific Assistant Administrators, who in turn establish their own internal management systems which may or may not be formalized into some identifiable way of setting priorities. \* \* \*"

Virtually every EPA scientist contacted agreed with the following assessment made by one EPA official.

"\* \* \* [An] issue is the waste of precious time and manpower that results from the complicated research planning system, which transmits excessive detail to almost every level of the research hierarchy and the lack of authority for resource management at the operational level. Decision making is too remote from the execution level \* \* \*."

Our review confirmed that many problems were associated with the planning system.

One problem was the tremendous volume of paperwork involved. The former Assistant Administrator for Research and Development referred to it as a "blizzard of paper" and many other officials have criticized it in a similar manner. An official in the Office of Air Quality Planning and Standards stated that the volume of paperwork was the single most important deficiency of the system.

Need sponsors submitted 2,843 need statements to OR&D in fiscal year 1973 and 2,215 statements in fiscal year 1974. In many cases, the statements were vague or illegible. Program area managers had to contact need sponsors for clarification on about 25 percent of the statements submitted by them for fiscal year 1974.

NERC-RTP officials also commented on the excessive amount of paperwork. For example, one program element director prepared 10 different plans for his program area for fiscal year 1975 before one was approved and another program element director prepared 17 separate plans for fiscal year 1974.

Other problems were identified.

- The system was a poor communication device because it was often not understood by the user.
- The needs statements often did not state the real research problems and contacting sponsors for clarification was very time consuming.
- Responding to every need was necessary, regardless of how frivolous or ill-conceived it might have been.
- Originators of need statements were not always informed of the disposition of their suggestions.
- The regions were not given guidance on the methods to be used in soliciting needs, and as a result, these needs were not solicited on a consistent basis.

Perhaps one of the biggest problems involved determining what research should be done after reviewing all the needs. EPA lacked criteria and guidance for establishing priorities.

#### Lack of guidance for setting priorities

The OR&D Program Planning and Reporting Manual required sponsors to set priorities for need statements but did not provide guidance on the methods to be used. As a result, there was a lack of uniformity in establishing priorities.

Region V had a committee of division directors or their representatives review and set priorities by group consensus. Region IX established its priorities on the basis of information gained from interviews and personal experience. Region X divided the needs into topical groupings and appropriate technical staff set the priorities which were reviewed first by the branch chiefs, then by the division chiefs, and finally by the regional officials.

Compared to the regional offices, the NERC-Cincinnati method of setting priorities was more sophisticated. The NERC Program Coordination Staff used a procedure whereby the NERC organizational components were ranked and given a weighted percentage.

After the need statements pass through the various regional screenings, the program area manager has final responsibility for reviewing and deciding which needs will be included in the detailed EROSS and ROAPs.

The ROAPs provide the input data necessary for preparing the annual OR&D Program Plan by the OR&D Program Assessment Group composed of the Assistant Administrators, the Director of the Office of Program Management, the research center directors, and any additional members who may be appointed at the discretion of the Assistant Administrator for Research and Development. At the Program Assessment Group meeting the EROSS and ROAPs are examined, their proposed priority ranking in each program area is reviewed and modified, and trade-offs among program areas are made. The various issues are debated by the group members and decisions are made by the deputy assistant administrators for issues within their program areas and by the Assistant Administrator for Research and Development for issues beyond a Deputy Assistant Administrator's area. This process results in setting priorities for EROSS and ROAPs within each of the OR&D's program areas and in distributing manpower and dollar resources among the program areas.

We found that there were no minutes of the Program Assessment Group meetings documenting the appropriateness of objectives, resources, and priorities leading to the proposed annual OR&D Program Plans. In addition there were no written procedures to accomplish these tasks. On the basis of comments we received from various EPA officials, there appears to be dissatisfaction with the practices for establishing research priorities. Some comments made by EPA headquarters officials were:

- "The current system for establishing research priorities is not formalized within ORD. Approval of the listed priorities is formalized once a year at the PAG [Program Assessment Group] meetings. Considerable debate is present on all levels. \* \* \*"
- "Because of little direct contact with program offices, we don't have a clear idea of what they want, so ROAPs cannot be effectively prioritized. \* \* \* Priorities are established by ROAPs, although various tasks within ROAPs are not prioritized. These tasks may not be of equal importance, but are considered as a unit, being within the same ROAP \* \* \*."
- "The linking of the need system with the annual program planning cycle make it an unresponsive vehicle for critical new problems demanding immediate



attention. Thus, the need system is unsuitable for short-term, immediate need situations."

#### Other studies of the planning system

In June 1974 we provided EPA with a summary of our views on the need to improve OR&D's Program Planning and Reporting System. The summary stated, in part, that the system was cumbersome and had not been responsive to the needs of research users. Since then, reports on the system were issued as a result of studies made by the National Academy of Sciences, the Senate Environmental Pollution Subcommittee, and by an EPA task force.

In a report dated August 27, 1974, the National Research Council, an arm of the National Academy of Sciences, stated that planning is separated from the responsibility for executing OR&D research plans, thus leading to severe resentment among performing researchers. The Council also stated that system's complexity made it counter-productive and that the excessive requirements for detail at all planning levels led to an oversized headquarters staff and stifled laboratory innovation. The Council recommended that the planning system be abolished and that program responsibilities be delegated to NERC directors, who should report directly to the Assistant Administrator for Research and Development. The Council also recommended that the Assistant Administrator have a small staff which would perform only staff functions and that it not serve as a layer through which NERC directors would report. The EPA Administrator said the recommendations would be the basis for changes in managing EPA's research and development program.

In its report dated September 23, 1974, the Environmental Pollution Subcommittee, Senate Committee on Public Works, concluded that the planning system should be simplified.

On October 3, 1974, an EPA task force report on the planning system stated:

"\* \* \* Seemingly, the demonstrated capability of the present system to digest and regurgitate any of thousands of program information bits--no matter how small--results in a complexity of operational detail and an overcontrol at all organizational levels that has made the system the master and the managers its servants. Thus, as the effort required to operate the system increases, the effort that can be applied to research activities and to exercising managerial judgment decreases,

creating an ingrained sense of frustration, irritation, and failure. The keywork in the charge is simplicity \* \* \*."

The task force recommended a planning system that included

- a simplified input system to replace the research needs approach,
- a problem-oriented OR&D strategy document, which defines--in a time-sequenced, priority manner--a program in terms of the Agency's requirements,
- decentralizing detailed planning and management functions for large segments of research and development to field centers (four NERCs and the Washington Environmental Research Center),
- instituting a program review process to insure an effective means of halting, decelerating, continuing, or modifying research in process, and
- establishing a single-line management relationship between the Assistant Administrator for Research and Development and the field center directors.

Decisions on carrying out recommendations to change OR&D's planning system, however, awaited the appointment of a new Assistant Administrator for Research and Development who was confirmed by the Senate on December 19, 1974. The previous Assistant Administrator left Federal service in May 1974. After the reorganization of the Office of Assistant Administrator for Research and Development announced by the EPA Administrator on April 24, 1975, changes were considered in OR&D's Program Planning and Reporting System.

In a letter dated October 24, 1975, commenting on a draft of this report, EPA stated that a comprehensive reorganization had been recently implemented and the OR&D organization criticized in our report had been replaced on June 1, 1975. EPA stated further that:

"All of the administrative issues raised by the the report were problems that the reorganization attempted to solve. Under the current structure, the headquarters staff engages in long-range planning. The detailed work plans for implementing broad objectives are now developed at the laboratory level. Headquarters is insulated from this level of

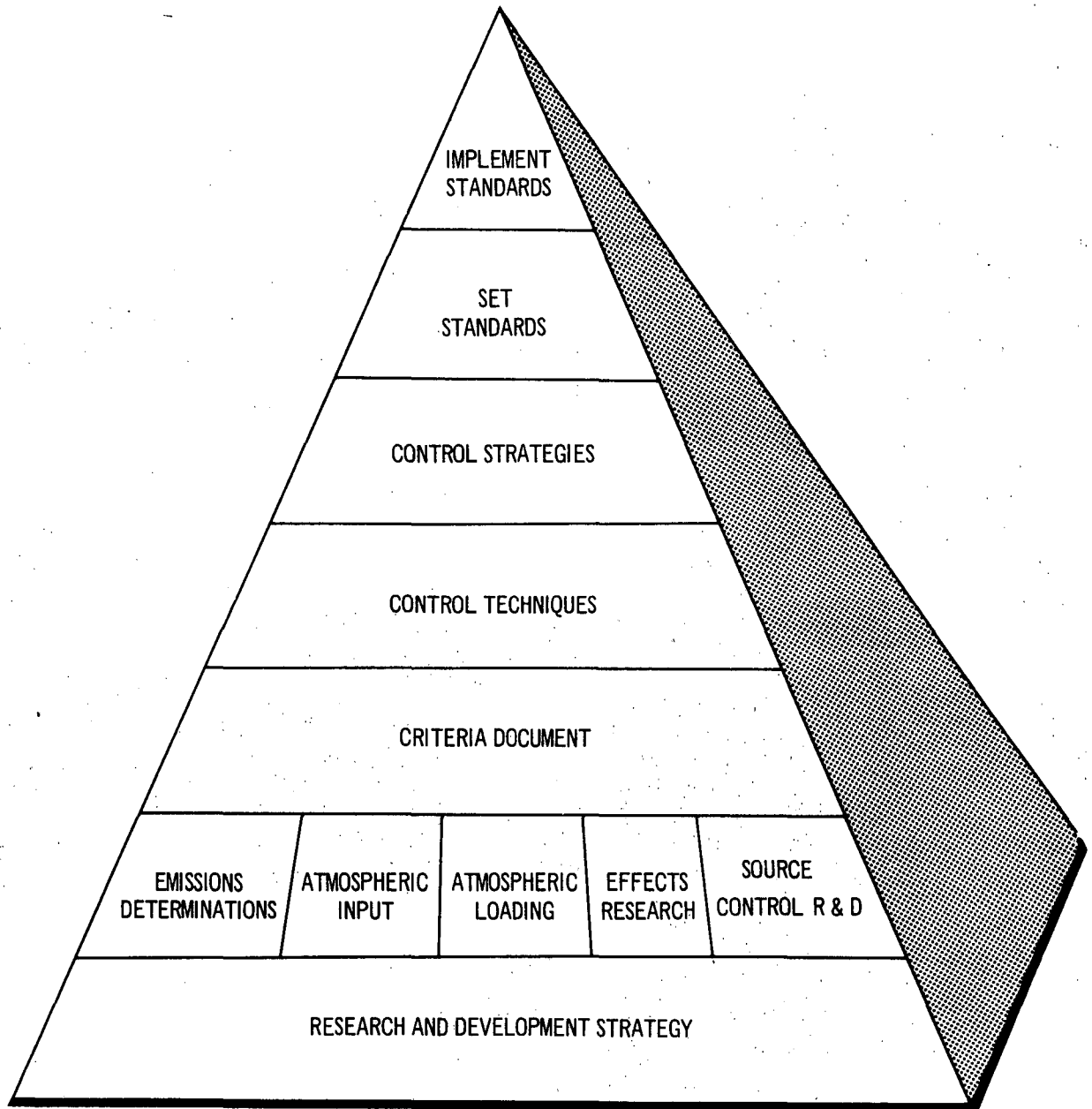
detail. The planning system has been converted from a bottom-up system (with headquarters becoming involved only late in the fiscal year ) to a top-down system (with headquarters delineating objectives early in the fiscal year, and the laboratories developing the accomplishment and work plans in response to these goals). The NERC structure has been eliminated, thus removing one layer of management and clarifying lines of responsibility. \* \* \* The new system is designed to reduce paper work."

