REPORT BY THE

Comptroller General

OF THE UNITED STATES

Federal Weather Modification Efforts Need Congressional Attention

Although the Federal Government has supported weather modification programs for more than 30 years, a coordinated Federal approach to these programs has never been established. Numerous studies have cited the need for coordination, including a GAO study in 1974.

In this report, GAO uses rainfall augmentation projects to illustrate problems of weather modification programs. Lack of integrated formal planning and coordination has hindered the progress of these projects. Although progress has been made, critical questions remain.

The Congress should define national weather modification research and development policy and direct that a program be developed with goals, objectives, priorities, and milestones. The Congress should designate one agency to administer, maintain, and control the program.

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COMPTROLLER GENERAL OF THE UNITED STATES
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Chairmen
Senate Committee on Commerce,
Science, and Transportation SEN06200
Senate Committee on Environment
and Public Works - SEN06400
House Committee on Science and
Technology - HSE03500
House Committee on Interior and
Insular Affairs - HSE01900

This report summarizes some of the general problems associated with Federal weather modification programs, as illustrated by rainfall augmentation efforts. It contains our conclusions and recommendations supporting the need for a congressionally mandated weather modification policy and program.

We focused our review on rainfall augmentation because of the interest in this most widely applied aspect of weather modification.

76C00027 We are sending copies of the report to the Director, Office of Management and Budget, and the Secretaries of Commerce and the Interior.

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Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE
SENATE COMMITTEE ON
COMMERCE, SCIENCE, AND
TRANSPORTATION
SENATE COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS
HOUSE COMMITTEE ON SCIENCE
AND TECHNOLOGY
HOUSE COMMITTEE ON INTERIOR
AND INSULAR AFFAIRS

FEDERAL WEATHER MODIFICATION EFFORTS NEED CONGRESSIONAL ATTENTION

D I G E S T

A coordinated Federal approach to weather modification has never been established but is needed badly. GAO's review supports the findings of nearly 15 years of studies which have identified similar problems, including

--lack of a national weather modification policy,

--no central authority to direct the programs,

--ineffective coordination, and

--fragmented research. (See p. 3.)

Problems of weather modification programs can be illustrated by rainfall augmentation projects. These are meant to produce additional useful rainfall over fixed areas. Some progress has been made but, overall, deliberate rainfall augmentation efforts have been disappointing and critical scientific questions remain unanswered. (See p. 12.)

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The Department of the Interior's Bureau of Reclamation and the Department of Commerce's National Oceanic and Atmospheric Administration administer rainfall augmentation projects. Since 1968 these agencies have spent over $40 million for the projects. However, lack of integrated,

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formal planning and coordination has inhibited progress. (See p. 13.)

In an August 1974 report, GAO recommended that the Office of Management and Budget develop a national weather modification program with goals, objectives, priorities, and milestones and that it designate an agency to administer and maintain the national program. GAO's recommendation was not carried out.

The Office of Management and Budget agreed that some consolidation of weather modification research was desirable, but it did not conclude that a lead agency approach was preferable. It pointed out that each weather modification research project is different and that, in recognition of this, it had instructed specific agencies to concentrate their efforts on certain areas. For example, the Department of the Interior would concentrate on precipitation enhancement and the Department of Commerce on severe storms. Nevertheless, Commerce has been receiving funds, with the Office of Management and Budget's approval, to do research in rainfall augmentation. (See p. 6.)

In a June 30, 1978, report to the Secretary of Commerce, the Weather Modification Advisory Board concluded that the outstanding characteristic of the Federal Government's weather modification organization is that no one is in charge and the results of fragmentation are clearly unsatisfactory. The board proposed

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--a congressional statement of national weather modification policy,

--a 20-year research and development effort with a clear focus on learning more about how to modify weather predictably and prudently, and

--an integrated program bringing together the scattered elements of the existing ineffective effort. (See p. 7.)

RECOMMENDATIONS

GAO reaffirms its 1974 recommendations calling for a national weather modification program and plan, and it supports the Weather Modification Advisory Board's recommendations to establish a national policy and develop an integrated research and development program for weather modification.

The Congress should set forth a national weather modification research and development policy and direct that a program be developed with goals, objectives, priorities, and milestones. Also, it should designate one agency to administer, maintain, and control the program.

Until the Congress establishes such a policy and program, the Secretaries of Commerce and the Interior should establish an integrated, formal planning program to help ensure coordination of their respective rainfall augmentation projects.

AGENCY COMMENTS

The National Oceanic and Atmospheric Administration said that GAO has provided an unbiased appraisal of the history and status of the management of Federal weather modification and of rainfall augmentation. It strongly endorsed the recommendation calling for the establishment of a consolidated national weather modification research and development policy and program to be administered by one agency. (See p. 10.)

The Bureau of Reclamation disagreed with this position and said that there already is a national weather modification policy. The Bureau said the Office of Management and Budget has continually cited the "mission agency" approach to weather modification and approved agency budgets without setting requirements for central agency control.

It added that because the Congress accepted this Office of Management and Budget policy by supporting budget requests, the Congress, in effect, concurred with the policy. (See p. 10.)

GAO does not agree that the Office of Management and Budget's actions constitute a national policy; furthermore, neither does the Congress or the National Oceanic and Atmospheric Administration. In approving the National Weather Modification Policy Act of 1976, the Congress obviously recognized that there was no national policy and directed work, not yet completed, to help develop one. Further, the two major Federal agencies involved in weather modification efforts have widely differing opinions on the need for a national policy. This, in GAO's view, makes it more important that the Congress mandate a policy.

The Bureau objected to the recommendation to designate one agency to administer, maintain, and control the program. (See p. 10) It is apparent that the Bureau has interpreted the recommendation to mean that only one agency--the one in which the program is located--will do all research. It also appears that the Bureau is concerned about losing its program because the Weather Modification Advisory Board has endorsed the National Oceanic and Atmospheric Administration as the agency in which to locate the program. GAO believes that the responsibility for administering and maintaining the overall National Weather Modification Program should be centered in and controlled by a single agency. However, GAO does not advocate that other agencies should be precluded from working on specific weather modification research.

Both the National Oceanic and Atmospheric Administration and the Bureau said that

substantial coordination has taken place between them via scientific conferences, letters, reports, and even the exchange of equipment. The Bureau, however, did agree that a more visible, more formal, and higher level forum for planning and coordination is needed. The National Oceanic and Atmospheric Administration disagreed and saw no value in attempting to develop an integrated, formal planning process until a national policy has been established. (See p. 22.)

GAO agrees that informal coordination may have been helpful. However, formal planning and Federal level coordination would, in GAO's view, provide better program control and would help in defining measurable goals; directing project funding to meet those goals; achieving scientific acceptance of research results; and obtaining Federal, State, and local support.

Contents

ABBREVIATIONS

GAO	General Accounting Office
NOAA	National Oceanic and Atmospheric Administration
OMB	Office of Management and Budget

CHAPTER 1

INTRODUCTION

Weather modification is the deliberate manipulation of the constantly changing atmospheric environment with the intent of improving it--to manage the weather 1/ for human purposes. Weather modification research includes:

--Precipitation enhancement.

