

96-64 WEATHER MODIFICATION

GOVERNMENT
Storage

HEARINGS
BEFORE THE
SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE
OF THE
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE
NINETY-SIXTH CONGRESS

FIRST SESSION
ON

S. 829

TO DECLARE A COMPREHENSIVE AND COORDINATED NATIONAL WEATHER RESOURCES MANAGEMENT POLICY, TO PROVIDE FOR THE DEVELOPMENT OF STANDARDS AND GUIDELINES FOR WEATHER RESOURCES MANAGEMENT, AND TO ESTABLISH A NATIONAL PROGRAM OF RESEARCH AND DEVELOPMENT IN THE WEATHER RESOURCES MANAGEMENT FIELD

AND

S. 1644

TO DECLARE A NATIONAL WEATHER MODIFICATION POLICY, TO ESTABLISH A NATIONAL PROGRAM OF RESEARCH AND DEVELOPMENT IN WEATHER MODIFICATION, TO PROVIDE FOR THE PROMULGATION OF REGULATIONS RELATED TO WEATHER MODIFICATION, AND FOR OTHER PURPOSES

OCTOBER 24 AND 26, 1979

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(II)

CONTENTS

Text of bills:	Page
S. 829	2
S. 1644	27
Agency comments:	
Department of the Interior	47

CHRONOLOGICAL LIST OF WITNESSES

OCTOBER 24, 1979

Bellmon, Hon. Henry, U.S. Senator from Oklahoma	48
Cleveland, Harland, director, Program in International Affairs, Aspen Institute for Humanistic Studies; Louis Battan, director, Institute of Atmospheric Physics, University of Arizona; and Robert M. White, Administrator, National Research Council, National Academy of Sciences	92
Prepared statement of Mr. Cleveland	95
Attachment	100
Prepared statement of Dr. Battan	110
Frank, Richard A., Administrator, National Oceanic and Atmospheric Administration, Department of Commerce; accompanied by George Benton, Associate Administrator; and Michael Glazer, Assistant Administrator for Policy and Planning	51
Prepared statement	68
Higginson, R. Keith, Commissioner, Bureau of Reclamation, Department of the Interior; accompanied by Bernard A. Silverman, Acting Chief, Office of Atmospheric Resources Management, Engineering and Research Center, Denver Colo.; Dr. Edward P. Todd, Acting Assistant Director for Astronomical, Atmospheric, Earth, and Ocean Sciences, National Science Foundation; and Dr. Anthony J. Calio, Associate Administrator for Space and Terrestrial Applications, National Aeronautics and Space Administration	78
Prepared statement of Dr. Todd	82
Prepared statement of Dr. Calio	87

OCTOBER 26, 1979

Opening statement by Senator Heflin	129
Veal, Donald L., head, Department of Atmospheric Sciences, University of Wyoming; Barbara C. Farhar, Boulder, Colo.; Ray J. Davis, College of Law, University of Arizona; Dr. D. Ray Booker, president, Aeromet, Inc.; and Paul C. Summers, cloud seeding program coordinator, division of water resources, Salt Lake City, Utah	130
Prepared statements of Dr. Veal	133
Prepared statements of Mr. Davis	146
Prepared statement of Mr. Booker	156

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

Calvo, Hon. Paul M., Governor of Guam, letters of:	
July 2, 1979	179
September 21, 1979	179
Changnon, Stanley A., Jr., head, atmospheric sciences section, Illinois Institute of Natural Resources, letter of December 21, 1979	187
Davis, Harvey, executive director, Texas Department of Water Resources, letters of:	
October 15, 1979	181
November 7, 1979	182

IV

	Page
Fleagle, Robert G., professor, University of Washington, letter of September 24, 1979	181
Kimball, Thomas L., executive vice president, National Wildlife Federation, letter of November 2, 1979	183
Project Skywater—The Bureau of Reclamation's Weather Modification Research Program	189
Schwinden, Ted, Acting Governor, State of Montana, letter of November 2, 1979	184
Sherman, Harris D., executive director, Department of Natural Resources, State of Colorado, letter of November 9, 1979	185
Smith, Lloyd P., president, Desert Research Institute, letter of August 2, 1979....	180
Teeple, Reid W., associate general manager—water, Salt River project, Phoenix, Ariz., letter of November 9, 1979	186

WEATHER MODIFICATION

WEDNESDAY, OCTOBER 24, 1979

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:35 a.m., in room 235, Russell Senate Office Building, Hon. Adlai E. Stevenson (chairman of the subcommittee) presiding.

Senator STEVENSON. The subcommittee will come to order.

This morning we begin hearings on weather modification. We have two bills before the subcommittee. One is S. 829, the Weather Resources Management Act introduced by my colleague, Senator Bellmon, and the other is S. 1644, the Weather Modification Management Act, which I introduced.

[The bills and agency comments follow:]

(1)

96TH CONGRESS
1ST SESSION

S. 829

To declare a comprehensive and coordinated national weather resources management policy, to provide for the development of standards and guidelines for weather resources management, and to establish a national program of research and development in the weather resources management field.

IN THE SENATE OF THE UNITED STATES

MARCH 29 (legislative day, FEBRUARY 22), 1979

Mr. BELLMON introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

A BILL

To declare a comprehensive and coordinated national weather resources management policy, to provide for the development of standards and guidelines for weather resources management, and to establish a national program of research and development in the weather resources management field.

- 1 *Be it enacted by the Senate and House of Representa-*
- 2 *tives of the United States of America in Congress assembled,*
- 3 That this Act may be cited as the "Weather Resources Man-
- 4 agement Act of 1979".

II—E

FINDINGS

SECTION. 1. (a) The Congress finds that it may soon be possible, with further research and development, to manage weather resources using a variety of techniques, and that great benefits can and should accrue from a vigorous and prudent use of the emerging technologies for weather resources management. In the use of these technologies, however, full recognition must be given to the fact that the atmosphere is a public resource, belonging to no person or interest, and that experiments in or deliberate modifications of the atmosphere carry with them a responsibility for carefully preserving the welfare of the general public and environment.

(b) Recognizing that water resources management technologies are of potentially immense benefit to the United States but must be better developed in order to preserve the well-being, prosperity, and security of people in the United States and around the world, the Congress finds and declares that—

(1) precipitation enhancement, snowpack enhancement, hail suppression, and related technologies must be developed and improved to help increase and stabilize the water supplies available for crops, municipal and industrial uses, irrigation uses, irrigation, and other applications, with agricultural production being the largest potential beneficiary;

1 (2) since the potential amount of damage resulting
2 from severe storms and other natural catastrophies is
3 increasing at an accelerating rate, it is important for
4 the United States to develop technologies to reduce the
5 adverse effects of hurricanes, hailstorms, and other at-
6 mospheric disturbances; and

7 (3) since the development and conservation of
8 solar energy, coal, shale, and other energy resources is
9 dependent to a large degree upon the supply of water,
10 sunshine, and other weather elements, it is important
11 for the United States to develop technologies to maxi-
12 mize the availability of favorable weather conditions for
13 energy exploitation and development, including the
14 opening of holes in clouds to admit more sunlight over
15 major cities during winter and over large solar collec-
16 tors; and

17 (4) the benefits that can be accrued from the de-
18 velopment of technologies for increasing precipitation,
19 mitigating the damaging effects of storms, and increas-
20 ing energy potential far outweigh the cost of develop-
21 ing and implementing them.

22 (c)(1) Most of the operational experience and much of
23 the research and development competence in this country is
24 presently to be found in the universities, private contractors,
25 user groups, and State and local governments.

1 (2) The development of weather resources management
2 science technology has been greatly retarded by the lack of
3 potent Federal leadership, the lack of a consistent Federal
4 policy, fragmented Federal organization, and instability of re-
5 search funding.

6 (3) An intensified and integrated program of scientific
7 inquiry and methodological development over the next two
8 decades, is needed in order to develop weather resources
9 management technologies and realize their potential benefits.

10 (4) There is no urgent need for comprehensive Federal
11 regulation of weather resources management at this time,
12 and in fact excessive regulation would be likely to impede
13 progress.

14 (5) The States have a vital role in the application of
15 these technologies, and responsibility for the management of
16 weather resources must be carried on with due regard for the
17 affected interests of the States and localities; the Federal
18 Government should seek partnership arrangements with the
19 States to establish long-term well designed joint operational/
20 research projects where significant research and operational
21 objectives can be achieved simultaneously.

22 (6) Weather is transnational, and weather resources
23 management will be furthered by international cooperation.

24 (7) Weather resources management technologies are
25 being used operationally, but are currently making an insuffi-

1 cient contribution to the national research and development
2 effort.

3 (8) The most widespread "weather modification" arises
4 from man's unintentional impacts on the atmospheric envi-
5 ronment, and more must be learned about these impacts.

6 POLICY

7 SEC. 2. It is therefore declared to be the policy of the
8 United States that—

9 (1) the Federal Government should proceed vigor-
10 ously with the development of weather resources man-
11 agement capabilities;

12 (2) these capabilities should be designed to pro-
13 vide the maximum possible economic, social, and other
14 benefits to the peoples of the United States and the
15 world at large;

16 (3) the Federal Government has a supervening re-
17 sponsibility for the management of weather resources
18 in the United States, but its regulatory activities
19 should be limited to those essential to the general wel-
20 fare;

21 (4) the universities, the private sector, and the
22 State and local facilities should be utilized to the maxi-
23 mum practical extent in the development of weather
24 resources management capabilities; and

3 PURPOSE

(1) to provide for the establishment of a program of focused basic research and experimental tests for the development of weather resources management technologies in those areas where the greatest benefit relative to cost is likely to be gained, specifically including—

(A) technologies for increasing precipitation from cumulus clouds in agriculturally productive areas and for increasing snowpack in mountainous areas;

(B) technologies for reducing the damaging effects of hurricanes, hailstorms, and other atmospheric disturbances; and

(C) technologies for energy resources development, with particular reference to increasing water supplies and available solar energy;

(2) to provide a consolidated Federal organizational structure that can deal effectively with the problems and opportunities for developing weather resources management technologies, including—

1 (A) adequate planning for two decades of re-
2 search, development, and implementation; and

3 (B) effective coordination and control of
4 weather resources management technologies
5 through consolidation of the existing small organi-
6 zational groups within the Federal Government
7 into a single more efficient organization capable of
8 managing complex experiments and operations in
9 the atmosphere;

10 (3) to accomplish the development of weather re-
11 sources management technologies primarily through
12 appropriate relationships with States, localities, univer-
13 sities, private businesses, and other countries;

14 (4) to establish partnership arrangements with
15 States for joint operational/research projects to pro-
16 mote technology transfer and improve the standards
17 used on operational projects and promote evaluation of
18 operational projects;

19 (5) to protect the public welfare and the environ-
20 ment through the establishment and promotion of
21 sound weather resources management practices;

22 (6) to provide for minimum Federal regulation and
23 reporting of weather modification activities; and

1 (7) to provide for adequate and stable funding of a
2 sustained research effort in weather resources manage-
3 ment over a period of two decades.