AIR POLLUTION CONTROL STRATEGY WOULD  
FACILITATE EPA RESEARCH PLANNING

According to OR&D's Program Planning and Reporting Manual, OR&D maintained a series of research strategy documents which showed how OR&D research activities flowed logically from the objectives and needs of EPA's regulatory programs, how the various major activities were interrelated--both programmatically and in timing--and how planned activities will try to anticipate emerging and future problems in environmental protection. The manual further stated that these strategies should ultimately come directly from agencywide master strategies for controlling pollution, which have been the joint product of all the program offices involved.

Our review showed that the present OR&D air research strategy documents were merely statements of what research has been accomplished and what research is going on. An OR&D headquarters official in the Office for Program Integration, an office which until 1975 had been responsible for assuring that research programs are responsive to agency goals, told us that the documents should deal with EPA's objectives, options on how to carry them out, and the effect of the various alternatives. He stated, however, that because EPA had not developed an overall air pollution control strategy, it was difficult for OR&D to develop a research strategy.

The chart below is an excerpt from a document used for a briefing for the Office of Management and Budget in November 1973. It shows the relationship of NERC-RTP research activities to EPA's mission under the Clean Air Act and that research and development should be the basis for implementing standards.



A November 1971 internal report to the EPA Deputy Administrator entitled the "Rationale for EPA Health Research: a Guide for Program Management," stated that:

"EPA urgently needs, but lacks, an overall regulatory plan to serve as a focus for effects research. To some extent, this requirement raises the chicken-egg dilemma. An overall regulatory plan requires identification of hazardous environmental agents, priority ordering of need for control, selection of research options and control strategies associated with least social costs and finally schedules for control that will permit the development of adequate bases for the action."

A good example that research is needed as a basis for regulatory decisions was the Administrator's decision to require automobile manufacturers to install catalytic converters on all 1975 model cars sold in California and on some 1975 model cars sold nationwide without a thorough study of the effects of emission from such converters, as discussed below.

#### The catalytic converter

The Clean Air Act of 1970 set the following deadlines 1/ for controlling major emissions from motor vehicles.

--Beginning with the model year 1975, carbon monoxide and hydrocarbons emission must be reduced by at least 90 percent from allowable emissions of 1970 model year cars.

--Nitrogen-oxide emissions from model year 1976 autos must be reduced at least 90 percent from the uncontrolled 1971 levels.

Combustion in an automobile engine yields carbon dioxide, water, hydrocarbons, carbon monoxide, nitrogen oxides, sulfur dioxide, and sulfur trioxide. Federal emission standards are designed to reduce the emissions of hydrocarbons, carbon monoxide, and nitrogen oxides. Federal standards for the reduction of sulfate (sulfur) emissions from automobiles do not currently exist. The contribution to regional airborne sulfate levels by the automobile is negligible (less than 1 percent) when compared with emissions by stationary sources, except in a few special localities such as Los Angeles.

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1/Compliance with the original emission standards was postponed for 2 years by the 1974 Amendments to the Clean Air Act, (Public Law 88 Stat. 258).

The catalytic converter (or oxidation catalyst) was expected to be the primary means for most 1975 and later model cars to meet Federal emission standards for hydrocarbons and carbon monoxide. The catalyst is a muffler-like device that fits on the tailpipe of most cars and changes carbon monoxide and hydrocarbons into harmless carbon dioxide and water. Nitrogen oxides are principally controlled by other kinds of engine systems. The catalyst can improve fuel economy by replacing current antipollution devices. Studies have shown, however, the catalyst also accelerates the conversion of small quantities of sulfur compounds in gasoline into sulfates. Such sulfate emissions (specifically sulfuric acid) could lead to undesirable concentrations of sulfates in the vicinity of roadways or other centers of vehicle use.

Sulfur oxides, when combined with moisture and oxygen, can cause the following adverse effects on health and the environment.

- Affect man's breathing.
- Irritate the upper respiratory tract.
- Injure lung tissue when carried on particulates.
- Yellow the leaves of plants.
- Dissolve marble.
- Eat away iron and steel.
- Limit visibility.

The possible use of a catalyst device to reduce automobile emission was proposed in the early 1960's. A NERC-RTP official said EPA did not pursue research on the catalytic converter because automobile manufacturers were not actively considering it to control pollutants and that a Federal agency did not have the authority to set emission standards until 1967. In addition, he said that NERC-RTP did not have the buildings and equipment needed for research on the converter until 1972.

EPA's active involvement began in March 1972 when a task force at NERC-RTP assembled to study the effects of fuels, fuel additives, and emission products on public health and welfare. This task force recognized the health danger of emitting compounds from advanced catalytic control systems and recognized the need for further study. At this point

EPA could not fully identify the health danger associated with catalyst emissions due to a lack of emissions data. The task force was only able to conclude, on the basis of EPA's limited research data and data supplied by contractors and private industry, that catalyst emissions "possess the potential for accumulating in human tissues and producing definite systematic toxicity \* \* \*."

In January 1973, NERC-RTP requested about \$2 million for fiscal year 1974 to study automobile emissions, including catalyst emissions. In April 1973 EPA headquarters responded to this request by authorizing \$150,000 (93 percent less than requested).

Congressional interest in the catalyst subsequently developed and, in May 1973, the NERC-RTP Program Element Director for catalyst research was ordered to prepare a report for a congressional committee. As a result of his report, NERC-RTP was allocated \$1,871,000, rather than the originally budgeted \$150,000.

However, on April 11, 1973, the EPA Administrator established emission standards for 1975 domestic cars sold in California and interim standards for all other 1975 cars. According to him, these standards would require using catalytic converters on all 1975 passenger cars shipped to California and on a portion of 1975 cars sold outside California.

In March 1974 the NERC-RTP Program Element Director for catalytic research said that catalytic emission controls on 1975 model cars will create an officially sanctioned public health risk. He further said that EPA does not know enough about the catalyst yet and "it's an inappropriate risk to expose the American people to these devices until we find out how great the public health risk is."

EPA concluded, however, that using oxidation catalysts on 1975 model cars was not likely to result in adverse impacts on public health or welfare, but that continued production of several model years of catalyst-equipped automobiles could result in adverse public exposures to ambient sulfate concentrations under certain conditions.

Pursuant to discretionary authority provided for in the Clean Air Act, the EPA Administrator on March 5, 1975, announced a 1-year suspension of 1977 automobile emission standards for hydrocarbons and carbon monoxide. He stated:

- Because catalytic converters are the only technology now available to automobile manufacturers to achieve further reductions of these pollutants to statutory levels in 1977, the converters would appreciably increase sulfuric acid emission.
- Though uncertainty exists as to the exact magnitude of the impact of such an increase in the sulfuric acid emissions on air quality, the weight of scientific opinion indicates a legitimate cause for concern that such emissions represents a risk to public health.

The Administrator said that had it not been for the sulfuric acid problem, he would not have granted the 1-year suspension. In announcing the suspension, he recommended a program for reducing hydrocarbon, carbon monoxide, and sulfuric acid emissions for the 1977-82 model years, including a sulfuric acid emission standard beginning with 1979 models.

As of March 1975 the health consequences from using the catalyst to control automobile emissions is still undefined. Nevertheless, there is a strong possibility that the sulfates produced by the catalyst constitute a public health risk. The possible adverse effects from the catalyst have been known for years; yet, catalyst research funds were authorized only because of congressional pressure; the funds that were authorized are still inadequate, according to NERC-RTP officials. The catalyst problem illustrates a need for better research to support regulatory decisions.

#### NEED FOR BETTER FINANCIAL INFORMATION

To properly manage and plan the research program, EPA needs certain basic financial information such as information on obligations, expenditures, funds not used, and funds re-programmed.

At the onset of our review, EPA officials said that the best financial data on air pollution research was at EPA headquarters. We found that the financial information on program elements available at the various NERCs differed considerably from that available at headquarters and we received information on a program element at EPA headquarters that varied from one headquarters office to another. In one instance EPA's Financial Management Division gave us financial information for a fiscal year which varied by over one-half million dollars from the division's final financial report for that year. In addition, the program area managers, who are responsible for managing all activities within a program area, including the allocation of resources, were not able in most instances to provide us with any pertinent financial data. One program area manager commented as follows:



"The current system does not provide adequate information on how money was spent in the previous year, which is necessary information for future planning."

Financial information at the Program Assessment Group meetings, during which ROAPs and tasks are reviewed for appropriateness of planned resources, consisted of estimates for previous year's activities. EPA did not prepare summary report on actual obligations or expenditures by ROAP and task. Tasks, which are also called projects, generally consists of a single contract, grant, interagency agreement, or in-house research under each ROAP.

We requested information from EPA's Financial Management Division on funds authorized, obligated, and expended for the individual tasks under the program elements covered by our review. Even though some OR&D officials informed us that this type of information would be helpful for planning purposes, officials of the Financial Management Division stated it had never been requested. EPA's Statement of Accounting Principles and Standards, approved by the Comptroller General on December 12, 1973, calls for a program and account classification structure which will establish the capability for recording and reporting financial information by appropriation, major activities, subactivities, elements, subelements, and tasks.

We believe that actual obligations, expenditures, and costs by ROAP and task would have been desirable to show application of resources and would have been helpful for determining the funding level of tasks to be undertaken during the next program planning cycle.

#### HIGH TURNOVER OF PROGRAM ELEMENT DIRECTORS AND PROGRAM AREA MANAGERS

EPA has experienced a high turnover and frequent changes of program element directors and program area managers directing its research on the effects of air pollutants on health and the environment. The loss of these key scientists has resulted in a lack of continuity of leadership and direction of research affecting billions of dollars of costs to the public.