--Fog and cloud modification.

--Hail suppression.

--Lightning modification.

--Hurricane and severe storm modification.

Various activities related to inadvertent weather modification (unintended weather changes resulting from human actions) are also generally included under the broad category of weather modification research.

Weather modification has great potential. For example, if weather modification research is successful, it may be possible in future years to enhance precipitation, reduce destructive forces of hurricanes, suppress lightning and damaging hail, and dissipate fog.

The Federal Government has been supporting and conducting weather modification research for more than 30 years. In 1946, American scientists first modified clouds by "seeding" them with dry ice. In the ensuing years, the level of effort for weather modification has grown sporadically among, between, and within various Federal agencies. In fiscal year 1978, $18 million was spent on Federal weather modification research projects. Periodic drought conditions in the United States and the resulting water shortage have heightened congressional, regional, and local interest in weather modification--specifically precipitation enhancement.

Precipitation enhancement includes research projects to explore, develop, and determine the feasibility of applying weather modification technology to meet the Nation's increasing demand for water through snowfall and rainfall.

1/Weather generally refers to the state of the atmosphere at any given time.

FEDERAL RAINFALL AUGMENTATION PROJECTS

The major Federal efforts in rainfall augmentation are currently being conducted by the Department of the Interior's Bureau of Reclamation and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Since 1968, these two agencies have spent or obligated over $40 million for rainfall augmentation projects.

In 1961, the Congress directed the Bureau to conduct research on increasing rainfall by cloud seeding. The Office of Management and Budget (OMB) later made the Bureau responsible for conducting the high plains cooperative experiment (high plains project), a major field experiment which is a local-State-Federal research effort in Kansas, Montana, and Texas. The high plains project was designed to resolve the critical scientific, technical, and social-environmental uncertainties of developing a reliable summer cloud-seeding technology in the plains area.

The Florida area cumulus experiment (Florida project), initiated and conducted by NOAA, is to determine whether precipitation from summer clouds can be altered to increase rainfall over a fixed target area. This study is based on the results of NOAA's research with single cloud seedings in southern Florida in 1968 and 1970. The Florida experiment is attempting to determine if these results can be applied to seeding of multiple clouds over a fixed target area in southern Florida.

SCOPE OF REVIEW

Because of the widespread interest in precipitation enhancement, the most widely applied aspect of weather modification, we concentrated our review on the major Federal rainfall augmentation projects. The high plains project and the Florida project were reviewed in detail.

Most of our fieldwork was conducted at NOAA's Weather Modification Program Office in Boulder, Colorado; the Cumulus Group of the National Hurricane and Experimental Meteorology Laboratory in Miami, Florida; and the Bureau's Division of Atmospheric Water Resources Management in Denver, Colorado. We also contacted NOAA and Bureau headquarters personnel and officials from the Department of Agriculture, the National Science Foundation, and the National Academy of Sciences. We contacted officials from several States and from academia and individuals and private organizations interested in weather modification. We also reviewed various research studies, documents, and publications pertaining to weather modification.

CHAPTER 2

A COORDINATED FEDERAL APPROACH TO WEATHER MODIFICATION IS NEEDED

A coordinated Federal approach to weather modification efforts has never been established and is badly needed. Federal funding for weather modification research projects over the years has been substantial. For example, total weather modification research funding has amounted to over $18 million a year for each of fiscal years 1976, 1977, and 1978.

Our observations of Federal weather modification efforts support the findings of nearly a decade and a half of studies. These studies, conducted by scientific panels, committees, and other interested groups, identified common problems, including lack of a national weather modification research policy, lack of a central authority to direct the programs, ineffective coordination, and fragmented research. We agree with the findings of the studies that call for a national weather modification program with one Federal agency responsible for ensuring that

--plans and priorities are established,

--sufficient program funding is requested,

--research efforts are effectively managed, and

--program results are adequately reported.

In our August 1974 report to the Congress, 1/ we recommended that OMB develop a national weather modification program and designate a Federal agency to have major program responsibility for it. However, an effective, comprehensive national weather modification program still has not been established.

LEGISLATION ON WEATHER MODIFICATION

Over the past 25 years, the Congress has enacted a number of laws dealing with various aspects of weather modification. Public Law 83-256, approved August 13, 1953, established an advisory committee on weather control. The

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1/"Need for a National Weather Modification Research Program," B-133202, August 23, 1974.

committee was required to study and evaluate public and private weather control experiments and determine the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions. Its final report, issued in 1957, was modestly optimistic about weather modification's potentials and recommended that further research be conducted.

Following up on the committee's recommendations, the Congress enacted Public Law 85-510 on July 11, 1958, which authorized and directed the National Science Foundation to initiate and support a program of study, research, and evaluation on weather modification and to report annually to the President and the Congress. In addition to establishing a weather modification research program, the National Science Foundation required all commercial and private weather "modifiers" to maintain records and submit reports to it on their activities.

In 1968, the National Science Foundation's authority under Public Law 85-510 was repealed. On December 18, 1971, Public Law 92-205 was enacted, which required all nonfederally sponsored weather modification to be reported to the Secretary of Commerce. In 1976, Public Law 94-490 (the National Weather Modification Policy Act) was passed, which required the Secretary of Commerce to study weather modification activities and to recommend a national policy on weather modification. To assist in this effort, the Secretary established the Weather Modification Advisory Board as an independent body to advise her on a national weather modification policy and program.

Recently, the Congress recognized the need to establish an integrated national program in a related area, climatology. 1/ In passing the National Climate Program Act of 1978, the Congress established a national climate program to be administered by one agency. The Department of Commerce was designated as the lead agency and a national climate program office was established within Commerce to administer the program. The program is to bring together and utilize all research and monitoring resources with the goal of knowing and anticipating the effects of climate fluctuation.

1/Climate generally refers to the state of the atmosphere in a region during an extended time period. This is in contrast to weather, which is generally defined as the state of the atmosphere at any given time.

STUDIES EVALUATING FEDERAL WEATHER MODIFICATION RESEARCH

A number of scientific panels and committees have reviewed, evaluated, and reported on Federal weather modification efforts. The reports have not only cited a need for a national program with single agency responsibility, authority, and control but have highlighted problems in coordinating multiagency activities and the lack of specific programs. Several studies are summarized in the following sections.

Report of the special commission on weather modification

In 1965, a special commission on weather modification issued a report to the Director, National Science Foundation. The report identified duplication of research activities and coordination responsibilities as problem areas. The report recommended that developing and testing methods for modifying weather should be assigned to one agency in the executive branch to help correct some of the problems.

Reports by the National Academy of Sciences

The National Academy of Sciences issued several reports dealing with weather modification: "Weather and Climate Modification Problems and Prospects" (1966), "The Atmospheric Sciences and Man's Needs" (1971), and "Weather and Climate Modification Problems and Progress" (1973). These reports identified administration and management problems and concluded that a single agency should be made responsible for all weather modification research.