4 DEFINITIONS

5 SEC. 4. As used in this Act—

6 (1) the term “weather resources management”
7 means the alteration or control of weather through one
8 or more weather modifications;

9 (2) the term “weather modification” means any
10 artificially produced change in the composition, behav-
11 ior, or dynamics of the atmosphere, when such change
12 is produced with intent to alter or control the weather;

13 (3) the term “weather modification activity”
14 means the use of any device, equipment, or apparatus,
15 or any chemical, material, compound, or other sub-
16 stance, for the purpose of effecting a weather modifica-
17 tion;

18 (4) the term “State” includes the several States,
19 the District of Columbia, Puerto Rico, Guam, the
20 Virgin Islands, the Trust Territory of the Pacific Is-
21 lands, and any other territory or possession of the
22 United States;

23 (5) the term “Administration” means the National
24 Aeronautics and Space Administration;

1 (6) the term "Program" means the National
2 Weather Resources Management Program established
3 and conducted as provided in section 6.

4 WEATHER RESOURCES MANAGEMENT BOARD AND
5 DIRECTOR OF PROGRAM

6 SEC. 5. (a) There is hereby established within the Na-
7 tional Aeronautics and Space Administration a Weather Re-
8 sources Management Board, which shall advise the Adminis-
9 trator on organizing, planning, designing, developing, and
10 carrying out the National Weather Resources Management
11 Program as provided in section 6, and for otherwise carrying
12 out this Act and the policy and purpose declared in sections 2
13 and 3.

14 (b) The Board shall consist of six members who shall be
15 appointed by the Administrator for terms of six years; except
16 that of the initial members one shall be appointed for a term
17 of one year, one for a term of two years, one for a term of
18 three years, one for a term of four years, one for a term of
19 five years, and one for a term of six years, as designated by
20 the President at the time of the appointment. Members shall
21 be persons selected from fields of professional life who have
22 performed distinguished service in one or more areas in-
23 volved in or important to the management of complex tech-
24 nologies and who have had responsible experience with gov-

1 ernment; but no person who is an employee of the Federal
2 Government may serve as a member of the Board.

3 (c) One member of the Board shall be designated by the
4 President as its Chairman.

5 (d)(1) Each member of the Board shall be entitled to
6 receive the daily equivalent of the annual rate provided for
7 level V of the Executive Schedule under section 5316 of title
8 5, United States Code, for each day (including traveltime)
9 during which he is engaged in the actual performance of the
10 duties of the Board; except that the Chairman of the Board
11 shall be entitled to receive the daily equivalent of the rate
12 provided for level IV of such Schedule (under section 5315 of
13 such title) for each such day.

14 (2) While away from their homes or regular places of
15 business in the performance of the duties of the Board, mem-
16 bers of the Board shall be allowed travel expenses, including
17 per diem in lieu of subsistence, in the same manner as per-
18 sons employed intermittently in the Government service are
19 allowed expenses under section 5703 of title 5, United States
20 Code.

21 (e) There shall be a Director of the National Weather
22 Resources Management Program, who shall be a person of
23 outstanding management ability with experience in govern-
24 ment and in complex research and development projects, who
25 shall be appointed by and serve at the pleasure of the Admin-

1 istrator. The Director shall be responsible for all planning,
2 implementation, budgeting, operations, and other activities
3 under the Program, shall secure the services of a highly
4 qualified professional staff and such other services as may be
5 necessary for the performance of the Board's functions, and
6 shall perform such other functions as the Board may assign
7 to him for purposes of carrying out this Act and the policy
8 and purpose declared in sections 2 and 3; and he shall regu-
9 larly advise and consult with the Administrator in the per-
10 formance of such activities and functions. The Director shall
11 receive compensation at the rate provided for level V of the
12 Executive Schedule.

13 NATIONAL WEATHER RESOURCES MANAGEMENT PROGRAM

14 SEC. 6. (a) There is hereby established a National
15 Weather Resources Management Program. The Program
16 shall have the objective of developing and improving the var-
17 ious weather resources management technologies as rapidly
18 as possible so as to assure the realization and effective imple-
19 mentation of the policy and purpose of this Act within a
20 period of twenty years. The Program shall include—

21 (1) a major effort in basic research focused on at-
22 mospheric processes relevant to weather resources
23 management;

1 (2) the conduct of experimental activities designed
2 to expedite progress;

3 (3) the provision of technical and financial assist-
4 ance to States and their political subdivisions, and to
5 private users and operators, in cases where operational
6 weather resources management projects can be benefi-
7 cially used for—

8 (A) expanding our understanding of scientific
9 questions,

10 (B) promoting sound evaluation of the effec-
11 tiveness of operational projects,

12 (C) promoting the use of high standards and
13 sound weather resources management practices
14 for operational projects,

15 (D) assisting and transferring research
16 knowledge to users,

17 (E) encouraging the use of well designed
18 weather resources management projects as a
19 water management tool,

20 and otherwise to carry out the policy and purpose de-
21 clared in sections 2 and 3;

22 (4) the development of and maintenance of a set
23 of Best Management Practices which shall be recom-
24 mended for all weather modification activities, includ-
25 ing the conduct of all Federal field experiments;

1 (5) such other activities as will effectively contrib-
2 ute to the full realization of the objective set forth in
3 this subsection.

4 (b)(1) The Program shall be carried out through a com-
5 prehensive five-year plan updated annually as provided in
6 this subsection. The comprehensive five-year plan (without
7 being limited to the matters set forth in this subsection)
8 shall—

9 (A) identify the major areas where weather re-
10 sources management research and development is mer-
11 ited;

12 (B) prioritize weather resources management
13 needs with a view toward establishing a coordinated
14 Federal program;

15 (C) identify the specific weather resources man-
16 agement activities which should be carried out with the
17 participation of other Federal agencies and those which
18 should be carried out within the Administration in ac-
19 cordance with this Act;

20 (D) make recommendations regarding the levels of
21 research and development which are needed to attain
22 the policy and purpose of this Act;

23 (E) give particular attention to the unintended
24 weather modifications resulting from the impact of
25 man's activities on the atmospheric environment;

1 (F) set forth the goals, objectives, and estimated
2 cost of each such activity; and

3 (G) include such other elements as may be neces-
4 sary or appropriate to carry out the policy and purpose
5 of this Act.

6 (2) The Administration shall annually update the com-
7 prehensive five-year plan in such manner and to such extent
8 as it deems necessary or appropriate to reflect changing con-
9 ditions, past congressional actions, accomplishments under
10 the Program, and recommendations of other Federal officials.

11 (3) The comprehensive five-year plan, and each annual
12 revision thereof, shall be submitted to the President and to
13 the Congress.

14 (c) In the development of the comprehensive five-year
15 plan and the annual revisions thereof under subsection (b)(3),
16 account shall be taken of the views and recommendations of
17 all Federal officers and agencies having duties or responsibil-
18 ities involved in or related to weather resources management,
19 and public hearings shall be held, with adequate opportunity
20 for all interested persons to present their views, comments,
21 and recommendations, as may be considered appropriate.

22 (d) In carrying out its function with respect to the Pro-
23 gram under this section, the Administration shall—

24 (1) give continuous attention to the environmen-
25 tal, economic, societal, and legal aspects of weather re-

1 sources management, and to the needs of the user
2 community;

3 (2) make the maximum possible use of contracts
4 with universities and private business concerns so as to
5 avoid the necessity to employ a large inhouse staff or
6 to acquire large amounts of property for its operations
7 and activities;

8 (3) encourage programs initiated by relevant pro-
9 fessional societies which have the purpose of increasing
10 standards of practice for weather resources manage-
11 ment activities while alleviating the need for direct
12 Federal regulation;

13 (4) conduct open consultations in areas and with
14 groups which are likely to be substantially affected by
15 federally sponsored activities under this Act, and par-
16 ticularly with States and their political subdivisions;

17 (5) make all possible efforts to include in the Pro-
18 gram the scientific and technological expertise which is
19 available in other countries; and

20 (6) take all possible steps, through or in consulta-
21 tion with the Secretary of State, to secure internation-
22 al acceptance of the Program and internal cooperation
23 of its conduct and implementation.

1 SOUND WEATHER RESOURCES MANAGEMENT PRACTICES

2 SEC. 7. (a)(1) The Board shall develop, formulate, pub-
3 lish, and continuously maintain a set of Sound Weather Re-
4 sources Management Practices, which shall be based on state
5 of the art technology and current knowledge with adequate
6 attention to the environmental, societal, and legal implica-
7 tions of weather modification, and which shall serve as guide-
8 lines for private and other non-Federal operational weather
9 modification activities and as the basis and operating proce-
10 dure for the design and conduct of Federal or federally spon-
11 sored weather modification activities.

12 (2) The Practices developed and published under para-
13 graph (1) shall conform to all applicable Federal laws, and
14 shall address (without being limited to) the following ele-
15 ments:

- 16 (A) Project design.
- 17 (B) Environmental assessments.
- 18 (C) Operations.
- 19 (D) Data collection.
- 20 (E) Evaluation.

21 (3) The Practices shall be developed and published by
22 the Board in tentative form within one hundred and eighty
23 days after the date of the enactment of this Act, and shall be
24 the subject of such informal public hearings as may be deter-
25 mined by the Board to be necessary or appropriate. The

1 Practices shall be published in the Federal Register in final
2 form within two hundred and seventy-three days after such
3 date.

4 (b)(1) Administration shall conduct such field experi-
5 ments and other weather modification activities as it may
6 determine will best promote the realization of the objectives
7 of this Act.

8 (2) Prior to initiating any such experiments, the Board
9 shall appropriately consult with the State or States (and lo-
10 calities therein) which may be affected, and shall conduct one
11 or more public hearings to receive the views and comments
12 of interested persons in the affected area.

13 REPORTING AND REGULATIONS OF WEATHER

14 MODIFICATION ACTIVITIES

15 SEC. 8. (a)(1) The Administration shall require that any
16 person who attempts deliberate weather modification prepare
17 and maintain daily reports covering any such weather modifi-
18 cation activity conducted and make such reports available to
19 the Administration on its request. Each such report shall in-
20 clude—

21 (A) the date and time of beginning and ending of
22 the weather modification activity, the nature of such
23 activity;

1 (B) a precise description of the location of such
2 activity, and of the location of the target area of any
3 weather modification;

4 (C) the type and amount of any weather modifica-
5 tion device, equipment, apparatus, or substance used in
6 such activity during the previous day; and

7 (D) a description of any weather modification re-
8 sulting from such activity, including—

9 (i) the manner in which such weather modifi-
10 cation was observed, measured, or recorded; and

11 (ii) the readings of any instrument used for
12 such measurement or recording prior to and after
13 such activity, including the times of such read-
14 ings.