Our analysis showed that during the 23-month period from March 1972 to January 1974 program element directors changed at least once in seven of the eight program elements involving air pollution effects research. During this period four directors terminated their employment in the

Federal service; one left to join the staff of the university, another left to become a missionary, and two retired.

Two program elements--CHESS and RAPS--for which EPA obligated more funds during fiscal year 1973 than for any of the program elements covered by our review each changed directors twice. The most recent changes involved one director who left Federal service for employment elsewhere and another who retired. One of the program elements is in the area of health effects research and the other is in the area of ecological effects research.

Our analysis showed also that during the 23-month period frequent changes were made in program area managers, who are OR&D headquarters division directors. Failure by EPA to fill the OR&D headquarters division director program area manager positions in the Health Effects Division and the Ecological Processes and Effects Division necessitated appointing acting program area managers. A former manager and director of the Health Effects Division was on a congressional fellowship. To fill the position, an acting division director was appointed. He served as a program area manager but left in June 1974 for a position on the faculty of a university after being employed by EPA for only a year. As of August 1974, the position of division director had not yet been filled.

The Ecological Processes and Effects Division had no director for about 10 months, the former director had transferred to NERC at Las Vegas. The Chief of the Watershed Ecosystem Branch was designated as the acting division director and the program area manager for the ecological effects area. However, insofar as program elements dealing with air pollution were concerned, responsibility as acting program area manager was assigned to the Chief of the Division's Atmospheric Terrestrial Ecosystem Branch because of that branch's involvement in air pollution control.

Other changes in EPA's top staff of scientists include the Assistant Administrator for Research and Development, who left the Federal service in May 1974. Shortly thereafter, the Assistant Administrator's Principal Science Adviser left for employment with another Federal agency and the EPA health effects adviser left Federal service.

A NERC-RTP official stated that research on three program elements was delayed because of the lack of leadership continuity brought on by turnover of program element directors at NERC.

An EPA headquarters official stated that insofar as the vacancies in the Health Effects Division and the Ecological Processes and Effects Division were concerned, the "acting" positions were due in part to difficulties in finding scientists with the proper qualifications to fill the positions.

## CHAPTER 4

### NEED FOR IMPROVED COORDINATION OF FEDERAL AIR POLLUTION RESEARCH PROGRAMS

The Clean Air Act directs the Administrator, EPA, to:

"\* \* \*promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution\* \* \*."

In addition to EPA, we identified six agencies within three Federal Departments which were conducting and/or supporting research on the effects of air pollutants on health and the environment. These agencies obligated about \$12.6 million in fiscal year 1972, \$11.5 million in fiscal year 1973, and \$14.7 million in fiscal year 1974 for such research. Private industry's research into the effects of air pollutants has been very limited. Its research was concerned mainly with measuring, monitoring, and controlling air pollutants.

Research was not formally coordinated among Federal agencies, although some coordination occurred on a scientist-to-scientist basis and through meetings of various committees. We noted several instances in which EPA scientists were unaware of research similar to their own which was being funded by other Federal agencies. A certain amount of planned redundancy might be beneficial, in that different approaches to the same problems may result in a variety of solutions, one perhaps being more efficient than the other. However, when the redundancy is unplanned, unnecessary duplication and inefficiency can occur. This is an important problem because needed research exceeds available resources.

No control point existed for disseminating air pollution research information, and as a result, there was no assurance that a potential user would become aware of all completed and on-going research in his area of interest.

The other Federal agencies involved in air pollution effects research and funds obligated during fiscal years 1972, 1973, and 1974 are shown below.

	<u>Funds obligated--fiscal year</u>		
	<u>1972</u>	<u>1973</u>	<u>1974</u>
Department of Health, Education, and Welfare			
National Institutes of Health:			
National Institute of En- vironmental Health Sci- ences	\$ 3,214,031	\$ 3,005,660	\$ 4,612,103
National Heart and Lung Institute	1,041,087	1,113,421	1,927,095
National Cancer Institute	217,655	67,754	131,803
National Institute of Occupa- tional Safety and Health	<u>1,248,355</u>	<u>750,398</u>	<u>1,013,512</u>
Total HEW	5,721,128	4,937,233	7,684,513
Department of Transportation (Climatic Impact Assessment Program)	6,586,400	5,703,800	5,874,715
Department of Commerce National Oceanic and Atmos- pheric Administration	<u>339,000</u>	<u>816,673</u>	<u>1,110,200</u>
Total	<u>\$12,646,528</u>	<u>\$11,457,706</u>	<u>\$14,669,428</u>

Department of Health, Education, and Welfare (HEW)

The National Institutes of Health in HEW are concerned with basic or innovative research on the effects of substances on human health. Three institutes obligated substantial funds for research on the effects of air pollutants: The National Institute of Environmental Health Sciences (NIEHS), the National Heart and Lung Institute, and the National Cancer Institute.

NIEHS' mission is to (1) identify environmental agents injurious to human health and (2) conduct, foster, and coordinate research on their biological effects and on ways in which the injurious effects can be neutralized.

The National Heart and Lung Institute conducts research on the causes of heart and lung disease and ways in which these diseases can be prevented. All air pollution research is done extramurally, through contracts, grants, and inter-agency agreements.

The National Cancer Institute performs research to identify cancer-inducing agents and the preventive action that may be taken against the disease. Most air pollution projects are done extramurally.

In addition to the National Institute of Health, the National Institute of Occupational Safety and Health (NIOSH)

conducts research on the health effects of pollutants in the occupational environment. Oftentimes, the effects of such pollutants in a closed occupational environment are similar to those in the open environment, varying only in intensity. Most research work is done extramurally.

#### Department of Transportation

The Department of Transportation has a Climatic Impact Assessment Program for determining the climatic changes that may result from pollutants generated by commercial supersonic aircraft. Proposed emission standards for supersonic aircraft have been formulated by EPA and, when formally established, these standards are to be closely monitored and reassessed by January 1, 1976.

#### Department of Commerce

The only Department of Commerce program that analyzes air pollutant effects is the National Oceanic and Atmospheric Administration's Global Monitoring for Climatic Change Program. The program consists of periodically collecting air samples at four observation stations in remote areas of the world. These samples are analyzed for changes in composition and correlated with climatic changes that may have occurred.

#### NO FORMAL COORDINATION OF FEDERAL AIR POLLUTION RESEARCH ACTIVITIES

There is no formal coordination of air pollution research activities among the various Federal agencies. Although the Clean Air Act directs EPA to promote research coordination, the agency has no written policies, procedures, or regulations for coordination. An EPA official said the EPA program area managers are expected to be knowledgeable of other agencies' research.

Officials of the Council on Environmental Quality (CEQ), the President's advisory group on environmental matters, said they do not coordinate air pollution research projects. The official said that the former Office of Science and Technology and the Council on Environmental Quality had established the Ad Hoc Committee on Environmental Health Research in September 1971 to survey environmental health research activities within the Federal Government. The committee's objective was to determine (1) how these research results were used in regulatory decisionmaking and (2) how coordination could be improved. The ad hoc committee concluded that "there is a need for a single focus of environmental health research which would serve to ensure the proper flow of needs and

information among the various agencies and to assist in identifying new problems and areas of needed research." In 1972 the committee sent a report to the President's Science Advisor which recommended establishing an interagency committee that would coordinate Federal health research. As of March 1975, the recommendation was not implemented.

As a successor to the Office of Science and Technology, the Department of Health, Education, and Welfare, in July 1973, established the Committee to Coordinate Toxicology and Related Programs. However, it is strictly HEW's committee. Although EPA participates in its meetings, many other agencies involved in air pollution effects research do not send representatives to the meetings.

Our review showed that although there was some coordination among individual researchers of various Federal agencies, it was on an informal basis (seminars, periodicals) and those responsible for planning and directing the programs had little knowledge of the nature and extent of other research.

NERC-RTP officials serve on three EPA advisory committees concerned with EPA's air pollution research. Committee members are predominately from nongovernment sources including scientists from universities and private industry. The primary purpose of these committees is to provide advice to EPA managers on research areas. According to a NERC-RTP official, these committees provide an opportunity for the non-EPA scientists to evaluate EPA's research programs and for EPA scientists to exchange information with other scientists.

EPA participates in committees and meetings sponsored by other Federal agencies conducting air pollution research. The scientists also informally discuss research with non-EPA scientists. Although the meetings provide a means for exchanging information, a National Heart and Lung official said the meetings have contributed little to the overall coordination of air pollution effects research.

Throughout the Federal structure many interagency committees and agreements relate in some way to effects research of air pollutants. For example, under an interagency agreement, EPA and the National Oceanic and Atmospheric Administration are involved in regional air pollution studies at NERC-RTP.

One typical example of an interagency committee in the Interagency Collaborative Group on Environmental Carcinogenesis. The group's membership consists of most of the agencies that have program concern and responsibilities in the area of environmental health. The purpose of the group is to share information, data, reports, and task force activities.

The interagency committees and agreements vary extensively as to their scope and purposes. None, however, provide for overall coordination of air pollution effects research activities.

Officials within EPA and NIOSH generally agreed that air pollution programs were not adequately coordinated between agencies. They also acknowledged the need for effective coordination to maximize the use of limited resources.

In line with the interest of the Subcommittee on the Environment, Senate Committee on Commerce, we examined the extent of coordination between EPA's NERC-RTP and NIEHS with regard to research on the health effects of air pollutants. NIEHS is also located at Research Triangle Park, North Carolina.

NERC-RTP annually exchange notices of active research projects with NIEHS. It does not, however, exchange research plans. The active project notices contain general project descriptions and identify research scientists.

A NERC-RTP official said that identifying similar research using project sheets from NIEHS was often difficult because many notices contained only general information and because the number of notices was large and not organized by research area. As a result, scientists must review all notices to identify projects of interest.

A NERC-RTP official said the NIEHS notices are not routinely sent to laboratory scientists. He said that such a practice would be helpful in making laboratory scientists more aware of NIEHS research projects and that laboratory scientists will be informed of the availability of NIEHS project notices in the future.

NERC-RTP also sends an observer to annual NIEHS meetings during which other Government agencies are invited to review the study sheets of grantees' proposed research projects.

We requested NERC-RTP scientists to review summaries of 13 selected projects involving air pollution effects research that were funded by NIEHS during fiscal year 1973. They were able to identify eight projects which were similar to those supported by NERC-RTP. NERC-RTP scientists said they had not been aware that NIEHS was working on seven of the eight projects. One EPA official was aware of the eighth project because he personally knew the NIEHS researcher.

Examples of the seven projects follow:



--A grant funded by NIEHS for \$69,768 during fiscal years 1972 to 1974 and a contract funded by NERC-RTP in fiscal 1974 for \$36,000 both involved the toxic action of ozone and related peroxidic compounds on animal tissues.