Reports by the National Advisory Committee on Oceans and Atmosphere

The National Advisory Committee on Oceans and Atmosphere, established in 1971 under Public Law 92-125, is made up of representatives appointed by the President from industry, science, and State and local governments. The committee is required to assess the status of marine and atmospheric science programs and report annually to the President and the Congress. Beginning with its first annual report issued on June 30, 1972, the committee has pointed out that weather modification research is fragmented and uncoordinated. It has been concerned that the research is not making scientific progress and that its costs are unnecessarily high because field experiments are performed by "mission" agencies

isolated from each other. The committee has recommended that one agency be appointed to coordinate weather modification research.

GAO REPORT RECOMMENDED A NATIONAL WEATHER MODIFICATION PROGRAM

In August 1974, we issued a report to the Congress entitled "Need for a National Weather Modification Research Program."

We identified common problems that hindered progress in Federal weather modification efforts. These included lack of a central authority to direct Federal efforts; ineffective coordination; and insufficient resources to achieve timely, effective results.

We recommended that OMB cooperate with the other Federal departments and agencies involved in weather modification research to:

--Develop a national program with goals, objectives, priorities, and milestones and designate one agency to have major responsibility for administering and maintaining a national program.

--Develop a plan to define and reassign, if necessary, the responsibilities of Federal departments and agencies that support or conduct weather modification research.

--Develop a plan to allocate resources for the national program.

In replying to our recommendations, OMB agreed that some consolidation of weather modification research was desirable, but it did not conclude that all such research should be concentrated in one agency or that a lead agency approach was preferable. OMB pointed out that the President proposed legislation to form a Department of Energy and Natural Resources which could, in its view, accomplish the appropriate degree of consolidation. Subsequently, legislation to establish a Department of Energy and Natural Resources was withdrawn.

OMB also pointed out that each weather modification research project is different and that, in recognition of this, it had instructed specific agencies to concentrate their efforts on certain areas. For example, the Department of the Interior would concentrate on precipitation enhancement and the Department of Commerce on severe storms.

As discussed in chapter 3, however, this delegation of responsibilities has been less than effective.

WEATHER MODIFICATION ADVISORY BOARD RECOMMENDED A CONSOLIDATED NATIONAL WEATHER MODIFICATION PROGRAM

The Weather Modification Advisory Board issued its study entitled "The Management of Weather Resources--Proposals for a National Policy and Program" to the Secretary of Commerce on June 30, 1978. The board concluded that the outstanding characteristic of the Federal Government's organization for weather modification is that "no one is in charge" and the results of fragmentation are clearly unsatisfactory. The board said weather modification has never attained momentum as a program of the Federal Government, has been marred by bureaucratic rivalries in the executive branch, and has never received more than marginal funding.

The board concluded that a usable technology for significantly enhancing rain and snow and ameliorating some weather damage is scientifically possible and within sight. The board said, however, that the broad research and development in weather resources management should not, at this stage, be oriented primarily to user constituencies.

The board suggested three actions to accomplish effectively the objectives of a national weather modification program. It proposed that

- --a congressional statement of national policy be issued,
- --a 20-year research and development effort be established with a clear focus on learning more about how to modify weather predictably and prudently, and
- --an integrated program be formed by bringing together the scattered elements of the existing ineffective effort.

The board further recommended that a national weather resources management board be established to define and oversee the Federal role in weather modification.

The board considered the merits of various Federal agencies, including the Bureau and NOAA, as the agency which should have responsibility for the weather modification

program. The board pointed out that the Bureau has had a sizable program in precipitation modification for 15 years under dedicated and highly competent leadership. It has a strong commitment to development of weather modification and is interested in being host to the new program. On the other hand, the board said that the Bureau's desire to maintain "grass roots" support has resulted in emphasis on "promises of results" while tending to underplay the scientific uncertainties and risks of certain actions. The board said the Bureau has not shown the interest in research that it believes is central to the new national program, although its concern with development and application is an asset that must be retained. Also, the Bureau's development activities have been restricted to rain and snow enhancement, and it has not been concerned with other aspects of weather modification. These considerations led the board to set aside the idea of assigning the program to the Bureau.

The board said that weather modification is closely related to NOAA's central mission and concerns. NOAA has a major weather forecasting mission and has been assigned lead responsibility for the National Climate Program. The Board pointed out that although NOAA's past performance in weather modification was seriously deficient, the intention of the present NOAA leadership is to repair the deficiencies and to make weather resources management an active and aggressive activity.

Taking into account all considerations, the board concluded that the best location for the program was in NOAA. The board also noted that if a Department of Natural Resources, combining Interior and NOAA, were created, the weather modification program and National Weather Resources Management Board would belong in that department.

The Secretary of Commerce is preparing a report, based on the board's recommendations, which will be submitted to the President and the Congress in accordance with Public Law 94-490. As of July 24, 1979, Commerce officials informed us that the Secretary's report still had not been finalized but that it would endorse the concept of a national weather modification policy and favor somewhat of a more centralized program.

PROPOSED DEPARTMENT OF NATURAL RESOURCES

In March 1979, the President said that he would propose creating a Department of Natural Resources to manage the

Nation's natural resources. The new department would include the Department of the Interior, NOAA, and several other Federal agencies.

In its December 1978 staff report supporting the proposed Department of Natural Resources, the President's reorganization task force pointed out that weather modification research is going on in several agencies, including NOAA and Interior. The report said that the results have been meager because of the dispersion of resources and accountability. The report stated that a Department of Natural Resources could enhance the Government's ability to address problems of work duplication and the lack of clear responsibility identified by the Weather Modification Advisory Board in its June 1978 report to the Secretary of Commerce. In May 1979, the President decided not to proceed with his plan to establish a Department of Natural Resources.

CONCLUSIONS

A coordinated Federal approach to weather modification efforts has never been established but is badly needed. Our observations support the findings of nearly a decade and a half of studies which identified common problems, including the lack of a national weather modification policy, lack of a central authority to direct the programs, ineffective coordination, and fragmented research.

In our 1974 report, we recommended that OMB develop a national weather modification program with goals, objectives, priorities, and milestones and designate one agency to be responsible for administering and maintaining the national program. Our recommendation was not carried out and, to date, an effective national weather modification program has not been established.

More recently, the Weather Modification Advisory Board in its June 30, 1978, report concluded that the outstanding characteristic of the Federal Government's organization for weather modification is that no one is in charge and the results of fragmentation are clearly unsatisfactory. The board proposed (1) a congressional statement of national weather modification policy, (2) a 20-year research and development effort with a clear focus on learning more about how to modify weather predictably and prudently, and (3) an integrated program bringing together the scattered elements of the existing ineffective effort. Also, taking into account all considerations, the board concluded that the best location for the program is in NOAA.

We support the National Weather Modification Advisory Board's recommendations to establish a national policy and develop an integrated research and development program for weather modification. We conclude that the Congress should set forth a national weather modification research and development policy and program with goals, objectives, priorities, and milestones and designate one agency to administer, maintain, and control the program.