15 (2) For the purpose of carrying out this Act, the Admin-
16 istration may require, by regulation, that any person who
17 attempts to modify weather to establish and maintain such
18 records and provide such other information as the Adminis-
19 tration may require; and the Administration or its authorized
20 representative, upon presentation of proper credentials—

21 (A) shall at reasonable times have a right of entry
22 to any premises in which any record required to be
23 maintained under this subsection is located; and

1 (B) may at reasonable times have access to and
2 copy any record required to be maintained under this
3 subsection.

4 (b) The Administration shall promulgate such rules and
5 regulations as may be necessary or appropriate to implement
6 and enforce this Act.

7 (c)(1) Any person who knowingly violates this section
8 shall be fined not more than \$50,000. Each day of such a
9 violation shall constitute a separate offense.

10 (2) Any person who knowingly violates subsection (a)(1)
11 or any regulation promulgated by the Administration under
12 subsection (b), (a)(2), or (a)(3) shall be fined not more than
13 \$25,000.

14 (3) The district courts of the United States shall have
15 jurisdiction to enjoin any violation of this section and to
16 enjoin any weather modification activity by any person who
17 is violating any regulation promulgated by the Administra-
18 tion under this Act. Any action to restrain any such violation
19 shall be brought by and in the name of the United States.

20 EXTRAMURAL FEDERAL RESEARCH AND DEVELOPMENT

21 ACTIVITIES

22 SEC. 9. (a) In carrying out its functions under the Pro-
23 gram, the Administration is authorized to make grants and
24 enter into contracts, to the extent specified in appropriation
25 Acts, for the conduct of research, development, and demon-

1 stration projects concerning weather modification in a
2 manner consistent with the comprehensive five-year plan
3 provided for in section 6. Any such grant or contract may
4 provide for payment of up to 100 per centum of the costs of
5 the project or projects involved. A research, development,
6 and demonstration project to be assisted or contracted for
7 under this section shall be described in detail in the applica-
8 tion for such assistance or contract and shall be accompanied
9 by a statement of its consistency with the comprehensive
10 five-year plan, whether such project is selected by the appli-
11 cant or initiated by the Board.

12 (b) Each such grant or contract shall be made or entered
13 into in accordance with such guidelines and regulations as
14 may be issued by the Administration.

15 (c) There are authorized to be appropriated such sums,
16 not exceeding \$ for any one fiscal year, as
17 may be necessary to carry out this section.

18 (d) The Administration shall include in its annual report
19 to the Congress each year a statement of the grants made
20 and contracts entered into under this section during the pre-
21 ceding year, with recommendations on ways of utilizing such
22 grants and contracts in more effectively meeting future re-
23 search, development, and demonstration needs concerning
24 weather modification.

1 ADMINISTRATIVE PROVISIONS

2 SEC. 10. (a) Within one year after the date of the enact-
3 ment of this Act—

4 (1) all functions of the various Federal agencies
5 and establishments with respect to weather resources
6 management, and

7 (2) all personnel, property, funds, and other assets
8 of such agencies and establishments which are con-
9 cerned with or involved in weather resources manage-
10 ment and which are determined by the Board to be
11 necessary or useful for purposes of carrying out this
12 Act, shall under the supervision and direction of the
13 Director of the Office of Management and Budget, be
14 transferred to the Administration.

15 (b) In carrying out its functions under this Act the Ad-
16 ministration may enter into suitable contracts and arrange-
17 ments with other Federal agencies and establishments for the
18 performance by them of any functions under this Act which
19 they are particularly well qualified to perform.

20 (c) The Administration is authorized to construct, lease,
21 or otherwise acquire such laboratories and equipment (includ-
22 ing aircraft for experimental purposes) as it may need in
23 order to conduct weather resources management activities
24 and otherwise carry out its functions under this Act.

ANNUAL REPORT

1
2 SEC. 12. The Board shall annually submit to the Presi-
3 dent and the Congress a full and complete report of its activi-
4 ties and of the progress being made toward the achievement
5 of the policy, purpose, and objectives of the Act. Such report
6 shall—

7 (1) set forth the comprehensive five-year plan as
8 currently revised;

9 (2) include an evaluation of the Federal weather
10 resources management effort, including the status of
11 personnel, facilities, and equipment;

12 (3) include a summary of the activities undertaken
13 and projected in carrying out the comprehensive five-
14 year plan;

15 (4) identify all major research and development
16 issues in the field of weather resources management
17 and their corresponding priorities;

18 (5) describe the significant accomplishments made
19 under the plan to date, and any significant instances of
20 failure to achieve its objectives (with the reasons there-
21 fore);

22 (6) include an annual budget summary, setting
23 forth the amount of funds used for the Program in past
24 years, the amount of funds requested for the Program
25 in the current fiscal year, and the estimated amount of

1 funds which will be needed for the Program in each of
2 the five ensuing fiscal years;

3 (7) include a listing of all programs and activities
4 (Federal and non-Federal), other than the Program
5 under this Act, which involve or are related to weather
6 resources management, with a description of the ac-
7 tions which need to be and are being taken by the
8 Board and others to coordinate their weather resources
9 management activities in order to insure cooperation
10 and eliminate unnecessary duplication;

11 (8) include a description of the actions which have
12 been taken to secure international acceptance of the
13 Program and international cooperation in weather re-
14 sources management activities, and of the extent to
15 which such actions have been successful; and

16 (9) include recommendations for the improvement
17 of the Federal weather resources management effort,
18 and such other matters as the Administration may con-
19 sider appropriate.

20 MISCELLANEOUS PROVISIONS

21 SEC. 13. (a) In all aspects of its operations and activities
22 under this Act, the Administrator shall consult and cooperate
23 with the States and political subdivisions which are or may
24 be affected by such operations and activities, and shall, to the
25 maximum extent possible, respect and take account of State

1 and local views and objections; but in any case where the
2 Administration determines that a particular operation or ac-
3 tivity is necessary to achieve the objectives of the Program
4 and presents no significant risk to life or health, the Federal
5 power to regulate or otherwise deal with weather resources
6 management, as evidenced or implemented by the Adminis-
7 tration in conducting such operation or activity, shall super-
8 sede State and local powers, laws, and interests. Any such
9 determination by the Administration, in a case where the
10 proposed operation or activity is opposed or objected to by
11 one or more affected States, shall be made on the record, and
12 shall be subject to judicial review at the instance of any such
13 State.

14 (b) The provisions of section 2620(a) of title 18, United
15 States Code, to the extent that they provide an exception
16 from the tort claims procedure for claims based on the exer-
17 cise or performance or failure to exercise or perform a discre-
18 tionary function or duty on the part of a Federal agency or
19 employee, and the provisions of section 2675 of such title to
20 the extent that they would otherwise prevent a class action
21 under such procedure, shall not apply with respect to claims
22 based on acts performed (or omissions to act) in any of the
23 Administration's field experiments or other weather modifica-
24 tion activities.

1 (c) Notwithstanding any other law or practice, the
2 extent of the Administration compliance with the Sound
3 Weather Resources Management Practices developed and
4 published under section 8, in the conduct of its field experi-
5 ments and other weather modification activities, shall not be
6 the subject of any private cause of action in any court.

7 (d) Unless specifically otherwise provided by law, the
8 Board shall cease to exist twenty years after the date of the
9 enactment of this Act.

10 (e) The Act entitled "An Act to provide for the report-
11 ing of weather modification activities to the Federal Govern-
12 ment", approved December 18, 1971 (15 U.S.C. 330 et
13 seq.), is repealed.

14 ANNUAL AUTHORIZATION OF APPROPRIATIONS

15 SEC. 14. There may be appropriated to carry out this
16 Act (subject to section 10(c)) only such sums as may be au-
17 thorized by annual authorization Acts hereafter enacted.



96TH CONGRESS
1ST SESSION

S. 1644

To declare a national weather modification policy, to establish a national program of research and development in weather modification, to provide for the promulgation of regulations related to weather modification, and for other purposes.

IN THE SENATE OF THE UNITED STATES

AUGUST 2 (legislative day, JUNE 21), 1979

Mr. STEVENSON introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

A BILL

To declare a national weather modification policy, to establish a national program of research and development in weather modification, to provide for the promulgation of regulations related to weather modification, and for other purposes.

- 1 *Be it enacted by the Senate and House of Representa-*
- 2 *tives of the United States of America in Congress assembled,*
- 3 That this Act may be cited as the "Weather Modification
- 4 Management Act of 1979".

5

FINDINGS

- 6 SEC. 2. The Congress finds that—

1 (1) the atmosphere belongs to no person, interest,
2 or nation;

3 (2) weather produces beneficial and harmful con-
4 sequences for individuals and society;

5 (3) the management of weather resources may
6 soon be technically possible and benefits may be real-
7 ized from the prudent use of emerging technologies in
8 weather modification;

9 (4) long-term, systematic research is required to
10 realize the benefits of weather modification and to un-
11 derstand the impacts from unintentional weather modi-
12 fication;

13 (5) a parallel effort is needed to understand the
14 economic, environmental, legal, and societal effects of
15 weather modification;

16 (6) research competence and operational experi-
17 ence in weather modification is found in universities,
18 private contractors, users and State and local govern-
19 ments, as well as in the Federal Government;

20 (7) the United States lacks a well-defined program
21 in weather modification, and a lack of Federal leader-
22 ship has slowed the development of science and tech-
23 nology in this field; and

24 (8) because of the potential impact of weather
25 modification activities and the nonuniformity of State

1 laws regulating such activities, the Federal Govern-
2 ment should establish a basic framework for regulating
3 and reporting certain aspects of weather modification
4 activities.

5 POLICY

6 SEC. 3. The Congress declares that it is the policy of
7 the United States that—

8 (1) the United States should develop the capabili-
9 ty to manage weather resources;

10 (2) the development of this capability should occur
11 under the direction of the Federal Government;

12 (3) the capability in weather modification should
13 be designed to provide maximum benefits with mini-
14 mum adverse economic, environmental, and societal ef-
15 fects;

16 (4) the resources of non-Federal entities should be
17 utilized in developing a weather modification capability;

18 (5) the Federal Government has responsibility for
19 advancing knowledge of weather modification in the
20 United States, but its regulatory activities should be
21 limited to those essential to the national interest; and

22 (6) international cooperation in weather modifica-
23 tion should be encouraged.

4

PURPOSE

1

2 SEC. 4. The purpose of this Act is to establish and pro-
3 vide for Federal management of a twenty-year coordinated
4 research program in weather modification within the Depart-
5 ment of Commerce, that includes—

6 (1) research and experiments to develop weather
7 modification technologies;

8 (2) licensing weather modification operations;

9 (3) reporting weather modification activities;

10 (4) promotion of technology transfer and uniform
11 operating standards with States and private contrac-
12 tors; and

13 (5) protection of the public and the environment.