--An NIEHS project funded by a grant of \$107,635 during fiscal years 1972-73 and a NERC-RTP in-house research project funded for \$150,000 in fiscal year 1974 were considered by the scientists to be very similar. both involved studies of the hazards to man associated with the inhalation of dusts and air pollutants and both measured the rates at which material cleared the lungs. The projects used different methods, however, to collect and measure material from the lungs.

--An NIEHS project funded by a grant of \$374,647 during fiscal years 1972-73 and a NERC-RTP in-house project funded for \$500,000 in fiscal year 1974 were considered similar in that healthy animals were exposed to mixtures of pollutants but different in that NIEHS also exposed diseased animals. NIEHS is concerned with disease processes caused by various mixtures of pollutants whereas NERC-RTP is concerned with determining what mixtures are harmful.

One EPA project that had been continuously funded since 1965 dealt with life spans of higher mammals subjected to relatively low level exposures of gaseous air pollutants. In the project description EPA stated its effort as being the only study in this area when, in actuality, similar research, according to an NIEHS official, had been funded for several years by both NIEHS and NIOSH.

NERC and NIEHS scientists agreed that these examples point out a need for better coordination of research. Better coordination could avoid unnecessary duplication of effort and waste of research resources.

#### NO CENTRAL POINT FOR DISSEMINATING RESEARCH INFORMATION

In addition to the lack of coordination for air pollution research activities, there has been no assurance that a potential user can become aware of all completed and ongoing research in his area of interest. To maximize use of research accomplishments, the reports of research results must be made available and must be in a form that encourages using the information.

In our report to the Congress entitled "Research and Demonstration Programs to Achieve Water Quality Goals: What the Federal Government Needs To Do" (B-166506 dated January 16, 1974), we referred to several studies that identified the need for better coordination of Federal research information systems. One report issued by the President's Science Advisory Committee in January 1963 recognized that adequate communication is a prerequisite for effective science and technology and that the health of the technical communication system must be a serious concern to the Government. Another report mentioned was one that we issued in 1973 to the Office of Management and Budget stating that there was a need to "improve the flow of information to the top levels of Government and to coordinate large and often overlapping research activities among agencies."

A report issued by Battelle Memorial Institute in February 1974 on EPA's Scientific and Technical Information Network Concept and Implementation Plan stated that at the 1972 National Environmental Information Symposium, 2 years after the organization of EPA, some 1,700 participants still expressed as their most common concern the need for improved awareness of, and access to, environmental information. This concern was echoed by EPA personnel who were interviewed in the course of the Battelle study. The report identified 19 independent sources of information on air pollution research conducted by Federal agencies other than EPA.

Several major Federal systems now disseminate scientific and technical information on the effects of air pollution. EPA operates the Air Pollution Technical Information Center which disseminates information on published research reports and reports in the process of being published. Other important Federal information systems are the Science Information Exchange (SIE) of the Smithsonian Institute, which has a computerized data bank of all ongoing Federal research, and the National Technical Information Service (NTIS) of the Department of Commerce which is concerned only with reports of completed research. EPA also publishes an annual publication, "Expro," which gives a brief description of extramural projects to be funded in that fiscal year.

Currently there is no one central information source on Federal air pollution research. None of the existing information systems are complete or comprehensive in coverage. SIE collects data on active research only, whereas NTIS is concerned only with completed research reports. Also, agencies are not required to submit reports to NTIS for dissemination. Agency officials told us they made only limited use of SIE and NTIS because the data was incomplete and not current.

To gather information on what research other agencies are doing, EPA officials use various means, including serving on EPA advisory committees, using SIE, attending grant review meetings, and obtaining informal agreements with other agencies (for example, with NIEHS for exchanging project notices).

## CHAPTER 5

### CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

#### CONCLUSIONS

Much more research is needed on the health and ecological effects of air pollutants to adequately support and/or modify present national ambient air quality standards and motor vehicle emission standards and to identify and set standards for other pollutants. In fiscal year 1974 EPA obligated \$25 million for research on the effects of air pollutants. Preliminary estimates for an adequate research program ranged from \$45 million to \$70 million a year. Much more needs to be spent for such research in view of the numerous gaps and uncertainties in present research knowledge.

There were numerous administrative problems in EPA's research program. EPA's research planning was highly complex, overly structured, and generated a great deal of dissatisfaction among EPA officials. As discussed on page , OR&D was reorganized on June 1, 1975. In a letter dated October 1975, EPA stated that all the administrative issues in this report were problems that the reorganization attempted to solve.

EPA also needs an air pollution control strategy to better plan its research activities to support that strategy and better financial information on its research activities.

EPA does not but should prepare periodic estimates of what resources would be needed to carry out an adequate air pollution effects research program. Such information would provide the Congress, the Office of Management and Budget and the public with a perspective of total air pollution needs and of that portion not funded. The estimates of research resources needed are preliminary but could be used as a starting point for preparing more firm estimates.

Each year millions of dollars are spent by Federal agencies to evaluate and analyze effects of the Nation's air pollution. Research was not formally coordinated among the Federal agencies, although some coordination occurred on a scientist-to-scientist basis and through meetings of various committees. The Clean Air Act directs EPA to promote coordination of research, but EPA has taken little positive action in this direction and has no written policies, procedures, or regulations for coordination.

We noted several instances in which EPA scientists were unaware of research similar to their own which was being funded by other Federal agencies. A certain amount of planned redundancy might be beneficial, in that different approaches to the same problems may result in a variety of solutions, one perhaps being more efficient than the other. However, when the redundancy is unplanned, unnecessary duplication and inefficiency can occur. This is an important problem because needed research exceeds available resources.

We believe more coordinated research, including a more systematic method to disseminate research information among all Federal agencies, would improve the information base for regulatory actions.

### RECOMMENDATIONS

We recommend that the Administrator, EPA:

- Establish criteria or guidance for setting research priorities.
- Develop an air pollution control strategy which would facilitate better research planning.
- Prepare periodic financial reports for use by research managers in planning research and in allocating resources, showing the funds allocated, obligated, and expended for research tasks. The reports should present such information for each grant, contract, interagency agreement, and in-house activity.
- Periodically prepare estimates of the resources needed for an adequate air pollution effects research program, even though all its needs may not be ultimately funded. Only in this way can the Congress, the Office of Management and Budget, and the public have a perspective of total air pollution research needs and of that portion not funded.

We recommend also that EPA develop written policies and regulations that will enable EPA to fulfill its responsibility to coordinate research under the Clean Air Act. One possibility might be to establish a clearinghouse operation located within EPA that would be aware of all ongoing air pollution effects research funded by the Federal Government and to more actively seek input of research results from other Federal agencies for the Air Pollution Technical Information Center. Also such policies and regulations should direct NERC-RTP to more fully coordinate its research activities with NIEHS which is also located at RTP, because both organizations conduct similar

research. Such coordination should entail obtaining more details concerning ongoing research activities and an exchange of research plans.

#### AGENCY COMMENTS

In a letter dated October 24, 1975, EPA stated that:

"A five-year Agency Research Statement is being prepared which will itemize the funding required if Agency goals and congressional mandates are to be met. The financial reporting system is being improved and has the capacity to report financial disbursements on a media as well as a problem-oriented basis."

With regard to coordinating research under the Clean Air Act of 1970, EPA stated that:

"\* \* \* there are at least three coordinating efforts in progress. They are (1) joint sponsorship of work at the National Center for Toxicological Research involving lower level long time exposure to toxicants, (2) Inter- and Intra-agency Committee work with HEW on Carcinogenicity and Toxicity and (3) joint studies with HUD, ERDA and NBS on indoor air pollution studies. Research is also being coordinated through the Interdepartmental Committee for Atmospheric Sciences. In addition to EPA, members include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the Department of Defense as well as several other Departments and Agencies."

Our review of EPA's coordination activities included examining the activities described above. As mentioned previously, we noted several instances in which EPA scientists were unaware of research similar to their own which was being funded by other Federal agencies. We therefore believe that EPA needs to take further action to enable it to fulfill its responsibilities to coordinate research under the Clean Air Act.

## CHAPTER 6

### SCOPE OF REVIEW

We examined pertinent documents, records, reports, and files on resources applied and needed by EPA for research on health and ecological effects of air pollutants. We interviewed knowledgeable EPA scientists and administrative personnel. (See app. V.) We did our work at EPA headquarters in Washington, D.C.; at NERC's in Research Triangle Park, North Carolina, Cincinnati, Ohio, and Corvallis, Oregon; EPA's Office of Air Quality Planning and Standards, Durham, North Carolina; and EPA Regional Offices in Atlanta, Chicago, San Francisco, and Seattle.

In addition we contacted officials of the Department of Health, Education, and Welfare, the Department of Transportation, the Department of Commerce, the National Science Foundation, the National Aeronautics and Space Administration, and the Council on Environmental Quality to obtain information on the extent such agencies were involved in research on health and ecological effects of air pollutants and on the coordination of such research.

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## United States Senate

COMMITTEE ON COMMERCE

WASHINGTON, D.C. 20510

FREDERICK J. LORDAN, STAFF DIRECTOR  
MICHAEL PERTSCHUK, CHIEF COUNSEL

October 16, 1973

B-166506

Honorable Elmer B. Staats  
Comptroller General  
United States General Accounting Office  
441 G Street, N.W.  
Washington, D.C. 20549

Dear Mr. Staats:

As you know, the Environmental Protection Agency (EPA) performs various types of research activities which are directed to determining the health and environmental effects of environmental pollution. Data on the effects of pollutants is obviously very important for setting standards to protect the environment.

Scientists within EPA have recently questioned whether the Agency has the necessary resources to properly determine the public health and environmental effects of pollutants, especially air pollutants. Additionally, serious questions have been raised about the extent to which EPA and other Federal agencies coordinate research in this area. Because of the importance of EPA decisions, it is imperative that the data base for these decisions be highly reliable.

Thus, it would be extremely helpful if the General Accounting Office would initiate an examination of EPA's research activities relating to the effects of environmental contaminants with special emphasis on air pollution. Specifically, your assessment of the following would be appreciated.

1. The adequacy of the manpower, funds and facilities used by EPA for research.
2. The establishment of research needs by EPA and the priorities assigned to them.
3. The extent to which these research needs have been met.
4. The coordination by EPA and other Federal agencies conducting similar research.

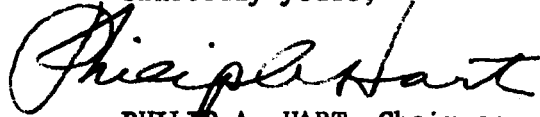
As you know, the Federal Water Pollution Control Act Amendments of



1972 require the General Accounting Office to evaluate EPA research with respect to water pollution. Of course, the information herein requested should not duplicate that required under that Act.