AGENCY COMMENTS AND OUR EVALUATION

NOAA said that we have provided an interesting, informative, and unbiased appraisal of the history and status of the management of Federal weather modification and of rainfall augmentation. NOAA strongly endorsed the recommendation calling for establishment of a consolidated national weather modification research and development policy and program to be administered by one agency.

The Bureau said that, contrary to what our report and other reports infer, a national weather modification policy is in effect. The Bureau said OMB has continually cited the "mission agency" approach to weather modification and approved agency budgets along this line without calling for central agency control. It added that the Congress has accepted the OMB policy by supporting the budget requests.

We do not agree that the OMB policy and practices constitute a national policy. Neither does the Congress nor NOAA. Although OMB said that certain weather modification activities were to be carried out by specific agencies, the Department of Commerce, which was designated to do research in severe weather, has been receiving funds with OMB's approval to do research in rainfall augmentation, which OMB assigned to the Bureau. In passing the National Weather Modification Policy Act of 1976, the Congress recognized that no national weather modification policy exists. The work that the Congress directed under the 1976 act to help develop a national policy has not yet been completed. Further, it is interesting to note that the two major Federal agencies involved in weather modification efforts have widely differing opinions on the status of a national weather modification policy. This, in our view, further supports the need for a congressionally mandated policy.

The Bureau strongly objected to our recommendation to designate one agency to administer, maintain, and have responsibility for the program. The Bureau supports the mission agency approach that provides several different avenues of funding for various types of projects and said

it should maintain its leadership role in precipitation management within a total national weather modification effort to help meet the varied water resource missions within the Department of the Interior.

In its response to our recommendation calling for a single agency to administer, maintain, and control the weather modification program, the Bureau has apparently interpreted this to mean that only one agency--the one in which the program is located--will do all research. It also appears that the Bureau is concerned about losing its program because the Weather Modification Advisory Board has endorsed NOAA as the agency in which to locate the program. We believe that the responsibility for administering and maintaining the overall national weather modification program should be centered in and controlled by one agency. However, our report does not advocate that other agencies should be precluded from working on specific weather modification research.

RECOMMENDATIONS

We reaffirm our 1974 recommendations calling for a national weather modification program and plan and support the Weather Modification Advisory Board's recommendations to establish a national policy and develop an integrated research and development program for weather modification. We recommend that the Congress set forth a national weather modification research and development policy and direct that a program be developed with goals, objectives, priorities, and milestones. Also, it should designate one agency to administer, maintain, and control the program.

CHAPTER 3

FEDERAL RAINFALL AUGMENTATION EFFORTS ARE FRAGMENTED; LACK INTEGRATED, FORMAL PLANNING; AND LEAVE CRITICAL SCIENTIFIC QUESTIONS UNANSWERED

General problems associated with weather modification programs are illustrated by the rainfall augmentation projects. Although the objective of rainfall augmentation efforts has been to produce additional useful rainfall over a large area and some progress has been made, overall progress in deliberate rainfall augmentation has been disappointing. Lack of integrated, formal planning and coordination has limited the progress of Federal rainfall augmentation research projects, even though such projects have been conducted over the past 30 years and some progress has been made. This lack of planning and coordination has contributed to a number of critical scientific issues remaining unanswered.

SOME PROGRESS HAS BEEN MADE

Over the past 30 years, some progress has been made in weather modification research. Specific achievements include

- --the capability to dissipate cold fog and low stratus clouds, to enhance mountain snowfall under certain conditions, and to increase rainfall in limited ways and places;
- --advances in instrumentation and technology, such as development of more efficient cloud-seeding methods, advances in meteorological aircraft, and more sophisticated radar to measure rainfall;
- --improved project design and evaluation techniques;
- --a cadre of well-trained atmospheric scientists to plan, operate, and evaluate weather modification projects; and
- --a better grasp of the types of social, economic, legal, and institutional impacts ensuing from weather modification.

Progress has also been made in understanding the inherent complexities of managing the atmosphere versus the overly simplified expectations of weather modification advocates in the 1950s and 1960s.

PROGRAMS ARE FRAGMENTED AND LACK INTEGRATED, FORMAL PLANNING

Rainfall augmentation projects with similar objectives are being conducted by separate Federal agencies with no central direction. These fragmented research efforts lack integrated, formal long-range planning and long-term commitment of resources. This lack has contributed to inconclusive results in most experimental projects.

Fragmented approach

The Bureau of Reclamation and NOAA are conducting or plan to conduct research to test rainfall augmentation techniques. The fragmentation and lack of continuity of Federal rainfall augmentation efforts are illustrated in the following table, which shows Bureau and NOAA projects for 1962-78. The table includes data on the Bureau's precipitation enhancement project, initiated in 1971 and discontinued in 1973, and NOAA's planned precipitation augmentation for crop experiment in Illinois project, which involves the same contractor and contains similar objectives and geographical areas as the precipitation enhancement project.

Bureau and NOAA Rainfall Augmentation Projects

	Bureau	NOAA
1962-73	In addition to the precipitation enhancement project and the high plains project, conducted eight separate experiments to test rainfall augmentation techniques without conclusive results	
1968-69		Developed rainfall augmentation objectives as an outgrowth of its hurricane research. Initiated Florida project.
1971	Contracted with the Illinois State Water Survey to conduct the precipitation enhancement project.	
1972		Proposed high plains experiment to develop precipitation enhancement technology for the benefit of agriculture.
1973	OMB directed the Bureau to initiate the high plains project. Bureau discontinued funding the precipitation enhancement project before completion because of a funding decrease.	
1976		NOAA and the Illinois State Water Survey jointly developed the precipitation augmentation for crops experiment with similar objectives as the Bureau's 1971 precipitation enhancement project.
1978	Bureau continued high plains project. The start of the first randomized experiment (field test) was delayed from 1974 to 1979.	NOAA continued Florida project by conducting confirmatory experiment and planned the new Illinois project.

As previously mentioned, in 1973 OMB designated the Bureau as the lead agency for precipitation enhancement and NOAA as the lead agency for severe storms. The Bureau was directed to manage the high plains cooperative experiment, and NOAA was instructed to focus its weather modification activities on the modification of hurricanes and other severe storms. According to NOAA and OMB officials, under an oral agreement NOAA continued the Florida rainfall augmentation project. Recently, an OMB official stated that OMB continued funding to allow NOAA to complete the research.

The proposed Department of Natural Resources would have included the Bureau and NOAA and thus would have consolidated rainfall augmentation projects within one agency. However, as noted in chapter 2, the President decided not to go forward with his plan to establish the new department.

Lack of integrated, formal long-range planning

Formal long-range plans were not developed for NOAA's Florida project. Specific experiment plans for the Bureau's high plains project were not available until the spring of 1979. Neither project has met projected completion estimates. Formal long-range planning is necessary to provide measurable goals and obtain project funding to meet those goals; to achieve scientific acceptance; and to obtain Federal, State, and local support.