14 DEFINITIONS

15 SEC. 5. As used in this Act, the term—

16 (1) "Council" means the Weather Modification
17 Advisory Council as established in section 7;

18 (2) "Director" means the Director of the National
19 Weather Modification Management Program, appointed
20 pursuant to section 6;

21 (3) "Program" means the National Weather
22 Modification Management Program, as established in
23 section 6;

24 (4) "Secretary" means the Secretary of Com-
25 merce;

(1) basic and applied research to understand the atmospheric processes related to weather modification;

(2) research on unintentional weather modification that results from society's use of land, water, and energy;

1 (3) experimental activities designed to test the
2 findings of these research efforts and to demonstrate
3 the feasibility of new operational methods;

4 (4) technical and financial assistance to universi-
5 ties, private contractors, user groups, and State and
6 local governments, as provided in section 11;

7 (5) investigation of the economic, environmental,
8 legal, and societal effects from weather modification;

9 (6) operating practices that will serve as stand-
10 ards for all Federal weather modification activities and
11 as guidelines for private and other non-Federal weath-
12 er modification activities;

13 (7) a system for licensing all individuals having
14 responsibility to design or perform any weather modifi-
15 cation activity, as provided in section 8;

16 (8) a procedure for reporting all weather modifica-
17 tion activities, as provided in section 9; and

18 (9) a five-year plan for the management of weath-
19 er modification activities by the Federal Government.
20 Each five-year plan shall identify—

21 (A) goals and priorities for the Program;

22 (B) Program activities and accomplishments
23 needed to ensure that Program goals are met
24 within the time frame established by the plan; and

1 (C) Federal funding necessary for the Pro-
2 gram to achieve such goals.

3 Such a plan shall be submitted to the Congress not
4 later than one year after the date of enactment of this
5 Act, and shall be revised and extended annually.

6 (c) **DIRECTOR.**—The Secretary shall appoint a Director
7 of the National Weather Modification Management Program.
8 The Director shall be an individual who possesses recognized
9 management ability in government operations and research
10 and development projects. The Director shall be compensated
11 at the rate provided for level V of the Executive Schedule
12 under section 5316 of title 5, United States Code.

13 (d) **DUTIES.**—In addition to any other duty prescribed
14 by law or assigned by the Secretary, the Director shall—

15 (1) be responsible for planning and implementing
16 the Program;

17 (2) secure and direct the services of a qualified
18 professional staff and such other assistance as neces-
19 sary to carry out the provisions, policies, and purposes
20 of this Act;

21 (3) utilize the expertise of the Weather Modifica-
22 tion Advisory Council, as established in section 7, uni-
23 versities, private contractors, State and local govern-
24 ments, and professional societies;

24 (B) developing operating practices;

1 (C) establishing an operator licensing system;

2 and

3 (D) establishing reporting requirements; and

4 (2) preparing the biennial report, as required in
5 section 10; and

6 (3) such other matters as the Council determines
7 to be of importance and related to the provisions, poli-
8 cies, and purposes of this Act.

9 The Director shall make available to the Council such infor-
10 mation, personnel, and administrative services and assistance
11 as may be reasonably required to carry out its duties.

12 (c) MEMBERSHIP, TERMS, AND POWERS.—

13 (1) The Council shall consist of up to fifteen mem-
14 bers who shall be appointed by the Secretary. The
15 Council members shall be individuals who are knowl-
16 edgeable in the areas of atmospheric sciences, weather
17 modification, social sciences, law, user needs, and other
18 areas related to weather modification;

19 (2) No member of the Council shall be an employ-
20 ee of the Federal Government;

21 (3) Each member of the Council shall serve for a
22 term of three years, except for those members initially
23 appointed to the Council, up to five members shall be
24 appointed for a term of one year, up to five for a term
25 of two years, and up to five for a term of three years.

1 Any individual appointed to fill a vacancy on the
2 Council shall serve for the unexpired term of the
3 member whom he is appointed to succeed;

4 (4) The Council shall select a member to serve as
5 its Chairman and another member to serve as its Vice
6 Chairman. The Vice Chairman shall perform the func-
7 tions of the Chairman in his absence; and

8 (5) Each member of the Council shall receive
9 compensation at the daily rate for GS-18 of the Gen-
10 eral Schedule under section 5332 of title 5, United
11 States Code, while actually engaged in the perform-
12 ance of his duties, and shall be reimbursed for actual
13 and reasonable expenses incurred in the performance of
14 such duties.

15 LICENSES FOR WEATHER MODIFICATION OPERATORS

16 SEC. 8. (a) IN GENERAL.—The Secretary shall issue
17 licenses to qualified persons who propose to conduct a weath-
18 er modification activity.

19 (b) INDIVIDUALS SUBJECT TO LICENSING.—Any indi-
20 vidual who has or will have the primary supervisory respon-
21 sibility for designing or performing any weather modification
22 activity in the United States must apply for and have been
23 issued a valid license before conducting such activity.

1 (c) LICENSE REQUIREMENTS.—Not later than ninety
2 days after the date of enactment of this Act, the Secretary
3 shall—

4 (1) develop standards and procedures governing
5 the application, issuance, renewal, denial, suspension,
6 and revocation of such licenses; and

7 (2) establish and revise as necessary the qualifica-
8 tions which an applicant must demonstrate to the Sec-
9 retary in order to be issued such a license. Such quali-
10 fications shall include, but not be limited to—

11 (A) educational background;

12 (B) technical knowledge; and

13 (C) practical experience.

14 Such standards and procedures shall not be unduly burden-
15 some, and the Secretary shall make a determination on any
16 license application within a reasonable time.

17 (d) REVIEW.—Any person whose license application is
18 denied or whose license is suspended or revoked by the Sec-
19 retary shall be entitled to a hearing on the Secretary's action,
20 in accordance with section 554 of title 5, United States Code.

21 (e) STRICTER STATE STANDARDS.—Any State has the
22 authority to adopt licensing standards that are more stringent
23 than those approved by the Secretary, but no State shall
24 adopt licensing standards that are not in compliance with
25 those approved by the Secretary.

1 (f) JURISDICTION.—Upon application by an individual
2 or the Attorney General on behalf of the United States, the
3 district courts of the United States shall have jurisdiction to
4 enjoin any violations of the provisions of subsection (b).

5 (g) PENALTY.—Any individual who knowingly and will-
6 fully violates subsection (b) shall upon conviction thereof be
7 fined not more than \$10,000. Each day of such a violation
8 shall constitute a separate offense.

9 REPORTING OF WEATHER MODIFICATION ACTIVITIES

10 SEC. 9. (a) IN GENERAL.—The Secretary shall main-
11 tain a record of weather modification activities that take
12 place in the United States and shall publish annual summar-
13 ies of such activities.

14 (b) INDIVIDUALS SUBJECT TO REPORTING.—Any indi-
15 vidual who has the primary supervisory responsibility for de-
16 signing or performing any weather modification activity in
17 the United States must prepare and maintain daily reports on
18 such activity and submit summary reports before, during, and
19 after such activity to the Secretary.

20 (c) REPORTING REQUIREMENTS.—The Secretary shall
21 prescribe, by rule, the specific information and format re-
22 quired in such reports. Each such report shall include, but
23 not be limited to—

24 (1) the date of the weather modification activity
25 and its time of initiation and conclusion;

1 (2) the location and description of such activity,
2 the target area, and actual location of any weather
3 modification;

4 (3) the type and amount of any equipment used in
5 such weather modification activity; and

6 (4) the type and readings of any instrument used
7 to measure the effect of such weather modification
8 activity.

9 (d) **AUTHORITY OF SECRETARY.**—The Secretary may
10 require, by regulation, subpoena, or otherwise, that any
11 person who conducts weather modification activities shall
12 maintain and furnish records and other information related to
13 such activities. The Secretary or his authorized representa-
14 tive may inspect the records, information, premises, and
15 property of any person as may be necessary or appropriate in
16 carrying out the provisions of this Act.

17 (e) **SIMILAR STATE REQUIREMENTS.**—The Secretary
18 has the authority to accept reports filed by individuals to sat-
19 isfy State requirements, if such reports satisfy the informa-
20 tion requirements of subsection (c).

21 (f) **JURISDICTION.**—Upon application by an individual
22 or the Attorney General on behalf of the United States, the
23 district courts of the United States shall have jurisdiction to
24 enjoin any violations of the provisions of this section.

1 (g) PENALTY.—Any person who knowingly and willful-
2 ly violates this section or any rule issued thereunder shall be
3 fined not more than \$10,000.

4 BIENNIAL REPORT

5 SEC. 10. The Secretary shall prepare and submit to the
6 President and the authorizing committees of the Congress,
7 not later than January 30 of the year occurring two years
8 after the date of enactment of this Act and thereafter every
9 two years, a report on the activities conducted pursuant to
10 this Act during the two previous fiscal years. Each report
11 shall include—

12 (1) a summary of the achievements of the Pro-
13 gram during the two previous fiscal years;

14 (2) an analysis of the progress made toward
15 achieving the goals of the Program;

16 (3) a copy of the five-year plan and any changes
17 made in such plan;

18 (4) a summary of the budget for the Program, in-
19 cluding past expenditures, present requests, and future
20 projections;

21 (5) a listing of other weather modification pro-
22 grams in the United States that are not part of the
23 Program;

1 (6) a description of actions which have been taken
2 to improve Federal-State and United States-interna-
3 tional cooperation in weather modification; and

4 (7) recommendations, including additional legisla-
5 tion, for improving the Federal weather modification
6 management effort in order to carry out the provisions,
7 policies, and purposes of this Act.

8 CONTRACT AND GRANT AUTHORITY

9 SEC. 11. (a) IN GENERAL.—The Director may enter
10 into contracts and make grants in order to carry out his re-
11 sponsibilities under this Act. Any such contract or grant may
12 provide—

13 (1) to a State or local government, up to 50 per
14 centum; and

15 (2) to any other entity, up to 100 per centum
16 of the total annual cost of the project or activity involved.

17 (b) ELIGIBILITY AND PROCEDURE.—Any individual,
18 corporation, public or private educational institution, or State
19 or local government may apply to the Director for a contract
20 or grant under this section. The Director shall prescribe the
21 form, manner, and content of the application for and actual
22 terms of any contract or grant.

23 (c) TERMS AND CONDITIONS.—Any individual or entity
24 who receives Federal funds from a contract entered into or

1 grant made under this section shall keep such records as the
2 Director shall prescribe by regulation, including—

3 (1) records which fully disclose the amount and
4 disposition by such recipients of such funds;

5 (2) the total cost of the project or activity for
6 which such funds were so made available;

7 (3) any amount of such costs supplied from other
8 sources; and

9 (4) such other records as will facilitate an effec-
10 tive audit.

11 Such recipient shall maintain such records for five years after
12 the completion of such a project or activity. The Secretary,
13 the Director, and the Comptroller General of the United
14 States, or any of their duly authorized representatives, shall
15 have access for the purpose of audit and evaluation to any
16 books, documents, papers, and records of such recipient
17 which, in the opinion of the Secretary, Director, or Comp-
18 troller General, may be related or pertinent to such contract
19 or grant.