With best wishes,

Sincerely yours,

A handwritten signature in cursive script that reads "Philip A. Hart". The signature is written in black ink and is positioned above the typed name.

PHILIP A. HART, Chairman  
Subcommittee on the Environment



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

OCT 24 1975

OFFICE OF  
PLANNING AND MANAGEMENT

Mr. Henry Eschwege  
Director, Resources and Economic  
Development Division  
U. S. General Accounting Office  
Washington, DC 20548

Dear Mr. Eschwege:

We have reviewed your proposed report to the Subcommittee on the Environment, Senate Committee on Commerce, entitled, "Assessment of Federal Programs for Research on the Effects of Air Pollutants."

During and since your review, several significant and constructive changes have taken place in our Research and Development organization. A comprehensive reorganization was recently implemented and we feel that many of the criticisms in this report, and those suggested by other studies, have already been corrected. The Agency's responses to the recommendations made in the report are enclosed.

We appreciate having the opportunity to review the report prior to its submission to Congress.

Sincerely yours,

A handwritten signature in cursive script that reads "Alvin L. Alm".

Alvin L. Alm  
Assistant Administrator  
for Planning and Management

Enclosure

Comments on the General Accounting Office's Proposed Report  
"Assessment of Federal Program for Research  
on the Effects of Air Pollutants"

Office of Research and Development (R&D) Administrative Structure.

The report criticizes the organization which was replaced on June 1, 1975. Enclosed is a current organizational chart and a copy of the statement issued by the Assistant Administrator for Research and Development on July 10, 1975, entitled, "Pertinent Information on the Office of Research and Development Reorganization."

All of the administrative issues raised by the report were problems that the reorganization attempted to solve. Under the current structure, the headquarters staff engages in long-range planning. The detailed work plans for implementing broad objectives are now developed at the laboratory level. Headquarters is insulated from this level of detail. The planning system has been converted from a bottom-up system (with headquarters becoming involved only late in the fiscal year) to a top-down system (with headquarters delineating objectives early in the fiscal year, and the laboratories developing the accomplishment and work plans in response to these goals). The NERC structure has been eliminated, thus removing one layer of management and clarifying lines of responsibility. A five-year Agency Research Statement is being prepared which will itemize the funding required if Agency goals and congressional mandates are to be met. The financial reporting system is being improved and has the capacity to report financial disbursements on a media as well as a problem-oriented basis. The new system is designed to reduce paper work.

Responsibility for Coordination of Research Under the Clean Air Act.

In the area of Health Effects there are at least three coordinating efforts in progress. They are (1) joint sponsorship of work at the National Center for Toxicological Research involving lower-level, long-time exposure to toxicants, (2) Inter- and Intra-agency Committee work with HEW on Carcinogenicity and Toxicity and (3) joint studies with HUD, ERDA and NBS on indoor air pollution studies. Research is also being coordinated through the Interdepartmental Committee for Atmospheric Sciences. In addition to EPA, members include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the Department of Defense, as well as several other Departments and Agencies.

Health Effects.

The comment that health effects of power plants and urban plumes are being overlooked is not meaningful, since health and ecological effects are measured on specific compounds or particles found in pollution sources. It is known, for example, that oxides of nitrogen, oxides of sulfur, unburned hydrocarbons, oxides of carbon, water vapor, heavy metals and particulates all come from urban plumes and these have been and are continuing to be studied.

The air pollution health and ecological effects research in the period FY 1974 - 1976 has covered both general effects (assay and epidemiological tests) and specific compounds. A partial list of studies in FY 1975 - 1976 includes:

- Respiratory effects of sulfur oxides
- Ozone and lung metabolism
- Effect of ozone and nitrogen dioxide on chronic lung disease
- Effect of ozone and nitrogen dioxide on smokers and non-smokers
- Effect of ambient methylmercury levels on health
- Biological effects of asbestos fibers
- Effects of selected trace metals on behavior patterns, neurochemistry, neuropathology and neural development on animals models
- Distribution of cadmium in biological samples -- a cooperative international study
- Non-regulated pollutants from mobile sources
- Health effects of sulfuric acid
- Annual catalyst research program report
- Annual report of the effects of oxidant air pollution on a forest ecosystem
- Health effects of lead emissions related to mobile sources
- Health effects of trace substances associated with smelter operations
- Effects of sulfates on human health
- Effect of air pollution exposure on mortality in the Los Angeles area
- Relationship of exposure to oxidizing air pollutants to occurrence of carcinogenesis and mutagenesis
- Effect of metal oxides on human health
- Effect of short-term exposures to air pollutants on incidence and severity of acute respiratory diseases

In addition to the health and ecological effects, there is work being done in the air control technology area on power plants and urban plumes. There are several issues related to these subjects that have been selected by the Director, Office of Energy, Minerals and Industry for reporting to the Agency during FY 1976. A list of pertinent FY 1976 milestones is attached for your information.

In summary, we feel that the draft report should be modified to reflect the current operation of our office. To this end, we are quite willing to provide additional information and continue to collaborate with the GAO.

ADVERSE HEALTH EFFECTS WHICH MIGHT BE ATTRIBUTED  
TO EXPOSURES INVOLVING SULFUR OXIDES  
AND SUSPENDED PARTICULATES

<u>Expected effect</u>	<u>RESEARCH DATA AVAILABLE</u>		
	<u>Epidemiology</u>	<u>Clinical studies</u>	<u>Toxicology</u>
Increased susceptibility to acute respiratory disease	Multiple studies	No data	Isolated studies
Aggravation of asthma	Few replicated studies	No data	No data
Aggravation of heart or lung disease	Multiple studies	No data	No data
Irritation symptoms	Multiple studies	Few replicated studies	No data
Altered lung function	Multiple studies	Few replicated studies	Multiple studies
Increased risk of chronic lung disease	Multiple studies	No data	No data
Cancer	No data	No data	No data
Congenital defects	No data	No data	No data
Impaired defense mechanisms	No data	No data	No data

ADVERSE EFFECTS WHICH MIGHT BE  
LOGICALLY EXPECTED TO FOLLOW  
CARBON MONOXIDE EXPOSURE

<u>Expected effect</u>	<u>RESEARCH DATA AVAILABLE</u>		
	<u>HUMAN STUDIES</u>		
	<u>Epidemiology</u>	<u>Clinical studies</u>	<u>Toxicology</u>
Diminished exercise tolerance	No data	Three studies	No data
Decreased mental activity	No data	Multiple studies	Limited studies
Aggravation of heart disease	Three studies	Multiple studies	No data
Increased risk of heart disease	Studies of smoking	No data	Limited studies
Impaired fetal development	Studies of smoking	No data	Limited studies

ADVERSE EFFECTS WHICH MIGHT BE ATTRIBUTED  
TO NITROGEN DIOXIDE EXPOSURES

<u>Expected effect</u>	<u>RESEARCH DATA AVAILABLE</u>		
	<u>Epidemiology</u>	<u>Clinical</u>	<u>Toxicology</u> <u>at low expo-</u> <u>sure levels</u> <u>( 9000 ug/m )</u>
Increased suscept- ibility to acute res - piratory disease	Three repli- cated studies	No data	Replicated rodent studies
Increased severity of acute respiratory disease	Two repli- cated studies	No data	Two studies with rodents
Increased risk of chronic respiratory disease	Two studies showed a worrisome finding of reduced ven- tilatory function in children	Anecdotal case re- ports	Four studies in rodents
Aggravation of asthma	One study suggests par- ticulate ni- trates aggra- vate asthma	No data	No data
Aggravation of heart and lung disorders	No data	No data	No data
Carcinogenesis*	No data	No data	No data
Fetotoxicity or mutagenesis	No data	No data	No data