For the Florida project, NOAA never developed a formal long-range plan; rather, the project was expanded on a year-to-year basis. NOAA officials said this approach was used because funding was obtained on an annual basis and each year's data was used in planning the next phase of the research.

In 1975, NOAA began using a different device to seed clouds in the Florida project. Results obtained from cloud-seeding experiments in 1976 combined with data obtained in the past indicated an overall increase in rainfall. However, the project director said that following the 1976 experiment it became necessary to validate the results by conducting a confirmatory experiment because the measurement techniques were not acceptable to the scientific community and a hypothesis for seeding had not been developed. Also, the concept of exploratory-confirmatory experiments for weather modification evolved after the Florida project was underway and the initial Florida efforts were exploratory.

In March 1979, the project director told us that 2 more years of field experimentation, at a cost of about $1.4 million per year, will be necessary to complete the confirmatory phase of the project. The total cost of the Florida project, including the confirmatory phase, is estimated to be $13 million, of which $12 million will have been spent or obligated through fiscal year 1979.

The Bureau developed a conceptual, long-range plan for the high plains project after OMB assigned it that responsibility in 1973. The Bureau obtained the input of the scientific community, State and regional interests, and the general public through scientific design workshops, agreements with involved States, and public meetings. The original goals were not met, in part because of funding limitations. Also, the project director said that because the project's approach has changed, it was necessary to redesign the project.

Bureau officials said it was necessary to redesign the high plains plan due to the adverse results of other weather modification efforts. The original plan was based on cloud-seeding technology developed and used in previous Bureau projects. When data produced by the Bureau and others proved inconclusive by the mid-70s, the Bureau decided that outside planning assistance was needed.

A contract with the Illinois State Water Survey was amended to design and provide project planning guidance beginning in 1975. Although this contract terminated in 1978 without developing specific experiment designs, the Bureau used the Illinois water survey recommendations as a general project design. It was also used as input in developing the specific experiment design. A new 5-year contract (through 1984) was awarded to the South Dakota School of Mines and Technology to study the impact of various design options, to periodically review the design and field operations, and to evaluate the effects of seeding.

The total cost for the high plains project is now estimated at $40 million, of which about $19 million will have been spent or obligated through fiscal year 1979.

NOAA plans additional projects

As previously mentioned, NOAA is planning to conduct a major new project in Illinois. The project--the precipitation augmentation for crop experiment--is designed to test whether rain can be increased to benefit agriculture

in Illinois and neighboring areas. NOAA is providing $100,000 for preliminary Illinois project studies in 1979.

The National Science Foundation, the Army, and the Air Force are providing similar amounts for related studies that will contribute to the Illinois project. Cost estimates for this project range from $25-$50 million.

NOAA also plans to conduct a new experiment in Florida on cumulus dynamics and microphysics. This project would attempt to define the cloud physics of the Florida area cumulus experiment type cloud seeding. No cost projections for this project are currently available.

NOAA and the National Science Foundation are also providing $150,000 each in support of the United Nations precipitation enhancement project in Spain during fiscal year 1979. Cost projections for the U.S. contribution to this project show an increase to about $800,000 per year when the seeding phase begins.

OMB officials informed us that they do not now plan to fund any additional major rainfall augmentation projects for NOAA, although they added that this could change as Federal priorities change. OMB has not approved the NOAA precipitation augmentation for crops experiment or the cumulus dynamics and microphysics project, and it would not consider funding these projects until the Florida area cumulus experiment is completed.

CRITICAL SCIENTIFIC QUESTIONS REMAIN UNANSWERED

Specific scientific issues critical to the success of rainfall augmentation projects have not been adequately addressed by researchers, and a degree of uncertainty hinders future progress. For example:

--Basic issues still must be answered concerning the physical basis for rainfall augmentation techniques.

--The total area effects for the target area and surrounding area effects from rainfall augmentation have not been adequately measured or analyzed.

--The techniques and assessment standards needed to accurately measure the results of a rainfall augmentation project have not been adequately defined.

--Understanding of the potential for cloud seeding to induce or aggravate severe weather is inadequate.

These questions should be addressed to permit development of predictable, acceptable rainfall augmentation as an operational technology.

Fundamental knowledge of cloud process is lacking

Fundamental knowledge concerning the physics and dynamics of cloud processes is inadequate, which hinders development of deliberate, useful rainfall augmentation techniques. NOAA's Florida project's environmental impact statement for 1976 states that seeding of individual clouds in southern Florida in 1968 and 1970 was effective in increasing rainfall. Yet, project officials admit that it is not clear whether these early experimental results can be applied to the seeding of many clouds over a fixed target area and if the additional rainfall from an individually seeded cloud may be at the expense of other clouds in the environment.

The Bureau's project has been delayed in part because of a lack of adequate scientific knowledge. The Bureau did not start randomized field experiments until the summer of 1979. The Bureau said that because of the difference in clouds it is using a different seeding method than the "dynamic seeding" applied by the NOAA project.

Total area effects remain uncertain

Total area effects of rainfall augmentation are undefined, and therefore rainfall augmentation projects are unable to predict results outside the target area. Recent evidence from cloud-seeding experiments suggests that the effects of cloud seeding may extend beyond the target area. While a few scientists have speculated that cloud seeding could be changing worldwide weather patterns, many others believe most important effects occur within approximately a 300-mile radius of the target area.

Present Federal rainfall augmentation projects do not adequately address total area effects. Usually, project plans require total area effects studies, but funding limitations preclude adequate research for this purpose. Because adequate studies have not been performed during the projects, it has been necessary to analyze total area effects after projects have been completed. The scientific community is reluctant to accept results when the evaluation criteria are established after the data has been

obtained. So far, after-the-fact analyses have indicated widely different effects, such as:

--Additional rainfall in target and surrounding areas.

--Less rainfall in target and surrounding areas.

--Additional rainfall in target and less rainfall in surrounding areas.

--Less rainfall in target and additional rainfall in surrounding areas.

In its report, the Weather Modification Advisory Board stated that a major concern of cloud seeding must be to identify the area and timing of seeding effects whenever they occur. The board recommended that this concern should be properly reflected in the design of all future seeding experiments.

The potential cost of evaluating total area effects was cited in a workshop on extended effects of weather modification sponsored by the National Science Foundation in August 1977. This workshop proposed an approach that would encompass an area of at least a 300-mile radius in the mid-United States and would be performed over approximately a 10-year period. The cost was estimated to be $10-$20 million per year--approximately the same as the annual Federal weather modification budget during the last decade.

Assessment standards have not been adequately defined

Assessment standards have not been established by the Federal Government or the scientific community to evaluate project results. There is no general agreement as to the methods of data collection or even the nature of data required to assess a rainfall augmentation project adequately. Several scientists had different opinions about the density of rain gauge networks, the adequacy of radar and satellite measurement, and the validity of statistical techniques to assess rainfall augmentation projects.