20

ADMINISTRATIVE PROVISIONS

21 SEC. 12. (a) TRANSFER OF ACTIVITIES.—Not later
22 than one year after the date of enactment of this Act, there
23 shall be transferred to the Secretary—

1 (1) responsibility and management of the weather
2 modification activities in all Federal departments and
3 agencies, except those of—

4 (A) the National Science Foundation, which
5 shall retain control over the supervision and direc-
6 tion of basic Federal research related to weather
7 modification; and

8 (B) the Department of Defense, which shall
9 retain the option to conduct research and develop-
10 ment activities for the purpose of avoiding techno-
11 logical surprise; and

12 (2) authority and ownership of all personnel, prop-
13 erty, funds, and other assets of such agencies and enti-
14 ties, which are related to weather modification and
15 which are necessary or useful, as determined by the
16 Secretary, to carry out the provisions, policies, and
17 purposes of this Act.

18 Such transfer to the Secretary shall be under the supervision
19 and direction of the Director of the Office of Management and
20 Budget.

21 (b) OTHER ADMINISTRATIVE POWERS.—The Secre-
22 tary may construct, lease, purchase, or otherwise acquire lab-
23 oratories or other equipment in order to carry out the func-
24 tions under the Program or his duties under this Act.

MISCELLANEOUS PROVISIONS

SEC. 13. (a) FEDERAL AND STATE AUTHORITY.—As described in subsection 6(c), the Secretary shall consult and cooperate with State and local governments and other interested groups that—

(1) are likely to be affected by the Program activities. When the Secretary determines that a particular Program activity is necessary to achieve the goals of the Program, the Federal authority of the Secretary's decision shall supersede State and local authority, laws, and interests. Any affected State that objects to the Secretary's decision may seek to enjoin such Program activity in the district courts of the United States;

(2) are likely to affect Program activities by conducting their own weather modification activities. When the Secretary determines that a particular non-Federal activity will interfere with an activity of the Program or will conflict with a policy or purpose of this Act, the Secretary may seek to enjoin such non-Federal activity in the district courts of the United States.

(b) FEDERAL LIABILITY CLAIMS ALLOWED.—
The provisions of the following sections of the United States Code shall not apply to claims based on acts performed (or

1 failure to act) in any of the Director's activities with respect
2 to weather modification—

3 (1) section 2680(a) of title 28, to the extent that
4 it provides an exception from the tort claims procedure
5 for claims based on the exercise or performance (or
6 failure to exercise or perform) a discretionary function
7 or duty on the part of a Federal agency employee; and

8 (2) section 2675 of title 28, to the extent that it
9 would otherwise prevent a class action under the tort
10 claims procedure.

11 (c) SUNSET PROVISION.—The Program shall cease to
12 exist twenty years after the date of enactment of this Act,
13 unless otherwise provided by law..

14 (d) REPEAL OF PREVIOUS REPORTING LAW.—The
15 Act entitled "An Act to provide for the reporting of weather
16 modification activities to the Federal Government", approved
17 December 18, 1971 (15 U.S.C. 330(e)), is repealed.

18 AUTHORIZATION OF APPROPRIATIONS

19 SEC. 14. There are authorized to be appropriated to the
20 Secretary, for the purpose of carrying out the provisions of
21 this Act, not to exceed—

22 \$30,000,000 for the fiscal year ending September
23 30, 1981;

24 \$35,000,000 for the fiscal year ending September
25 30, 1982;

- 1 \$40,000,000 for the fiscal year ending September
- 2 30, 1983;
- 3 \$45,000,000 for the fiscal year ending September
- 4 30, 1984; and
- 5 \$50,000,000 for the fiscal year ending September
- 6 30, 1985.
- 7 Such sums shall remain available until expended.

○

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., October 25, 1979.

HON. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This responds to your request for our views on S. 829, a bill "To declare a comprehensive and coordinated national weather resources management policy, to provide for the development of standards and guidelines for weather resources management, and to establish a national program of research and development in the weather resources management field", and S. 1644, a bill "To declare a national weather modification policy, to establish a national program of research and development in weather modification, to provide for the promulgation of regulations related to weather modification, and for other purposes."

We oppose enactment of these bills.

S. 829 would (1) declare a comprehensive and coordinated national weather resources management policy, (2) provide for the development of standards and guidelines for weather resources management, and (3) establish a national program of research and development in the weather resources management field. S. 1644, a similar bill, would (1) declare a national weather modification policy, (2) establish a national program of research and development in weather modification, and (3) provide for the promulgation of regulations related to weather modification.

We support the need for a better directed, stable, and focused weather modification research program. Coupled with a need for a statement of national policy regarding weather modification is a requirement for a commitment to continued scientifically sound experimentation and to stable funding for research, especially for basic research.

We do not believe that centralization of weather modification activities in one agency is desirable. However, we support improved coordination of existing activities and recommend the Committee on Atmosphere and Oceans as a vehicle for achieving that objective.

S. 1644 proposes Federal regulation of weather modification through licensing procedures. During the last few years, approximately \$5 million has been expended annually on non-Federal weather modification programs. Most of these activities are in States that have enacted legislation requiring licenses and/or permits. We believe that regulation of weather modification can be adequately accomplished by the States at this time. The basis for this decision is noted in the finding in section 1(c)(4) of S. 829, that: "There is no urgent need for comprehensive Federal regulation of weather resources management at this time, and in fact excessive regulation would be likely to impede progress."

Section 7 of S. 829 proposes the development of a set of Sound Weather Resource Management Practices. These practices are to be published in tentative form within 180 days of enactment, and in final form within 273 days of enactment of the bill. While we support the concept and long range need for developing standards, in regards to weather modification activities, we believe the specified time for implementing such standards is too premature. With the research and development completed thus far, it would be difficult to propose meaningful standards. Moreover, we lack adequate instrumentation to develop and to enforce such standards. Because of the lack of information and instrumentation, too much personal judgment would be required in monitoring compliance with proposed standards.

Both bills would revise existing tort claims provisions concerning the exercise of discretionary functions by subjecting weather modification activities to liability under the Federal Tort Claims Act. A transfer of liability is not necessarily indicated at this time, since experience with actual claims is very limited. Based on available information, it is difficult to distinguish between weather related losses which would have occurred naturally and weather related losses which would have been induced by weather modification.

The Office of Management and Budget has advised that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely,

GUY R. MARTIN,
Assistant Secretary.

Senator STEVENSON. We will hear this morning from four agencies, and then from a panel of experts.

First, let me call on my colleague, Senator Bellmon. Would you like to begin, Senator?

STATEMENT OF HON. HENRY BELLMON, U.S. SENATOR FROM OKLAHOMA

Senator BELLMON. Yes, Mr. Chairman. Shall I come down here?

Senator STEVENSON. Oh, why don't you join us up here. We hope you'll stay beyond any opening statement that you'd like to make and participate.

Senator BELLMON. I'd like to do that, Mr. Chairman. I have a problem, in that our Conference on Agricultural Appropriations bill is also meeting. We hope to finish that this morning. It should take only a few minutes. I'll need to go and then I will come right back.

Senator STEVENSON. All right.

Senator BELLMON. Mr. Chairman, I would like to begin by expressing my appreciation for the timely manner in which you scheduled these hearings, and also for allowing me to appear.

The bills which you mentioned are intended to reach the same objective, which is to establish a well-coordinated and comprehensive program for weather resources management.

I might say, just by way of a side comment, that coming as I do from the State of Oklahoma, weather modification is really a big thing for us. We have a rather erratic climate down there, and often in the summer when our crops are growing we have extensive periods of dry weather. The past pattern has been that when a drought begins to develop and people become interested in weather modification, by the time all of the pieces come together usually several weeks have passed and the crops are burned up and then we try cloud seeding or some other technique and many times seem to get results, but often too late to really solve the problem. By then the crops are ruined and, while we get rains, it often is too late to be helpful.

So I got into this trying to figure out a better way to coordinate the activities and the investment which the Government makes in weather modification, and to try to develop a system of providing help in a timely way.

I might say I have been working at this for a good many years, and I am very glad now that we have come to this point. While our bills differ in approach, we each recognize the potential benefits that weather modification can provide.

So I would like again to congratulate you for the interest you have in this subject and for getting these hearings underway.

These efforts in weather modification which the Federal Government carries on now are really spread across several agencies. We have not had, so far, a good way of coordinating what the Government does for getting the maximum results in the investment that we make.

There are at least six Federal departments that have some responsibility for weather modification activities, with the principal responsibility resting in the National Oceanic and Atmospheric Administration of the Department of Commerce.

I would like to spend a little time being critical of NOAA because it seems to me they have not made the most of the responsi-

bility they have. It is for that reason that my bill, S. 829, puts the leadership for weather modification in NASA.

It has now been 3 years since NOAA was charged with the responsibility of conducting a 1-year study to recommend a national policy on weather resources management, and we have not yet received their report.

The study itself which was conducted by the Weather Modification Advisory Board, as authorized by Public Law 94-490, has been completed for some time, but unfortunately NOAA's recommendations for a national policy have been bogged down, as best we can figure out, somewhere between NOAA and the Office of Management and Budget.

The Chairman of this Weather Modification Advisory Board, Mr. Cleveland, is here. Also, my constituent from Oklahoma, Ray Booker, who is very prominent in weather modification, is also here and perhaps he has some idea about what the problem is.

It seems to me that NOAA has not exhibited the leadership that they should have either in conducting weather modification activities nor in following through in getting this report from OMB.

This is but one of several examples of NOAA's apparent lack of interest or inability to properly manage weather modification activities.

Another example includes NOAA's failure to hire a senior person and put this person at a high level to manage their present weather modification activities, although those in NOAA have given assurance that this was to be done.

As a result, in my opinion these programs are still poorly managed. As the chairman is aware, NOAA has given its lowest budget priority to weather modification programs in its last budget request. Fortunately, Mr. Chairman, you've been instrumental in remedying this deficiency.

And finally, bureaucratic delays within NOAA prevented funding for the Florida air cumulus experiment this year until it was too late to operate that program. When funds were finally made available, half the season was lost and the result was an inadequate and wasteful program.

Such waste is further evidenced by the fact that the last hurricane seeding experiment was conducted back in 1962. Although this program has been maintained for most of the years since then nothing much has been done. As a result, we do not now have a viable program for conducting research in hurricane seeding in any ocean. International negotiations in this area should certainly be stepped up.

It is for these reasons, Mr. Chairman, that S. 829 establishes the National Aeronautics and Space Administration as the agency responsible for administering and implementing the weather modification policy and the program provided for in this bill.

NASA has established an excellent track record in solving complex scientific and engineering problems, and I feel it is best suited to assure proper management of the national weather resources management program at least during the early and experimental stages. Possibly, once we are through that phase and get into an operational program totally, then some changes could be made. But it seems to me that NASA is the one Government agency that is

oriented toward the type of complex scientific and engineering research that is going to be required to get weather modification into a role where it can play a major part in dealing with the weather problems in this country.