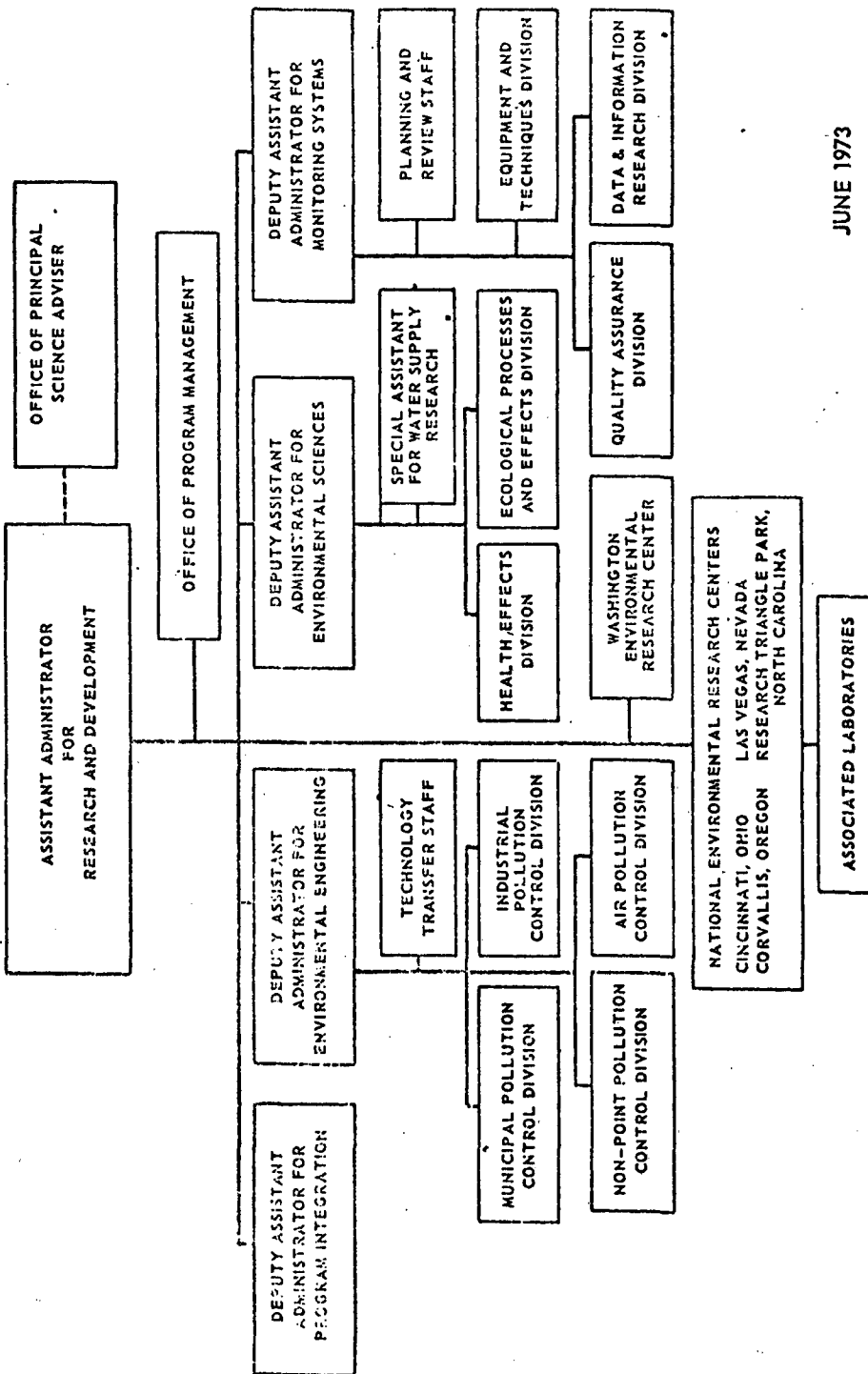
\*Through nitrates or nitrites



ADVERSE HEALTH EFFECTS WHICH MIGHT BE ATTRIBUTED  
TO PHOTOCHEMICAL OXIDANT EXPOSURES

<u>Expected effect</u>	<u>Research data available</u>		
	<u>Epidemiology</u>	<u>Clinical studies</u>	<u>Toxi-cology</u>
Aggravation of asthma	Single study	No data	No data
Aggravation of chronic obstructive lung disease	Three early studies	Two early studies	No data
Aggravation of heart disease	Three early studies	No data	No data
Aggravation of hemato-poietic disorders	No data	Single study	No data
Accelerated aging	No data	No data	No data
Irritation of eyes and respiratory tract in healthy subjects	Multiple studies	Multiple studies	Multiple studies
Decreased cardiopulmonary reserve in healthy subjects	Two studies	Two studies	No data
Increased susceptibility acute respiratory disease	Single study	No data	Multiple studies
Increased risk of chronic lung disease	Single study	Single study	Two studies
Respiratory malignancies	Single study	No data	Single study
Mutagenesis, embryo-toxicity and teratogenesis	No data	No data	Two studies

EPA  
OR&D ORGANIZATIONAL CHART



JUNE 1973

EPA Order 1110.22C  
 April 24, 1975

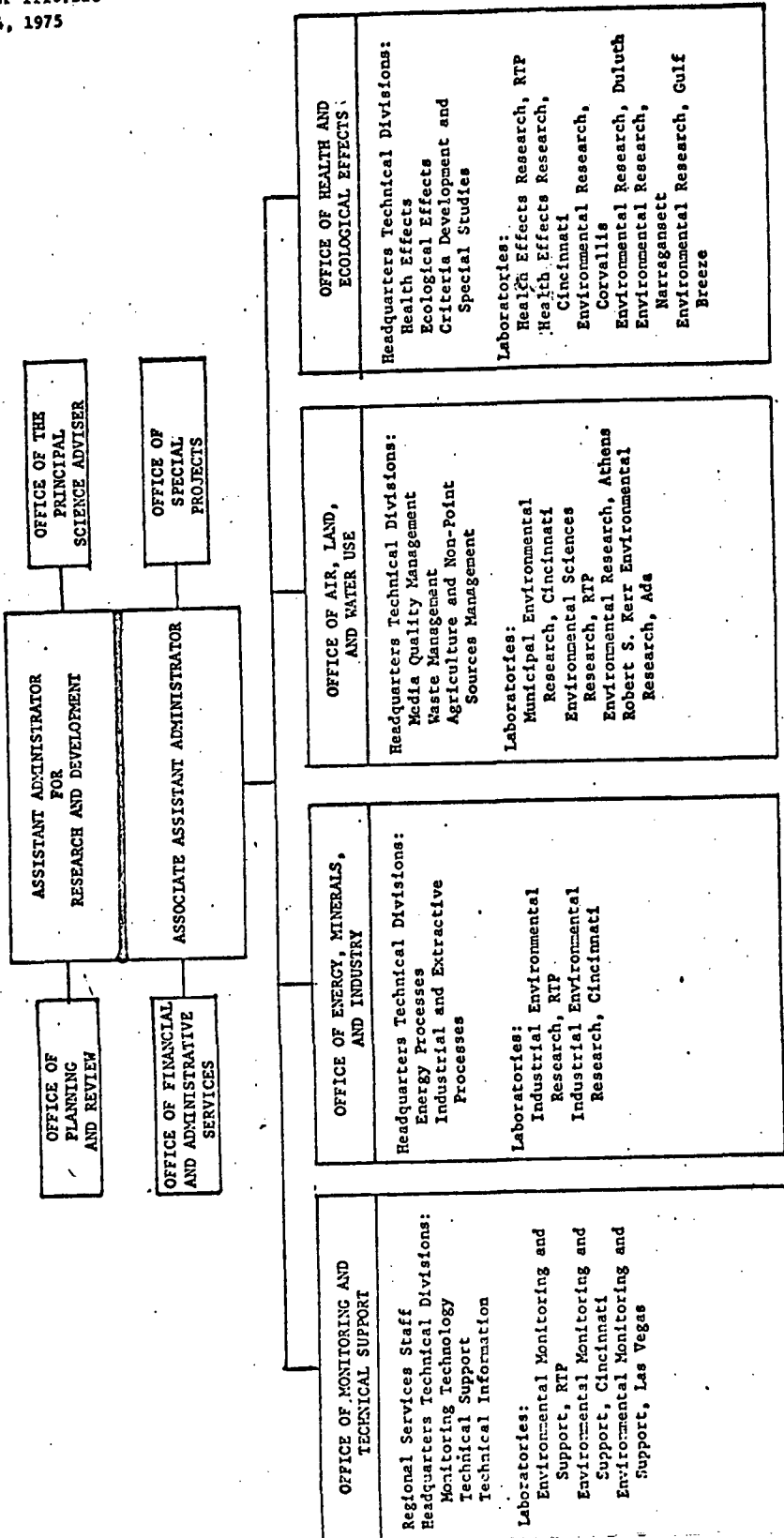


Figure 1. Assistant Administrator for Research and Development Organization Chart

DESCRIPTIONS OF AIR POLLUTION RESEARCH EFFORTS  
IN THE HEALTH EFFECTS AND ECOLOGICAL  
PROCESSES AND EFFECTS PROGRAM AREAS

HEALTH EFFECTS PROGRAM AREA

Health effects research is directed toward assessing health hazards associated with environmental pollution from several media and categories including air, water, pesticides, radiation, and noise. Major program emphasis on air pollution is devoted to the Community Health Effects Surveillance Studies (CHESS) program. CHESS consists of a series of epidemiologic studies in various communities throughout the United States whose objective is to evaluate the effects of exposure to common pollutants on sensitive health indicators.

Complementing CHESS is the Biomedical Research Program which is directed at assessing, at the community level, pollution effects on human physiology. Evaluations are made of health effects resulting from community level environmental pollution and classical and innovative toxicologic research studies. Scientific information is collected on the health effects associated with exposures to fuels, fuel additives, and their combustion products. Detailed EROS and ROAP information for the air pollution research program elements in the health effects program area follow.

Pollutant Characterization  
Program Element #1AA001

Air quality criteria - EROS/ROAP #26AAA

EROS-Develop the scientific information required to upgrade air quality criteria. Air quality criteria for emission from all sources should be developed for, but not be limited to, sulfur oxides, particulate matter, carbon monoxide, nitrogen oxides, hydrocarbons and photochemical oxidants.

ROAP approach-Develop the scientific information required (1) to evaluate the need for control of pollutants, (2) to define the control approach best suited for each established control need, and (3) to clearly establish air quality criteria for air quality and emission standards.

ROAP output-Summaries of sources, effects, measurement and existing atmospheric concentrations of pollutants and recommendations for the needs and methods of control. Criteria for air quality and emission standards.

Community Health Effects Surveillance Studies (CHESS)  
Program Element #1AA005

Community health effects surveillance studies (CHESS) - EROS/ROAP #21AFW

EROS-To develop and utilize in populations sensitive indicators of human health, to determine dose response relationships with environmental pollutants singly or in combination.

ROAP approach-A series of coordinated epidemiologic studies designed and carefully supervised by in-house personnel has been instituted in selected areas of the country. Under contract, prescribed methods are followed to collect health data and to measure pollutant exposure in CHESS neighborhoods. All data are processed and analyzed by in-house staff. Special research tasks are undertaken to deploy more sensitive impact indicators, to improve bioenvironmental exposure monitoring and to refine statistical procedures.

ROAP output-A series of intramural and published technical reports (at least 8 each year) will be produced. These reports quantify the impact of community exposure to NO<sub>2</sub>, SO<sub>2</sub>, oxidants and particulates on the 8 CHESS health indicators. Progress in using new and more sensitive health indicators and in development of a national tissue bank will be summarized. The reports will provide health intelligence for appraisal and setting of environmental standards.

Biomedical Research  
Program Element #1AA007

Fuel and fuel additive health effects research - EROS/ROAP #21AFK

EROS-To provide background health intelligence required for development of fuel and fuel additive control strategies. Presently available fuel and fuel additive usage, toxicologic and chemistry data should be combined with appropriate epidemiologic and laboratory studies for this purpose.

ROAP approach-Determine toxicologic effects of fuel and fuel additives emissions in order to provide background health intelligence required for development of emission control strategies. Using appropriate animal species in vivo and other bioeffect indicators provide a definitive complete toxicology screen for fuel and fuel emissions and components thereof. Included are gaseous and particulate (trace metal) emissions which result from use of fuels, fuel additives and addition of control devices to the combustion systems. Comparative toxicity is measured using multiple bioeffects criteria based on effects in the various organ systems; they comprise parts of standard test protocol.

ROAP output-Research reports include: (1) Data on toxic effects of fuel and fuel additive emissions following combustion, listed in a graded classification order. (2) Development of a protocol for fuel and fuel additive toxicologic screening. (3) Laboratory assessment of adverse effects of the emission products considered to be of greatest public health concern. (4) Evaluation of the impact of emission control devices upon emissions which may prove potentially harmful.

#### Emergency high exposure episodes - EROS/ROAP #21AFP

EROS-To minimize adverse health effects resulting from unplanned exposure episodes.

ROAP approach-Professional resources, study protocols, and data acquisition instrumentation will be made available to respond to high exposure episodes. The mobile laboratory will constitute a unique facility for deployment of requisite personnel and instrumentation to document acute human health effects of the episode.

ROAP output-The capability for conducting sophisticated physiologic testing of populations, on site, during acute exposure episodes is assured by the professional staffed mobile laboratory. ROAP output will consist primarily of reports and data documenting symptoms, cardiopulmonary effects, resulting from acute exposure to NO<sub>x</sub> and CO. Similar studies will be performed when other substances are involved in acute emergency episodes.