In its report, the Weather Modification Advisory Board pointed out that there are two types of cloud-seeding experiments--exploratory and confirmatory. Exploratory experiments are conducted to explore physical-meteorological relationships and to develop seeding hypotheses. The end results of a good exploratory seeding experiment are a

physically plausible model of the weather system under investigation and of the impact of a particular seeding method upon it.

The objective of confirmatory seeding experiments is to establish a particular hypothesized seeding effect within a small and well-defined margin of error, both clearly stated before the experiment. Confirmatory experiments must be precisely designed, tightly controlled, and free of unconscious or accidental bias.

The following sections illustrate the varying methods of data collection used to evaluate project results.

Bureau and NOAA projects employ radar for some evaluation of rainfall augmentation experiments. Rather than measuring actual rainfall with rain gauges, scientists estimate the amount of rainfall by radar echo characteristics of cloud and precipitation particles. Radar is used to supplement rain gauges to minimize the expense of installing a large rain gauge network and to measure large-scale precipitation patterns. However, the scientific community cannot agree on the adequacy of radar to evaluate rainfall. NOAA had problems with the primary radar system in 1971 and 1976 which caused the data collected to be not totally acceptable. In part because the scientific community would not fully accept the reported results of the Florida project, NOAA is now performing a 3-year confirmatory experiment. For this experiment, NOAA is employing, in addition to radar, a network averaging one rain gauge for every 39 square miles of target area.

The planning for the Bureau project also clearly demonstrates the varying criteria used by agencies to evaluate research effects. When NOAA proposed the high plains experiment in 1972, the primary evaluation was to be a network averaging one rain gauge every 10 miles of target area. After the Bureau was designated to perform the high plains project, the Bureau selected radar for the primary evaluation technique. But after the problems with radar became known, the Bureau decided to rely more on rain gauges; plans were changed to specify a network averaging one rain gauge every 20 square miles.

Severe weather effects are unknown

Rainfall augmentation has the potential for aggravating severe weather in addition to producing rain, but an adequate understanding of the relationship between cloud seeding and severe weather has not been developed. In order for

operational rainfall augmentation projects to be considered safe and acceptable, the potential for instigating or aggravating severe weather must be determined.

NOAA and Bureau scientists told us that since much of the rain in the Midwest and Plains States occurs with severe weather, such as hail, strong winds, and tornados, there is concern that artificial augmentation of rain may also increase the occurrence of unwanted severe weather. The high plains project director said that based on the Bureau's analysis of past weather patterns in Kansas, 25 to 75 percent of the cloud-seeding opportunities would have to be foregone because of the presence or forecast of severe weather in the operational area.

The Florida project director told us that before applying Florida project techniques to cloud systems in Illinois in the precipitation augmentation for crops experiment, several serious questions would have to be answered, including the potential for causing severe storms. In southern Florida, the target area encompasses a rural area where daytime summer thunderstorms have little potential for severe weather. The agricultural area, where NOAA proposes to test the Florida project techniques, produces high-yielding crops which could be damaged as well as helped by rainfall augmentation.

CONCLUSIONS

General problems associated with weather modification programs are illustrated by the rainfall augmentation projects. Although the objective of rainfall augmentation has been to produce additional, useful rainfall over a large area, and while some progress has been made, overall progress in deliberate rainfall augmentation has been disappointing. More formalized, integrated long-range planning of weather modification projects is needed to provide measureable goals and to direct project funding to meet those goals; to achieve scientific acceptance of the project results; and to obtain Federal, State, and local support. Lack of formal, integrated planning and coordination continues to inhibit the progress of Federal rainfall augmentation research projects. As a result, even though projects have been conducted during the past 30 years and some progress has been made, basic critical scientific questions remain unanswered.

Until the Congress acts to establish a national weather modification policy and program, program improvements could be made through more formal, integrated planning procedures

and better coordination of rainfall augmentation projects between the Bureau and NOAA.

AGENCY COMMENTS AND OUR EVALUATION

The Bureau of Reclamation concurred that a more visible, more formal, and higher level forum for planning and coordinating the national weather modification program is needed. The Bureau said that the forum should have representatives of all involved Federal agencies and weather modification interests, including States, local agencies, and user groups, and should cover all aspects of weather modification. The Bureau also pointed out, however, that it believes no wasteful duplication or harmful lack of coordination has occurred. The Bureau said important coordination has taken place at numerous scientific conferences, open reviews of planned and existing projects, interchange of scientific teams and equipment between projects, open scientific discussion of results, joint representation on national planning and review committees, and frequent personal communication of key scientists.

NOAA disagreed with our recommendation. NOAA saw no value in attempting to develop an integrated, formal planning process until the shape of the national policy has been determined. NOAA said that over the years, the two agencies have maintained a cooperative approach in planning and conducting their respective projects. Technical interaction has been continuous via conferences, letters, reports, and even exchange of equipment. Discussion and review of short- and long-range plans for experiments and projects have been commonplace.

We agree that informal coordination can be helpful. However, we continue to believe that formal planning and Federal level coordination would provide better program control and help in defining measurable goals; directing project funding to meet those goals; achieving scientific acceptance of research results; and obtaining Federal, State, and local support. Also, the Bureau, notwithstanding its position that there has been substantial coordination, agrees that a more visible, more formal, and higher level forum for planning and coordination is needed.

RECOMMENDATIONS

We recommend that until the Congress establishes a national weather modification policy and program, the Secretaries of Commerce and the Interior establish an integrated, formal planning program to help ensure coordination of their respective rainfall augmentation projects.

APPENDIX I

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

16 JUL 1979

Mr. Henry Eschwege
Director, Community and Economic
Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in reply to your letter of June 4, 1979 requesting comments on the draft report entitled "A Congressionally Mandated Weather Modification Policy and Program is Needed".

We have reviewed the enclosed comments of the Associate Administrator, National Oceanic and Atmospheric Administration and believe they are responsive to the matters discussed in the report.

Sincerely,

Elsa A. Porter for
Assistant Secretary
for Administration

Enclosure

APPENDIX I

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852
OFFICE OF THE ADMINISTRATOR

RD2:MTC

Mr. Henry Eschwege
Director
Community and Economic Development
Division
U.S. General Accounting Office
441 G St., N.W. - Rm. 6146
Washington, D. C. 20548

Dear Mr. Eschwege:

Secretary Kreps has asked me to reply to your letter of June 4, 1979, that requested a review and comments on the draft of a proposed report, "A Congressionally Mandated Weather Modification Policy and Program is Needed".

The draft report has been reviewed thoroughly by appropriate members of this agency. Several general comments are provided below, and specific suggestions for changes in the draft report are included in an enclosure to this letter.

Our overall reaction to the draft report is favorable. The General Accounting Office investigators have provided an interesting, informative and unbiased appraisal of the history and status of the management of Federal weather modification and of rainfall augmentation. The recommendation calling for the establishment of a consolidated National Weather Modification Research Policy and Program to be administered by one agency is consistent with the National Oceanic and Atmospheric Administration's (NOAA) recent view on this matter and we strongly endorse this position.