To assist NASA in its responsibility, S. 829 would establish the Weather Resources Management Board to advise the Administrator of NASA in organizing, planning, designing, developing, and carrying out the national resources program and policy established by this legislation.

This program would include basic research, experimental activities, and operational projects that can be beneficially used for expanding technological achievement. It is the experimental and operational aspects of such a program that are so essential for a sincere and comprehensive effort in developing weather modification techniques.

Although there is still a great deal of research to be done in this field, many favorable results from previous weather modification have been produced. I feel we need to continue to build on these results by encouraging and promoting continued operational projects and from these operational projects we can gain a great deal of useful information if they are properly monitored and properly designed.

Finally, S. 829 provides for an emergency capability so that we may be able to react to unforeseen situations in a timely way, or to continue efforts to arrest prolonged periods of unfavorable weather. This is the part of the bill that most attracts me, as an Oklahoman. I feel that we do need to have in place the capability of reacting in a timely way to the emergencies that we do have in the Midwest from time to time when the rains fail to come.

I see this emergency capability as providing a response to such destructive forces as drought, perhaps tornados, maybe even blizzards, fog around airports, hurricanes, and in trying to deal with hailstorms. This is particularly important in view of the destructive nature of these atmospheric disturbances and the effect they have upon our Nation's food production.

This emergency capability can also have a beneficial effect upon our urban areas, particularly in trying to deal with fog suppression around some of our major airports.

Mr. Chairman, you have indicated that the time has come to put in place an effective weather resources management program. I certainly agree with this feeling, and I want to do everything I can to help. I feel certain that these hearings over the next several days will provide us with a wealth of information as to how Congress should proceed in reaching the objective that you have outlined.

I appreciate the consideration of S. 829, along with S. 1644, and I believe this is the most encouraging development in the weather modification field that I have seen since I have been in Congress these last 11 years. So I want to do all I can to help, and I assure the chairman that this area is certainly worth the effort you are putting into it. I believe the time has come for action, and that Congress is ready to move.

Thank you very much.

Senator STEVENSON. Thank you, sir.

You began this effort and are to be commended for that. As a matter of fact, legislation in the 94th Congress which directed the report by the Secretary of Commerce was your legislation and we have some reason to think that we will receive that report very soon. But, as you pointed out, it is long overdue.

I think your optimism about the possibilities at last for some positive action in both the executive and the legislative branches is justified. I will certainly do all I can.

And now if you can stick around, we will have a chance to hear from NOAA, and also NASA.

Senator BELLMON. Certainly.

Senator STEVENSON. Our first witness is the Administrator of NOAA, Mr. Richard Frank.

Let me invite all of the witnesses this morning to summarize their statements. If they do so, the full statements will be entered in the record.

STATEMENT OF RICHARD A. FRANK, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE; ACCOMPANIED BY GEORGE BENTON, ASSOCIATE ADMINISTRATOR; AND MICHAEL GLAZER, ASSISTANT ADMINISTRATOR FOR POLICY AND PLANNING

Mr. FRANK. Mr. Chairman and members of the committee, I am pleased to be here with you this morning to discuss national weather modification policies and research and development programs, and to comment on S. 1644 and S. 829.

My written testimony covers four areas: the Department of Commerce's study of these subjects pursuant to the National Weather Modification Policy Act of 1976; the present status of national weather modification policies and programs; the activities of NOAA in this area; and the major outstanding issues with respect to the future direction of national weather modification policies and programs.

I would like to summarize various aspects of the testimony and then to have the testimony submitted for the record.

Senator STEVENSON. The full statement will be entered in the record.

Mr. FRANK. When Congress very properly charged the Secretary of Commerce with proceeding with an examination of this subject, the Secretary felt it was of sufficient importance to have independent advice on the wide range of issues addressed by the act. Consequently, she established a Weather Modification Advisory Board consisting of 17 very distinguished individuals who in one way or another were expert in the field of weather modification or very knowledgeable about it.

The report of the Advisory Board has been made available to the Congress and will be submitted formally within a matter of days. I compliment the Board. The Board has produced a remarkable report, not only because of its artistry, thoroughness, and balanced judgments on complex scientific and social issues, but also because it was the product of the Advisory Board members themselves rather than their staff.

That report exists as a landmark, I believe, on the subject of weather modification and has been the basis for the Administra-

tion report on the same subject. The Administration report has now been cleared by the executive branch and, within a matter of days, will be made available to you, Mr. Chairman. It will take sometime longer for the report to be printed and published, but we will see that you receive advance copies soon. I will be able this morning to tell you some of the conclusions that are in that report.

The Advisory Board report is very comprehensive. I will summarize some material from that report, and some from ours.

The Board's report describes weather modification activities that are already taking place, as does my testimony and the Administration's report. Suffice it to say here that weather modification activities are taking place, although to a limited degree. In 1978, 50 operational programs, covering approximately 5 percent of the country's land area, were reported to the Department of Commerce pursuant to the National Weather Modification Reporting Act of 1971. About a dozen relatively small contractors regularly furnish commercial cloudseeding services in the United States. This is an industry which amounts to a few million dollars a year.

Weather modification presently is not regulated by the Federal Government, but is regulated by several State governments in varying degrees. Some State governments require licensing, or notifications. About 33 State governments have legislation on this subject. Some State legislation is in our view adequate at least for present purposes.

Weather modification research activities and the current state of scientific knowledge are also summarized in both reports. Let me briefly summarize the current state of knowledge, since that is a question of significant importance in determining how to proceed on this subject.

Techniques for clearing supercooled fog from airport runways are now proven and in use.

The seeding of orographic clouds over mountainous regions to stimulate precipitation, particularly to enhance snowpack, has been one of the most actively pursued weather modification activities. Experiments have shown positive results in certain types of meteorological situations, and apparent precipitation increases as high as 20 percent have been observed.

Summer cumulus clouds are even more important than orographic clouds as producers of precipitation and generators of severe weather. Cumulus experiments using the dynamic seeding concept have demonstrated fairly convincingly that the growth of a single cumulus cloud can be stimulated using this technique. But the question is still open about whether predictable increases in areal precipitation will occur as a result of seeding and the subsequent growth and merger of clouds and cloud systems.

With respect to winter cumulus clouds, one project in Israel has established statistically convincing results—precipitation increases of about 15 percent—and is now operational.

Very little experimentation has been pursued on modification of severe storms. We have done a good deal of research and much study of theory in connection with hurricanes. Senator Bellmon referred to that earlier. NOAA has searched hurricanes, and we have empirical evidence that the wind velocity of hurricanes can

be reduced by seeding. That is consistent with some theories on the subject.

The available scientific information leads NOAA to a conclusion which is shared by the rest of the Federal Government and is I believe, consistent with the report of the Advisory Board. That is, that modification of the weather in useful ways is scientifically possible, and good reasons exist to believe that a carefully constructed research and development program can supply many of the missing answers necessary to establish an effective weather modification program. As indicated in more detail in my written testimony, the major scientific problem is to develop a substantially improved understanding of cloud systems and cloud dynamics.

In addition, we believe that the benefits of reliable weather modification technologies would be substantial and would greatly outweigh the costs of those technologies. The benefits are set forth, in part, in a study done by the Weather Modification Advisory Board. Admittedly it is difficult in this area to conclude what precisely the benefits would be. However, I believe the Board has done as good a job as anyone. If one looks at just the damages that are caused by storms annually—a billion dollars in the area of hurricanes and another billion dollars in the area of hail—together with the benefits that could come from saving crops, I think one readily can conclude that there are conceivably immense advantages to weather modification.

Another element of weather modification extends beyond our borders—its international importance. The United States has been working with other countries on this subject for quite some time. We have several programs going now, and have participated in several studies undertaken by the World Meteorological Organization.

The Federal Government's current program is described in the advisory committee report, which shows that the total program has varied somewhat but is in the area of \$16 to \$18 million a year. Obviously, it depends on how you count as to what the exact figure is.

NOAA's program has varied also, but is approximately \$4 to \$5 million. NOAA has several laboratories that spend substantial amounts of time on activities that are related to weather modification.

I have already mentioned our hurricane seeding effort—Storm Fury—so I will not repeat that, except to note that the project is done by our laboratories.

NOAA's national severe storms laboratory in Norman, Okla., is dedicated to understanding origin, structure, and life history of tornadoes, thunderstorms, and other forms of severe convection.

NOAA's National Hurricane and Experimental Meteorology Laboratory in Miami, Fla., conducts theoretical and analytical work on the dynamic structure and energetics of hurricanes and penetrates tropical hurricanes using our instrumented aircraft.

NOAA's Atmospheric Physics and Chemistry Laboratory in Boulder, Colo., devotes special attention to the numerical modeling of mesoscale meteorological phenomena so important to precipitation.

NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, N.J., is best known as the international leader in mathematical

modeling of the atmosphere's general circulation. It also pursues an active program of numerical simulation and theoretical study of the smaller scale motions related to convective processes and cloud dynamics, all of which are important to weather modification techniques.

NOAA's Wave Propagation Laboratory in Boulder is a world leader in the development and experimental application of new methods for remote sensing of the atmosphere.

In addition, other activities in NOAA outside of our laboratories are also related to weather modification. I am speaking of the atmospheric services provided by the National Weather Service, the National Environmental Satellite Service, and the Environmental Data and Information Service.

I mentioned earlier the activities of the WMO. NOAA has been the U.S.'s representative to the WMO for quite some time. The WMO is engaged in many weather modification activities. Seventy-four countries have used weather modification techniques at some time, and over 30 countries reported projects to the WMO in 1977.

NOAA has been the initiator or major proponent of most of the international weather and weather modification programs now being pursued by the United States, such as the global atmospheric research program and the precipitation enhancement project.

With the Department of State, NOAA has actively pursued formal negotiations with the Government of Mexico, and informal discussions with representatives of the Government of Australia, to conduct bilateral hurricane seeding programs. We hope to conclude an agreement with Australia in the relatively near future. Discussions with Mexico, on the other hand, are not proceeding as quickly as we would like.

NOAA has a number of current activities which I think are important. We have monitored and measured recent Atlantic hurricanes, and obtained extensive physical data to examine critically the concepts behind Project Stormfury.

We have initiated the second phase of the Florida area cumulus experiment—FACE—being conducted by our National Hurricane and Experimental Meteorology Laboratory in Florida. FACE-2 will continue during the summer of 1980 in an effort to confirm the results of FACE-1, which indicated that dynamic seeding increased precipitation over a fixed target area in southern Florida.

During fiscal year 1980 we will also be conducting the pre-experimental phase of PACE, the precipitation augmentation for crops experiment, which I believe will be a particularly important to you, Mr. Chairman, because Illinois will be substantial component of that program.