#### Odor health effects - EROS/ROAP #21AFO

EROS-Identification and quantification of the health effects of odor

ROAP approach-Identify and quantify the effects of odors on human health and welfare using community and laboratory studies. Possible adverse human reactions to be determined are: disease states, including either causation or aggravation of disease; annoyance; social and economic impact; and physiological responses. This approach requires the development of sensitive measurement techniques.

ROAP output-A series of research reports summarizing the impact of odor exposure on public health and welfare. These documents will provide background information for use in regulatory actions.

#### Multimedia toxic substances - EROS/ROAP #21AFR

EROS-To evaluate potential adverse health effects resulting from exposures to multimedia toxic substances. More specific objectives include development of comprehensive hazard awareness systems to prevent exposure to toxic substances before damage has occurred.

ROAP approach-Rapid preliminary toxicologic screening systems and more definitive toxicologic evaluation systems will be developed, using cell culture lines and whole animals, to determine the toxic potential of hazardous substances prior to human exposure. Experimental human exposures and studies of pollutant burdens in communities after exposure will also be carried out.

ROAP output-Research reports assisting in the development of quality criteria for the environmental pollutants studied. Included will be HCl, oxidants, NO<sub>x</sub>, trace metals, organics and hydrocarbons.

#### Gaseous air pollutants - EROS/ROAP #21AFU

EROS-To develop additional background information with regard to the health effects of the gaseous air pollutants.

ROAP approach-Determine by means of human clinical studies or suitable animal models the effects of CO exposure and resulting reductions in oxygen supplies for individual tissues on the brain or cardiac system as indicated by mental or cardiac performance. To determine in animals or isolated tissues the effects of single or combinations of pollutants on respiratory tissues, on pulmonary defense mechanisms and on various blood components. To supplement and varify field observations by means of a mobile laboratory which will permit the delivery and application of controlled laboratory techniques to the field study populations.

ROAP output-Results of research will be published as individual manuscripts in scientific journals or as in-house reports and in this manner will become available for consideration in establishing or revising air quality criteria standards.

#### Trace metals - EROS/ROAP #21AFT

EROS-To determine effects of low level chronic trace metal exposures upon human health and welfare, as well as to evaluate the health impact of accidental high level exposures to trace metals in general populations. Routes of exposure to human populations and specifically susceptible groups to trace metal exposures must also be identified. Potential interactions of trace metal exposure with each other as well as other classes of pollutants must be determined.

ROAP approach-To determine by means of controlled human exposure studies the effects of specific heavy metals, e.g. lead or manganese, on blood levels, tissue levels and particular metabolic systems. To determine in animals the carcinogenic, mutagenic, or other adverse response to trace material exposure, singly or in combination, and to develop a tissue bank wherein tissues will be stored to provide in subsequent years a rapid flashback capability to demonstrate increasing tissue burdens over time resulting from exposure to trace substances currently in the environment or that might be introduced into the environment.

ROAP output-Results of research will be published in scientific journals or included in in-house reports so that they will be available for consideration and review prior to selection of those materials in the environment which need to be controlled and the regulatory strategies used to implement this control. Data showing dose-response relationships can also be used to develop cost benefit data.

#### ECOLOGICAL PROCESSES AND EFFECTS PROGRAM AREA

The ecological processes and effects area involves the effects of air and water pollutants on the structure and function of ecosystems and on biotic and abiotic subcomponents of these ecosystems. One major objective of the program is to develop scientific information necessary for water quality criteria and secondary air quality criteria.

Investigation of the effects of major air pollutants on crops and vegetation are conducted to provide information for establishing secondary vegetation are conducted to provide information for establishing secondary ambient air quality standards. Specific studies of the effects of NO<sub>x</sub>, SO<sub>x</sub>, hydrocarbons, and oxidants are conducted on representative terrestrial ecosystems.

A second major objective of this program area is to determine a chemical, physical, and biological process associated with sources, pathways, persistences and fates of pollutants in ecosystems.

#### Fuel and Fuel Additive Registration Program Element #1AA002

#### Development of information for fuel or fuel additive control or prohibition - EROS/ROAP #26AAE

EROS-Develop the scientific information necessary to recommend candidate fuel and fuel additives for control or prohibition. Such information should include, but not be limited to, consideration of combustion emission products, atmospheric loading and transformations, health effects, and ecological effects.



ROAP approach-Develop the scientific information necessary to recommend candidate fuels and fuel additives for control or prohibition, including considerations of combustion emission products, effects on performance of control devices, atmospheric loading and transformations, health effects and ecological effects.

ROAP output-Recommendation for the control or prohibition by EPA of the use of specific fuels and fuel additives whose emission products endanger the public health or welfare or significantly impair the performance of emission control devices or systems.

Regional Air Pollution Study (RAPS)  
Program Element #1AA003

Evaluation and demonstration of the effectiveness of air pollution control on a regional scale - EROS/ROAP #26AAI

EROS-Develop a comprehensive and empirically validated predictive model for regional air resources management, by providing general methods by which air quality for all major pollutants can be quantitatively estimated, as a function of time and space, from detailed specification of the primary pollutant sources and the meteorological conditions in the region.

ROAP approach-The Regional Air Pollution Study (RAPS) will consist of a detailed analysis of the sources and transport of pollution, meteorology, and air quality in the St. Louis region plus effects and economic studies. Special field studies involving atmospheric tracers aircraft, mobile laboratories and remote sensing techniques will be used, together with an extensive network of air quality and meteorological stations to provide a detailed measurement program for a 3-4 year period.

ROAP output-A predictive model based on and including an analysis of the transport, dispersion, and other atmospheric processes associated with both stable and reactive pollutants in sufficient detail to predict pollutant concentration distributions over distances of the order of 100 miles; and understanding of atmospheric reactions associated with SO<sub>2</sub>, NO, hydrocarbons, ozone, organic nitrates and aldehydes; optimum emission air quality and meteorological sampling networks; data output for assessing the effectiveness of control strategies and effects of air pollution on a regional basis. A better understanding of certain human, social, and economic factors will be gained.

Subsidiary research objectivesRAPS measurements and instrumentation - ROAP #56AAI

ROAP approach-It will provide instrument development, prototype testing, field operations of two semimobile monitoring stations in St. Louis area, and feasibility studies of new techniques.

ROAP output-Measurements made will be used for distinction of photochemical diffusion model in RAPS.

Air quality characterization - ROAP #56AAJ

ROAP approach-This ROAP responds to the SRO (Subsidiary Research Objective) for Air Quality Characterization under RAPS. Isotopic ratios in  $C_2H_2$  and CO will be measured. The level and distribution of  $SO_2$ , NO,  $NO_2$ , hydrocarbons PAN and ozone will be measured. Photochemical reactivities of the air will be determined under controlled conditions. The pattern of hydrocarbon pollution will be studied by chromatography and infrared spectroscopy. Size spectra of aerosols, their chemical composition and their distribution in time and space will be determined.

ROAP output-Data permitting a choice of tracer substances for further study of the regional atmosphere; chemical inputs to the meteorological-photochemical modeling effort; experimental data permitting a proper site selection for the regional monitoring network; indications of the effectiveness of controlling pollutants from specific sources; identification of area-wide and point sources of pollutants in the region; information on the removal paths of pollutants; indications of the sources of visibility loss in the area.

Ecological studies - ROAP #56AAK

ROAP approach-To develop an environmental effects monitoring system which will be tested and refined thru a supportive interdisciplinary mechanism established in the Regional Air Pollution Study. Work will be accomplished primarily via extramural contracts. The first phase (FY-73) will entail the development of a workable effects monitoring protocol for the urban, rural and natural environment in and around a large city (St. Louis). A comparable environmental monitoring network will be implemented in FY 74 for the duration of the regional study (phase II).

ROAP output-A series of reports and/or recommendations relating to:  
(1) A prototype environmental effects monitoring package for general use at selected sites throughout the U.S. (2) Acute and chronic pollutants stress effects on specific receptors and critical components of the natural ecosystem. (3) Correlation of ambient air pollutant concentration gradients with measurable ecological impact indicators.

Economic costs and benefits of air pollution control  
in St. Louis - ROAP #56AAL

ROAP approach-The major objective of RAPS is development of a system that will provide decision relevant information to Air Pollution Control Region Administrators. As part of that system this ROAP will provide information on; (1) the costs of control for each source or set of sources, for different kinds of abatement practices, and for different levels of control; (2) the identification of least cost solutions for existing and possible new standards; (3) the benefits gained by meeting any standard, and (4) the cost-benefit relationship for any standard or set of standards. These benefits and cost functions will relate to specific geographical locations and to social-economic groups within the region.

The information needs of the APCR are the end products in mind for the ROAP. The economic analysis will provide some information directly and will help translate these information needs into requirements for the monitoring network and the diffusion modeling. For example, how should the modeling network be designed to reflect the location of all economically important receptors; how accurate should the models be in view of variances in the transport processes being modeled, the sensitivity of the model to parameter estimates, and the information needs of the APCR. This ROAP will lead to a comprehensive cost of control-benefits of control analyses of the region, as determined by locations of sources and receptors and the transport processes in the region.

Because the information from the economic studies will feed back directly into the RAPS project, perhaps modifying modeling design it should be started early. Also the benefit studies need a longer time to complete and should start early. The main thrust of the benefit aide is a \$100K per year health panel. This study will also contribute to the objectives of the CHESS program.

Benefits to human activity (non-medical), land use, animals, vegetation, and materials will also be studied. On the costs of control side the major activity is the development of a linear programming model that, specifying many control alternatives will identify the least cost implementation plan.

ROAP output-Description of how the economic important receptors are distributed within the region, description of how the human receptors are distributed by race, income and social class, a model that maps onto the receptors the benefits from any control program, a model that maps onto sources the distribution of costs of any control program, and methods of developing these models. Some of the cost and benefits functions may be transferable to other regions with only minor adjustments and the least cost solutions for the St. Louis Region may provide some simple rules of thumb that can be applied quickly in other regions.

Ecological Impact  
Program Element #1AA006

Strengthen scientific basis for existing  
secondary air quality standards - EROS/ROAP #21ALR

EROS-To provide a sound scientific basis for secondary air quality standards for SO<sub>x</sub>, NO, O<sub>3</sub>, photochemical oxidants, hydrocarbons, and particulates. The separate and combined effects of these pollutants, including acid rainfall, on productivity of natural vegetation and crops, on successions of forest vegetation, and on vegetative growth, reproduction and survival, should be determined so that legally defensible air quality standards can be strengthened.