On the other hand, NOAA does not support the report's other recommendation that, in the interim, the Secretaries of Commerce and Interior establish an integrated formal planning program and Federal level coordination of their respective rainfall augmentation projects. Over the years, the two agencies have maintained a cooperative approach in planning and conducting their respective projects. Technical interaction has been continuous via conferences, letters, reports and even exchange of equipment. Discussion and review of short and long range plans for experiments and projects have been commonplace. We see no value in attempting to develop an integrated, formal planning process until the shape of the national policy has been determined.

Thank you for sending the draft report to us for review. I trust that our comments will be useful to you.

Sincerely yours,

George S. Benton
Associate Administrator

Enclosure

APPENDIX II

United States Department of the Interior

BUREAU OF RECLAMATION
WASHINGTON, D.C. 20240

IN REPLY REFER TO: 1900

AUG 27 1979

Mr. Henry Eschwege
Director, Community and Economic
Development Division
United States General Accounting Office
Washington DC 20548

Dear Mr. Eschwege:

On June 19, 1979, a meeting was held, as you requested, between members of our respective staffs to discuss the draft report "A Congressionally Mandated Weather Modification Policy and Program is Needed." This letter transmits our formal comments on the revised draft report by your office subsequent to that meeting and made available to us on August 1, 1979. These comments should be the basis for any agency comments cited in the final report. Our views, on this matter of great importance to the Bureau of Reclamation, will be best represented if these comments, in their entirety, are incorporated as part of the final report.

The Nation's largest weather modification program is conducted by the Department of the Interior's Bureau of Reclamation. The fiscal year 1980 funding for our research program is $9,371,000, all of which is devoted to developing practical precipitation management techniques for both winter orographic snowfall and summer rain to augment the Nation's water supplies from renewable atmospheric sources. I have a strong interest in continued vigorous research in cloud seeding, and, as soon as scientifically and socially feasible, I plan to integrate this technology into the Bureau's comprehensive system for managing water and energy resources. This is becoming especially important at a time when growing demands are being made on existing water resources.

I am proud of the progress made in this scientifically complex and socially controversial field, much of it occurring through the Bureau's research program which I believe has been responsive to the repeated confidence and increasing resources given it. Many of the current operational cloud seeding projects in the Western States by State and local sponsorship can be directly attributed to the scientific findings from our "Project Skywater" program and our fostering of local expertise by the cooperative research that has enabled their

APPENDIX II

responsible management. The Bureau's research has, I believe, been a major contributor to the main finding of the Weather Modification Advisory Board in their report to the Secretary of Commerce that "the key conclusion in this report is that a usable technology for significantly enhancing rain and snow and ameliorating some damage is scientifically possible and within sight." Precipitation enhancement research in general and the Bureau's programs on augmenting winter snowpack and summer rainfall in particular are at the forefront of the Board's recommendations for A Twenty-Year Program of Action.

In this regard, the achievements and high regard of the Bureau, which the Board recognized on page 200 of its report, should be pointed out:

> "The Bureau of Reclamation has had a sizable program in precipitation modification for 15 years under dedicated and highly competent leadership. It has a strong commitment to development of weather modification. It is interested in being the host of the new National Weather Resources Management Program. This may be a natural choice if a new Department of Natural Resources is formed with the Department of the Interior as the core. The Bureau of Reclamation has viewed weather modification as an integral part of water resources management, a logical perspective on a new technology."
>
> "Much of the R&D supported by the Bureau of Reclamation has been performed by the private sector and university and state agencies, largely in the Western United States. Useful scientific discoveries relating to snowfall modification in the mountains have resulted. Through the strong organizational regional ties of the Bureau of Reclamation, its weather modification program has focused on technology transfer and a strong interaction with users. This is a valuable characteristic of the Agency."

In view of this background and the expanding interest in weather modification, we had expected a more positive and constructive report by the General Accounting Office that would focus more clearly on how to accelerate the Nation's weather modification efforts. The following general comments are offered on the major issues raised in the report which should be considered in any of the forthcoming decisions on this important technology:

1. The GAO report repeats and stresses the allegation of "fragmented research." It reviews the Bureau's High Plains project and NOAA's Florida project and contends that the findings for these two rainfall augmentation projects are relevant to the entire Federal weather modification program. In fiscal year 1979 there are only three Federal agencies involved in research on deliberate weather modification, and these two projects represent a major portion of the total program. The total budget of $12.8 million consists of $8.6 million in the Department of the Interior for snow and rain augmentation research, $3.1 million in the Department of Commerce for rain augmentation research and hurricane amelioration research, and $1.1 million in the National Science Foundation which does not have a specific budget for weather modification but devotes this amount of their atmospheric sciences funding to basic research directly related to weather modification. More than half of the total budget is devoted to rain augmentation research, about a third for snow augmentation research, and the remainder to hurricane amelioration research and other small weather modification efforts. Where more than one rain and snow augmentation research program exists, they are conducted in different climatic regions with different precipitation-producing conditions. Recognizing the scientific and economic importance of precipitation enhancement, the Weather Modification Advisory Board recommended a program of experimental tests, some operated in parallel in different regions to expedite progress. There is little or no federally supported research on the other areas of weather modification mentioned in the report, namely fog and cloud modification, hail suppression, lightning modification, and severe storm modification. We, therefore, fail to see the basis for the repeated charge of "fragmented research."

2. The GAO report also reiterates the allegation of "ineffective coordination," a charge that has been made in many of the past weather modification reviews. Yet there has <u>never</u> been a specific instance cited or facts presented to substantiate these charges. The Bureau believes that there has been no wasteful duplication or harmful lack of coordination. We, in fact, contend that there has been substantial coordination. Important coordination has taken place at numerous scientific conferences, open reviews of planned and existing projects, interchange of scientific teams and equipment between projects, open scientific discussion of results, joint representation on national planning and review committees, and frequent personal communication of key scientists. The 1974 GAO report, "Need for a National Weather Modification Research Program," was faulted by the Office of Management and Budget and the Department of Agriculture for lack of substance in the criticism of coordination. This report, as drafted, is similarly lacking in substance.

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3. Statements in the reports on the "lack of formal planning" overlook a great deal of coordinated detailed planning, review, and preproject study by the Bureau. We have gone to great lengths to include all groups - Federal scientists, State agencies, universities, private industry, local groups, concerned individuals, etc., in our planning and review process. Thirteen Skywater conferences have been held, formal reviews of the environmental impact statements conducted, and many scientific workshops and progress review meetings have been convened. In 1966 the Bureau prepared a formal plan for an $800 million nationwide precipitation management program "Plan to Develop Technology for Increasing Water Yield from Atmospheric Sources." This was presented to Congress and OMB and funds were provided by Congress to initiate the planned program. The Bureau is still operating under this plan and mission assignment and has followed specific directives from the Congress to accelerate portions of the overall plan.