In 1980 we will initiate plans on a selective basis for collaboration with State operational seeding projects to evaluate their effectiveness and to add to the weather modification research base. I hope that our 1981 budget, regardless of the results of these hearings, will show a substantial increase in weather modification, at least in the area of fundamental research.

I might say that in the past, NOAA's orientation to inhouse activities, many of which I have described here in the atmospheric sciences, has been criticized by National Academy of Science Advisory Panels as well as by the Weather Modification Advisory

Board. NOAA's Assistant Administrator for Research and Development, Dr. Ferris Webster, as well as NOAA's Associate Administrator, Dr. George Benton, and I have been among such critics. We have now taken a number of steps to remedy this situation. Suffice it to say that we will be collaborating closely on weather modification with the outside community. Indeed, we believe that the outside community in many areas has the best expertise and ought to be used. We have established guidelines for that purpose, and we will have better integration of outside and inside activities in the coming months.

A primary concern to all of us is the shape of future Federal research programs. As I indicated earlier, modification of the weather is scientifically possible. If it can be done reliably and with predictable results, society will benefit substantially, both economically and by the saving of lives.

As the Advisory Board concluded, "The prime requirement of a National Weather Modification Policy is to know more about the atmosphere itself." We agree with that. We in NOAA would like to take a leadership role in performing the necessary fundamentally oriented research and development. I mentioned earlier the large number of activities in which we are involved and the reasons why I believe our weather modification program is important. Those reasons also demonstrate that NOAA is equipped to play a leadership role.

I might add that there is another element which the Weather Modification Board itself shows to be true—the substantial need for public involvement of two kinds in any policy we might have. The Weather Modification Advisory Board performed an extremely useful service and produced an essential report. However, it was not only the substance of the report that was important. Equally important was the fact that the report came from individuals who represented the public sector. It is important to involve the interested public. That includes individuals who are involved in weather seeding, those in scientific and academic communities, and others who are interested in this subject.

One group I have not mentioned is those who may be skeptical of weather modification. I think that group too ought to be involved in these hearings, and in other considerations of this subject. I might refer to a point made succinctly in a letter I received on the Advisory Board's study from the New Jersey Department of Environmental Protection. That letter reported the view of the department's commissioner, which was, "Don't fool around with Mother Nature." While I conclude, on reflection, that we should modify some elements of Mother Nature, we should do so very carefully.

Over the last months since the Weather Modification Advisory Board's report has been made available, we in the executive branch have been discussing this subject with other members of the outside community. All agencies within the Government have been consulted on the subject, as well as the Office of Management and Budget. We are now prepared to indicate to you our views on the critical subjects. I would like to refer to my testimony and read parts of it, because I think it is a very important part of our conclusions.

First let me focus on the organization of Federal weather modification programs. That organization is treated differently in the two bills that are before this subcommittee at the present time.

The Advisory Board concluded that the present Federal strategy of viewing particular weather modification efforts as one of several possible approaches to achieving various agency missions should be changed. It recommended that all civilian research and development programs be centralized in a single Federal agency, and that it be managed by an autonomous public board with direct authority over the operation of the national program. One bill before this subcommittee recommends that the agency be NOAA, and another that the agency be NASA.

The Administration believes that well-coordinated research and development programs carried out by a number of Federal agencies can best achieve advances in weather modification science and technology. To that end, the Administration has decided to establish a Weather Modification Subcommittee under the Committee on Atmosphere and Oceans of the Federal Coordinating Council on Science, Engineering, and Technology.

I am the Chairman of the Committee on Atmosphere and Oceans, and a NOAA official will chair the subcommittee. The subcommittee will be charged with developing, within the next 6 months, a 5- to 10-year weather modification research plan that emphasizes fundamental research on cloud microphysics and mesoscale meteorology, as well as the effect of seeding on the structure and dynamics of cloud systems. The program will include a careful analysis of required field experiments, especially with regard to effective monitoring and improved scientific and statistical design. The subcommittee will also provide a coordinating mechanism for the conduct of this plan, once approved, and will assist the Office of Management and Budget in analyzing annual agency program budget submissions for consistency with the plan.

This form is similar to the National Climate Program Office established in NOAA pursuant to legislation of this Congress.

The Administration recognizes the need for close public scrutiny and involvement in field weather modification programs, but does not believe that it is necessary or desirable for an independent board of private citizens to manage such Government programs.

The Administration intends to establish a committee of individuals knowledgeable in the field of weather modification whose members represent diverse viewpoints to act as a special advisory board to this subcommittee.

The Administration has successfully established similar advisory committees on other national research and development programs in the past under existing authorities, and believes that such a committee can provide valuable scrutiny of the planning and conduct of the Federal program.

With respect to weather modification legislation, the Advisory Board concluded that legislation at the Federal level was desirable, both in order to license private weather modification operators and to establish the framework for a national weather modification policy and program.

The Administration agrees that legislation is desirable, but does not believe that such legislation should establish a comprehensive regulatory scheme.

As effective technologies are developed, the Federal Government will have the principal responsibility for regulation of the impacts of weather modification because of its interstate implications. However, the Administration believes that comprehensive Federal regulation is not yet necessary in view of the relatively small levels and limited impacts of non-Federal weather modification activities. Any licensing scheme involves setting standards to renew and revoke licenses, as well as monitoring performance—activities little different from those under a comprehensive system of regulation of operations.

The advantages of Federal licensing at this time are small. Non-Federal activities can be regulated by any State that chooses to do so to protect its citizens. And because weather modification operations are currently conducted on a small scale, a State's failure to do so would impact only its own citizens.

On balance, by small advantages of a Federal licensing system are outweighed by the associated costs. I might add that this does not mean that the Administration believes we should never legislate such regulation. Rather, our conclusion is that, given our limited knowledge about what type of weather modification activities will take place and the small nature of the activity, regulation should not now be enacted and imposed.

Although the Administration believes that enactment of a Federal regulatory regime is premature, the Administration does support enactment of legislation which states clearly the national interest in weather resources management, identifies the goals of a national weather modification program, and sets forth the respective roles of the State and Federal Governments. Both the bills introduced by the two Senators present today do that, in one form or another, and therefore we support those elements of that legislation.

With regard to funding for weather modification research and development, the Advisory Board concluded that major increases in the levels of Federal funding would be required to support a national weather modification research and development program. The Administration does not believe that funding increases of that magnitude are necessary.

The Administration supports modest budget initiatives in this area, especially for basic research, but believes that special plans to carry out the new coordinated Federal research program must first be developed by the CAO Subcommittee. Any such increases should also include provisions for cost-sharing by the States when the research programs have major payoffs in particular areas or the findings will be of use primarily to small areas or types of operation. In other words, we do believe that weather modification needs to be enhanced and that more funds should be spent for it. We do not believe that the amounts set forth by the advisory Board are realistic, for a number of reasons, including other priorities and the ability of the outside and inside communities to absorb those funds.

The Administration recognizes that a continuing effort is necessary for research in this field, and its preparation of annual Federal budgets will include a review of funding requirements to assure that sustained program requirements are met—and I want to emphasize “sustained” because that was one of the critical issues mentioned by the Advisory Board.

Mr. Chairman, some mention has been made of the Administration’s delay in submitting the Administration’s plan.

It is true that it was over 2 years ago that Congress asked the Secretary of Commerce to submit to Congress a weather modification plan. It is also true that we have taken longer than we had originally anticipated. But I would like to explain why that length of time has been taken, and then I would like to suggest that we not belabor the subject.

It was possible for the Federal Government to prepare its report without the advice of the Weather Modification Advisory Board. It is our conclusion that the Advisory Board was truly essential. It took the Advisory Board about a year to complete its research, and it did so in a very thorough fashion, not treating the subject lightly. The quality of the resulting report is proof enough of its value.

We too needed time to prepare our report. It is now ready and will be submitted to Congress shortly. One reason for the length of time between the Advisory Board’s report and ours is that the subject was highly controversial. The Advisory Board did not compromise in many areas; it stated some definitive conclusions. We wanted to discuss those conclusions with elements of the public, with Members of Congress, and with other parts of the executive branch before submitting our report to you.

Weather modification is a subject with which we should proceed. On the other hand, whether we proceeded with it 6 months ago or 6 months from now is not relevant. We want to see legislation passed, and we would like to see it passed before the end of next year. I do not think it is time sensitive on a monthly basis.

It seems to me then that there were good reasons for the time that has passed, but the reason I would like not to dwell on that subject is that we already have a good deal of meat on our plate. We have an excellent report by the Advisory Board, written primarily by its distinguished Chairman Harlan Cleveland. We have a report which will be to you in a matter of days from the executive branch, which does recommend legislation. We have two bills which are provocative, and the Administration supports the essence of these bills. We have the views and commentaries of a number of people who will testify before you today.

The subject is significant. The information that you will have before you is important. And what I suggest is that we discuss that substance, rather than the past.

In terms of NOAA in particular, I want to assure you that NOAA has a strong commitment to weather modification. I personally was involved in weather modification before coming to the Government, as was Dr. Benton. We believe strongly that there should be an enhanced, coordinated Federal program, and we will do our best to see that come about.

In conclusion, Mr. Chairman, the Department of Commerce's extensive study regarding national weather modification policies and programs has indicated that modification of the weather in useful ways is scientifically possible and that prudent steps need to be taken now to enhance activities designed to investigate those possibilities. The Federal Government must develop a coherent, long-term research program and organize seriously for a longer term effort. We look forward to working with the Congress to achieve those goals. We will submit specific legislative recommendations to the committee shortly, and as I mentioned earlier we do favor legislation and legislation before the end of next year.

Thank you. I would be pleased to respond to any questions that you may have at this time.

Senator STEVENSON. Thank you, sir.

Senator Bellmon, do you have to leave? Would you like to make any comments?

Senator BELLMON. I would, Mr. Chairman, if you would allow me.

Senator STEVENSON. Please go ahead.

Senator BELLMON. I will be very brief.

First, Mr. Chairman, I am sort of pleased by what appears to be some enthusiasm on the part of Mr. Frank for this business. I've talked with him in the past, and somewhere along the line somebody got his attention. I'm glad to see that this has happened.

I would hope that someone from Nebraska might realize the importance of weather modification more than someone from other areas where weather is a little more dependable.

Mr. Frank, just to get the record straight, my comments about lack of emphasis on the part of NOAA in weather modification is partly due to looking at the budget. Around here you can really tell what is happening when you look at the amount of money people are willing to invest in an activity. And if you look at the record, in 1972 the Department of Commerce invested \$3.94 million in weather modification; in 1979, despite the fact that we have had substantial inflation during that period, the investment was \$2.7 million. It came down. Now you probably were not in a position to make those decisions, but it is pretty obvious to me that during that 8-year period the Department had deemphasized weather modification by a factor of at least 50 percent.

This is one reason that I have a hard time believing, until I hear your testimony, that NOAA is really seriously interested in taking a leadership role in weather modification.