ROAP approach-Determine the effects of SO<sub>x</sub>, NO<sub>x</sub>, Photochemical oxidants, Hydrocarbons and Particulates on selected plant species representative of all the major plant families. A comprehensive approach will be used to determine the effects of all aspects of plant growth and reproductive stages. Both acute and chronic investigations will be undertaken utilize controlled exposure facilities, greenhouses and special field facilities. Techniques for exposing plants have been developed but systems for a comprehensive study of effects must be designed. The ecological effects on the species studied will feed into ROAP 21ALR and ROAP 21ALS. Milestone for work within prescribed tasks will be coordinated with scheduled revision of Air Quality Criteria Documents.

ROAP output-A series of research reports of the effects of the pollutants on individual plant receptors. Summary reports for each pollutant will be prepared recommending levels of pollutants, based on data obtained, that will not harm individual plant or plant communities. These levels will strengthen the scientific basis for secondary air quality standards.

Impact of ambient oxidant concentrations  
on forest vegetation - EROS/ROAP #21ALS

EROS-To determine the effect of ambient oxidant concentrations on forests, including but not limited to coniferous, deciduous, tropical rainforest, by indepth investigations of naturally occurring situations.

ROAP approach-The effects of ambient oxidants on a forest ecosystem will be investigated through an extramural contract by a multi-disciplinary team utilizing coordinated laboratories and field research effort. A mathematical model will be developed to (1) direct and coordinate research, (2) predict the effect on continued, intensified, or reduced oxidant stress, and (3) extrapolate prediction capabilities to other forest systems.

ROAP output-The effect of oxidant stress on a mixed conifer ecosystem in southern California will be determined; major components and systems will be emphasized. A mathematical model describing the above relationship will be developed; the model will be refined to provide reasonable predictions regarding the effect of various stressor levels (a test of secondary oxidant standards and a justification for control measures) on the test ecosystem. The model will be tested for applicability to other forest types.

Predictive modeling of the impact of air pollutants on terrestrial ecosystems - EROS/ROAP #21ALU

EROS-The objective is a mathematical model which can be used as a tool in predicting the ecological impact of excess levels of  $SO_x$ ,  $NO_x$ ,  $O_3$ , hydrocarbons, PAN, and other pollutants upon specified terrestrial ecosystems. The objective of the model will be to predict levels of these pollutants which will not be harmful to the ecosystem.

ROAP approach-To develop a set of biomathematical models using an integrated research program on modeling, field experimentation, and laboratory experiments. These models will be developed by interdisciplinary teams consisting of both biological and mathematical personnel. These models will then be linked to employ a system approach in predicting pollutant impact upon particular terrestrial ecosystems. In the first phase of this program, models will be developed for the Piedmont of North Carolina. Upon validation, these models will be generalized and tested for three other biome types. The data for the extension will be obtained by two contracts and one inter-ROAP activity (ROAP 21ALS).

ROAP output-A series of research reports on the modeling and experimental compartments of the program. These will include experimental data and predictive models for pollutants impact on biomass, population dynamics, succession and transport.

Effect of air pollutants on materials - EROS/ROAP #21AMN

EROS-Determine the effects of air pollutants, such as  $SO_x$ ,  $NO_x$ ,  $O_3$ , and mist, etc., on materials of importance.

ROAP approach-Conduct step-wise factorial experiment in controlled environment chambers to determine direct and synergistic effects of seven climatic and pollutant variables on nine classes of materials. Based on these results, design and conduct orthogonal square controlled environment experiment that will product dose-response relationships for those materials found sensitive to direct and synergistic pollutant effects. Support part of this effort through contracts and grants. Complete state-of-the-art studies on textiles and stress-corrosion cracking of metals.

ROAP output-(1) Progress reports will be written after each set of 1000-hour exposures. Reports will include completed results, and decisions based on those results. For example, if there are no direct and first order synergistic effects of one pollutant, those portions of the experiment, designed to determine if higher order synergistic effects exist, will be dropped. (2) The final output will be reports on each of the nine classes of materials giving damage function of relative humidity, temperature, SO<sub>2</sub>, O<sub>3</sub>, NO<sub>2</sub>, light & cycle. These functions will be presented with confidence limits over ranges expected in the U.S. State-of-the-art reports on textiles and stress-corrosion cracking of metals.

Formation and Decay of Pollutants  
Program Element #1AA008

The dynamics and chemisorption of particulate  
in ambient air - EROS/ROAP #21 AJX

EROS-The investigation of the dynamics and chemisorption characteristics of particulate matter in air.

ROAP approach-Study condensation, evaporation, charging and motions of sub-micron particles; use infrared spectroscopy to observe the chemical and physical state of gases absorbed on such particulates as Fe<sub>3</sub>O<sub>4</sub>, CaO, and MgO; study resonance and raman scattering and radiation depolarization as a function of particle size; study formation of sub-micron particles from reacting gases in a flow system; study the effects of nuclei on formation and growth of light scattering particles; study the effect of aerosol composition on the formation of noxious substances at the surface.

ROAP output-Reports containing basic data on particle dynamics, size distribution and chemisorption rates; information to be used in a fine particles criteria document; an understanding of the dynamics of particulates will permit better specification of air quality standards.

Atmospheric aerosol dynamics - EROS/ROAP #21AKB

EROS-To determine the physical and chemical conditions which control the behavior of aerosols in the atmosphere, including the effects of solar radiation.

ROAP approach-Determine the size spectra, growth processes, and chemical composition of atmospheric particles by measurements in the field and in the laboratory. Correlate the observations with existing theory. Through calculations and analyses, extend the theory where necessary. Calculate and measure light scattering by particulate pollutants. Study the division between fine and coarse particles; study gas-particle conversions and particle removal processes.

ROAP output-Relationships between visibility loss and aerosol characteristics such as size and composition; insights into the production of aerosols from gaseous pollutants; scientific data for fine particle criteria documents; data for justification of atmospheric fine particle standards; data from which to derive pollution control strategies which will improve atmospheric visibility.

Process for the formation and/or removal of toxic and noxious substances from the atmosphere - EROS/ROAP #21AKC

EROS-To investigate the possible physical and chemical mechanisms for the introduction, transport and removal of toxic or noxious substance in the atmosphere.

ROAP approach-Trace the transformations within classes of pollutants such as the sulfur compounds, the nitrogen compounds and the organic compounds. Study the interactions among the various compounds both in the gaseous state and in the condensed phase. Study reactivities and reaction paths. Identify and measure reactive intermediates and final oxidation products. Measure real polluted atmospheres at selected locations and study simulated polluted atmospheres under controlled conditions in the laboratory.

ROAP output-Reports on the chemical and physical processes involved in the creation, transport and removal of toxic substances in the atmosphere; insights into the self-cleansing properties of the atmosphere, and identification of the strains that human activities are placing on that self-cleansing property; indications of long-term atmospheric degradation; data on which to base optimum pollution control strategies.

Meteorological Research  
Program Element #1AA009

Determination of the dispersion, dilution, and physiochemical changes of effluent from large single source  
- EROS/ROAP #06AJR

EROS-To determine and quantitatively describe in terms suitable for inclusion in mathematical models the dispersion, dilution and physiochemical changes of effluent from large single sources.

ROAP approach-Field studies will be continued to determine the dispersion and physiochemical changes of effluent (pollutants, water vapor and heat) from large single sources. Analyses will be continued to determine environmental data necessary for definition of these processes. Methods of calculation, including models, will be developed to describe the impact of effluents as modified by these processes.

ROAP output-Methods of calculation, including computer models, for characterizing both short-period (one hour or less) and long-period average concentrations of effluents from large sources. These methods will be designed for use with climatological and other records of meteorological measurements to assess most probable impacts, as well as for use in particular circumstances which maximize environmental effects.

Analysis of climatological information for abatement and compliance actions - EROS/ROAP #21ADN

EROS-Gather and evaluate climatological data for abatement and compliance actions and provide technical guidance to State and local agencies on meteorological investigations.

ROAP approach-Meteorologists provide technical support to various EPA components and progress external to the Division of Meteorology.

ROAP output-Technical assistance in air pollution meteorology and climatology to various EPA offices and programs, to State and local agencies, and assistance in emergency situations.

Development of a mathematical model which describes air quality over an urban region from multiple sources  
EROS/ROAP #21ADO

EROS-The development and demonstration of a mathematical model or models which quantitatively describe the significant atmospheric (chemical and physical) phenomena which occur over urban regions. Such models should include, but not be limited to, numerical terms for the time-space distribution of atmospheric pollutants from multiple sources and for atmospheric reactions involving  $SO_x$ ,  $NO_x$ , hydrocarbons, ozones and CO.

ROAP approach-The development, evaluation, and application of numerical, physical and empirical environmental simulation models is promoted by this ROAP. While far from perfect, these models serve to provide important additional information regarding the effect on pollutant concentrations of prospective control-strategy decisions or land-use plans.

ROAP output-The products and results of this ROAP will be disseminated in the form of techniques, methodologies, and models for describing the temporal and spatial variations in air quality as a function of the emissions distribution and the local meteorology. To facilitate model applications, EPA users will also be provided access to models and data in storage at a central computer facility.



Development of a model which describes the large scale (GLOBAL) movement/long term effects of air pollutants - EROS/ROAP #26AAS

EROS-The development and demonstration of a model or set of models which describe the global effects of air pollution on weather and climate and the long term effects of atmospheric processes on air pollutants. Such a model or models should include, but not be limited to a description of radiation energy budgets, acid precipitation, stratospheric content of particles and trace gases and CO<sub>2</sub> partition between the atmosphere and oceans.

ROAP approach-It is necessary to develop information on effective man-made and natural emissions (e.g., location, rate ) of pollutants, their airborne concentrations, the factors affecting concentrations (e.g., transformations, dispersion, deposition ), and ultimately their global disposition and effects based on global atmospheric circulation models (under developemnt elsewhere).

ROAP output-A description of the global atmospheric distribution of pollutants from man-made and natural emissions modeling techniques for assessing large scale (meso to global) distributions of pollutants and their predicted or current effect on weather and climate.

PRINCIPAL OFFICIALS OF THE  
ENVIRONMENTAL PROTECTION AGENCY  
RESPONSIBLE FOR ADMINISTRATION OF ACTIVITIES  
DISCUSSED IN THIS REPORT

	<u>Tenure of office</u>	
	<u>From</u>	<u>To</u>
<b>ADMINISTRATOR:</b>		
Russell E. Train	Sept. 1973	Present
John R. Quarles, Jr. (acting)	Aug. 1973	Sept. 1973
Robert W. Fri (acting)	Apr. 1973	Aug. 1973
William D. Ruckelshaus	Dec. 1970	Apr. 1973
<b>ASSISTANT ADMINISTRATOR FOR RE- SEARCH AND DEVELOPMENT:</b>		
Dr. Wilson K. Talley	Dec. 1974	Present
Dr. Albert C. Trakowski, Jr.	May 1974	Dec. 1974
Dr. Stanley Greenfield	Feb. 1971	May 1974