The High Plains Cooperative Program began in January 1973 with a formal assignment from OMB and a $1 million budget. The Governors of the involved states were informed and invited to enter the planning by formal letter. Many public meetings were held, including those in local areas as part of a site-selection process, and formal agreements were negotiated with each state prior to start of research in the state. Several scientific design workshops were held to incorporate the most current and pertinent ideas into the development of plans and designs. Plans, designs, and detailed budgets have been presented to OMB and the Congress and funds have been approved.

These and other actions reflect the Bureau's sincere effort to make the planning of "Project Skywater" as open and formal as possible and include the input of the scientific community, regional interests, and the general public in the planning and review process.

4. The repeated statements of "disappointing progress in weather modification" do not reflect an appreciation for the very real scientific complexity of the problem and the substantial progress that has been made. Modern weather modification is a relatively young (33 years old) applied meteorological science whose progress is intimately dependent on advances in meteorological understanding in general. Progress during this period on describing and predicting the diverse and complex behavior of clouds and their environment has been very slow but meaningful. The oversimplified expectations of rainmaking promoters in the 1950's and 1960's have been replaced by a realization of the problem's true complexity and the length of

APPENDIX II

time and magnitude of resources required to develop the concepts into a verified, responsible technology. Viewed in this perspective and considering the relatively recent start and meager resources applied to weather modification research and development, the fact that substantial progress has been made is very noteworthy. This progress was recognized by the Weather Modification Advisory Board.

The real issue is what can we do to accelerate this progress. To state that ". . . lack of formal planning and coordination continues to inhibit the progress of Federal rainfall augmentation research projects. As a result, even though such projects have been conducted over the past 30 years and some progress has been made, critical scientific questions remain unanswered" is misleading and fails to recognize that resources commensurate with the complexity of the problem and the benefits to be gained have never been provided for this research. Failure to appreciate and remedy this has led to frustration and the resulting charges of fragmented research, ineffective coordination, etc. In our opinion, budgets and funding do not relate as much to organizational management as to national needs, priorities, and public support. In this regard, it should be recognized that weather modification is not an end in itself but is a potentially valuable technology for managing the atmosphere to serve many of society's important needs.

5. Contrary to what the GAO report states, there is a national weather modification policy in operation. OMB instituted a mission agency approach in 1971 and has continually supported it. OMB instructed specific agencies to concentrate their efforts on certain areas of weather modification and, for example, they designated the Bureau of Reclamation as the lead agency for precipitation enhancement and NOAA as the lead agency for hurricanes and severe storms. OMB reiterated this policy in their response to the 1974 GAO report. This policy was restated and reinforced by the White House in their 1975 statement on Federal weather modification policy (reply of Norman E. Ross, Assistant Director, Domestic Council to Honorable Gilbert Gude, House of Representatives - Congressional Record June 17, 1975):

> ". . . we believe that the agency which is charged with a particular national problem should be given the latitude to seek the best approach or solution to the problem. In some instances this may involve a form of weather modification, while in other instances other approaches may be more appropriate."

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"While we would certainly agree that some level of coordination of weather modification research efforts is logical, we do not believe that a program under the direction of any one single agency's leadership is either necessary or desirable."

". . . a series of lead agencies have been established to concentrate efforts in particular areas: Interior in precipitation; Agriculture in lightning suppression; Commerce in severe storms, including hurricanes; NSF in hail research; and Transportation in fog suppression."

OMB and Congress have essentially implemented this policy and approved budget requests in accordance with this approach. The Bureau has been very conscientious in following this policy. Justification of research funds in budget requests is based on this policy and actual use of funds follows these budgets.

Concerning the two major recommendations of the report, we offer the following comments:

1. The Bureau strongly objects to the recommendation to "designate one agency to administer, maintain, and have responsibility for the program." The Bureau strongly supports the mission agency approach that also provides several different avenues of funding for various types of projects. The Bureau should thus retain its role of leadership in precipitation management within a total national weather modification effort to help meet the varied water resource missions within the Department of Interior.

Recommendations of past review committees, some incompletely cited in the GAO report and some not mentioned at all, support the role of mission agencies in weather modification research. A few are cited below to counter-balance the exaggerated remarks in the report that "GAO's review support the findings of nearly a decade and a half of studies . . ."

In connection with the proposed NOAA Organic Act, the role of the Federal agencies in atmospheric research and development was discussed in the Boston Workshop of October 1978 sponsored by the Subcommittee on the Environment and the Atmosphere of the House Committee on Science and Technology jointly with the Senate Committee on Commerce, Science, and Transportation. The draft report of this workshop states the following conclusion:

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"Succinctly expressing the nearly unanimous view of Federal agencies (including NOAA) on this issue, Dr. Bernard Silverman of the Department of Interior's Bureau of Reclamation contended that: The overriding principle in this issue is that mission agencies need strong research and development programs to enhance the specific Federal policy goals that have been entrusted to them. There is no single or universal model for organizing, managing, and conducting an R&D program. What makes sense for one agency may be unworkable for another. The interrelationship and interaction between policy planning, the R&D function, and transferring any resulting technology into practice are all agency-specific, requiring agency-specific strategies for their successful accomplishment. All the atmospheric research and development requirements of the various mission agencies cannot, in short, be satisfied by the program of one Federal entity no matter how comprehensive it may be.'"

National Academy of Sciences report "Weather and Climate Modification: Problem and Prospects" (1966) states:

". . . major responsibility for weather modification should be centered in a single agency; at the same time, however, a degree of delegated responsibility should be maintained that will allow other agencies to meet mission requirements for work on this field."

National Academy of Sciences report "Weather and Climate Modification: Problems and Progress" (1973) states:

". . . the mission oriented agencies must maintain their weather modification programs."

ICAS (Interdepartmental Committee for Atmospheric Sciences) report No. 10a, "A Recommended National Program in Weather Modification" (1966) states:

"It is desirable to maintain a multi-agency approach to weather modification, and each agency's basic mission should determine its role in weather modification, but not to the exclusion of basic research."

"A formal procedure must be developed to achieve continuing visibility and coordination of the total weather modification program."

U.S. Domestic Council, Environmental Resources Committee, Subcommittee on Climate Change, "The Federal Role in Weather Modification" (1975) recommended:

"Continued coordination and planning through ICAS, with each agency following its mission directed role, . . ."

2. In regard to the final recommendation, the Bureau concurs that a more visible, more formal, and higher level forum for planning and coordinating the national weather modification program is needed. It should have representatives of all involved Federal agencies and weather modification interests (including States and local agencies and user groups) and cover all aspects of weather modification. The forum could provide substance to the existing national policy that is responsive to national and regional needs through the mission agency approach. It could develop a consolidated budget for 5-year R&D programs on an annual basis for a highly coordinated and synergistic combination of mission agency efforts. The Bureau believes that such a forum is the only new ingredient that is required to extend the existing and highly desirable mission agency approach into a more visibly coordinated and more formally planned national modification program.

I appreciate the opportunity to comment on the report in draft form.

Sincerely yours,

R. Keith Higginson
Commissioner

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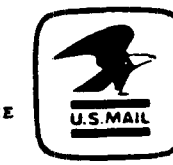

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