Mr. FRANK. Senator, I think that that is a very legitimate concern on your part. I would like to say that the trend downward which you just mentioned has now changed, and that we have moved up well over \$4 million. It is my hope and expectation that in 1981 we will again have a substantial increase of over 33 percent. We are now going in what you and I would both consider the right direction.

I might add that the Federal Government does not always respond as quickly as it should to some of these issues. I think, because of the prodding of Congress, we will move forward more quickly than otherwise would have occurred. Therefore, I look forward with enthusiasm to these hearings, and appreciate the

interest that you have shown in this subject. I commit my agency to responding as well as it can, considering other priorities.

I might say that NOAA is a growing agency. It has had an immense number of new responsibilities given to us because of congressional legislation. Unfortunately, that occurred during eras of tight budgets. Other organizations, such as NASA, were able to grow during the 1960's when money was more readily available; we were not. We have grown more during the 1970's, when funds have not been available to us as we would have liked.

In any event, I do commit to high priorities in the area, and to a substantial amount of interest on the part of NOAA's management.

George Benton, who is in part responsible for NOAA's budget, would like to add a comment to that, Senator.

Dr. BENTON. Thank you, Mr. Frank.

Senator, the funds that are specified as "weather modification" in the NOAA budget are specifically for that limited purpose. However, I would like to point out also that the Weather Modification Advisory Board, and indeed all scientific groups that have looked at the problem of weather modification, have emphasized the tremendous importance of examining some of the fundamental scientific problems related to cloud dynamics and mesoscale systems. The NOAA budget for work in these fields is very substantial and includes work in quite a number of our laboratories, including as you know our National Severe Storms Laboratory in Norman, Okla.

Senator BELLMON. Well, Dr. Benton, as you can imagine, I have been in that laboratory many, many times, and they are, of course, making a valuable contribution; but I do not see that they have much to do with weather modification.

Mr. BENTON. I believe they do, Senator, because basically weather modification will succeed only if we understand the dynamics of clouds, their physics. This involves careful observation of cloud systems, such as those carried out by the Severe Storms Laboratory.

Such background studies are absolutely essential, and in fact are endorsed by virtually all scientific proponents of the weather modification.

Senator BELLMON. I guess you and I are thinking of two separate things. I agree that research and all the studies are necessary, but we've been at that for generations, and it seems to me that now is the time we ought to be moving into the operational phase and monitoring the results, certainly.

I do not see the Severe Storms Laboratory carrying on activities of that kind. I think they would like to, but they have not been given their budget to do that.

So I am not criticizing what they are doing, I am simply saying that we can study these things to death, and sometime we have to get out of the laboratory and into the field, and it seems to me that time is now, as far as weather modification is concerned.

Mr. FRANK. Senator, we agree that we should be out in the field. However, we think it would be a mistake solely to be out in the field. The problem simply is, as in weather forecasting and weather

prediction, that this is a very complex area and we do not know enough about the fundamental science yet.

Senator BELLMON. Well, when will you? That is my concern, I guess. You talk in your statement a lot about the research you are doing, but I have not seen anything that indicates NOAA is doing any operational work.

Mr. FRANK. I cannot tell you precisely when we will know the answers. I can be somewhat optimistic for one reason, and that is that we have tools available to us now which we did not have 15 years ago. We have advanced radar, computers, and aircraft which are highly instrumented and very sophisticated.

Because of these tools we will be able to advance more quickly. We have been at weather prediction and weather forecasting for decades, and in that area, too, there are still difficulties. It is solely because of the complexity of the subject which we are studying.

I do not mean to say that we should not proceed with field programs; we should. But I think it would be a grave mistake, as Dr. Benton mentions and as the Weather Modification Advisory Board concluded, not to find out some basic information about cloud physics.

Senator BELLMON. Well, if your position is that NOAA wants to continue research until you have all the answers, then I think we are kidding each other. We will never have all the answers about a subject as complex as this, and that is what troubled me about your statement. You say you believe that NOAA is well equipped to take the lead in performing the necessary fundamentally oriented research and development.

I am not criticizing you for wanting research and development, but to me the operational area is where we are presently lacking. You know what happens. Drought comes; some—I won't say they're slick salesmen, but some clever salesman comes in and makes certain promises, and the local city dads, or the local farm organizations put up some money, and someone puts in a little machine and it sprays iodine crystals up into the sky, and if it rains everybody is happy, and if it doesn't rain the salesman collects his fee anyway, and no one knows exactly whether there were any results from that activity or not.

It seems to me that it is going to have to require a Government agency getting into it on a fairly large scale and over a lengthy period of time, and monitoring what happens before we really know whether there is a possibility here of regular use of this technology on a wide-scale basis, and you cannot do that in a laboratory.

Mr. FRANK. I think we agree with each other. We are not saying that this should only be done in the laboratory. We are in favor of such things as FACE and Project Stormfury.

Senator BELLMON. What is your budget for operational weather modification in 1980?

Mr. FRANK. I would be happy to give you that figure, but if you are talking about operational as opposed to field experimentation—it may be difficult to separate the two because—

Senator BELLMON. Well, I think it is zero. You don't have a dollar in there for operational activity in 1980.

Mr. FRANK. We may have a semantic problem by what you mean by "operational." FACE and PACE are both in the 1980 budget, and those, in the terminology I've been using, are operational. That is, PACE and FACE does involve active cloud seeding. Stormfury is used whenever it can be used, and that involves actual seeding.

Senator BELLMON. Well, that is one phase of weather modification. I am thinking more of weather modification as it affects the area that I know of in the Great Plains.

Mr. FRANK. Well, the results of FACE, the Florida area cumulus experiment, and PACE, which I just mentioned, both will affect that area.

Senator BELLMON. But they don't have anything to do with the Great Plains.

Mr. FRANK. They have to do with the seeding of clouds for the purposes of rainfall. Also, PACE will take place in the Midwest.

Senator BELLMON. I would appreciate knowing more about it.

Mr. FRANK. I would be happy to submit information to you on that.

[The following information was subsequently received for the record:]

The Precipitation Augmentation for Crops Enhancement (PACE) project is a comprehensive program to determine the potential for modifying convective precipitation in the Midwest and the socio-economic impacts of such modifications. Model calculations indicate the meteorological conditions there are highly suited to dynamic seeding. A good research data base on clouds and precipitation exists in that area; the social, economic, and legal climate is conducive to experimentation; contamination from other experiments or actual seeding operations can be avoided; and the air traffic will not inhibit the airborne seeding and research.

Background.—The design of the experiment is based on considerable research conducted over a period of 12 years at the Illinois State Water Survey and University of Illinois dealing with the feasibility and desirability of weather modification. The PACE program will build upon the experience gained during the Florida Area Cumulus Experiment (FACE) conducted by NOAA. FACE is planned to continue in the field in Florida through the summer of 1980. The Agricultural Experiment Stations at the University of Illinois, Michigan State University, Purdue University in Indiana, and the Ohio Agricultural Research and Development Center have all identified interest in particular aspects of impact studies. Thus, information derived for the agricultural, environmental, and societal impacts will be easily and rationally dispersed throughout the Midwest.

Current Actions.—NOAA funded a contract with the Illinois State Water Survey in June 1979 to continue the pre-experiment research. This contract is for one year at a cost of \$103,000. It is designed to 1) synthesize past information on the dynamical and microphysical characteristics of convective clouds in the Midwest, 2) continue the analysis of 1978 cloud and echo data, 3) integrate these findings with others to begin to sharpen modification hypothesis, and 4) initiate the research on the statistical and physical design with particular emphasis on coverates. For FY 1980, cloud measurements will continue. Additional background studies are needed before a seeding experiment can be designed.

Senator BELLMON. Only one other question. You commented that you would like to see legislation passed before the end of next year. I am curious. do we need to wait another year? Why can't we move now?

Mr. FRANK. I would be happy if the subcommittee could move that quickly. I'm not establishing a minimum time. If legislation can be passed this year, that would be fine. Indeed, it would be our hope that the subcommittee would proceed promptly, and conceivably this year, or perhaps the beginning of next year, legislation would be passed.

Senator BELLMON. It is our position, then, that one of these two bills is satisfactory? I'm sure you would prefer to see the authority lodged in NOAA. Other than that, do you generally approve of the approach these bills take?

Mr. FRANK. We certainly agree with the basic thrusts of the bills. Some elements of the bills would be inconsistent with some things I have said, and it depends on which bill you are talking about as to whether or not that is so.

As I mentioned in my testimony, it is our view that it would be preferable to have coordination in the Federal Government, rather than having all weather modification activities in one agency. That is something which Congress ought to consider.

Senator BELLMON. But there ought to be a lead agency.

Mr. FRANK. We do believe that there has not been adequate coordination in the Federal Government, and that there needs to be coordination and a comprehensive, consolidated program—but not operationally consolidated. So that is one place we would recommend a modification in the bills.

In terms of authorization for funding, we have not listed a specific figure. Our figure would be oriented more toward appropriations than authorizations.

In terms of regulation, there is a difference in the bills, too. We believe there should not, at this time, be regulation; but that would be consistent, I believe, with your bill.

In terms of grants to outside entities, we believe that the Federal Government ought to be working with outside entities. We do believe that there should be cost-sharing, and that should be provided for in the legislation.

There are some other minor differences.

Senator BELLMON. What level of cost sharing do you feel is appropriate?

Mr. FRANK. We would be happy to give you a specific level of cost sharing. I think that that is an issue which would be subject to discussion and then negotiation.

[The following information was subsequently received for the record:]

Some operational cloud seeding projects present an opportunity for gather research information. We should consider partial Federal support, primarily for developing and implementing experimental designs, of carefully selected State or local cloud-seeding programs in which the long-term benefits to the field are deemed large. In particular, we favor projects whereby evaluation techniques can be studied and improved. The projects to receive such support should be chosen from among those that are well controlled, which have adequate environmental monitoring, and in which the project managers are willing to modify the design to optimize its information output.

The Federal support could take the form of equipment loans to enable additional measurements to be made as may be required by the evaluation scheme, and funding of evaluation studies. In some cases, Federal involvement could take the form of special research studies conducted in collaboration with State programs, so that both might benefit from joint facilities and the knowledge gained. The dollar amount would be a small portion of the original project cost.

Senator BELLMON. Mr. Chairman, that is all I have. Thank you very much.

Senator STEVENSON. Thank you, sir.

Well, let me try to clear up the semantics. As I understand it, the administration really does not contemplate any operational

role for NOAA, does it? It is a development responsibility which begins with another study, and the activities that you referred to specifically are part of that effort to develop the systems, not to operate them for modification purposes. Is that correct?

Mr. FRANK. That is correct, and I think that at some point—depending on how we define “operations”—we would get into the question of whether the Federal Government should take over responsibilities which I believe would best be done by the private sector.

Senator STEVENSON. Now you said the administration supports the legislation, and in your statement you said the administration felt enactment of a Federal regulatory regime is premature. Yet it does support legislation which states clearly the national interest in weather resources management, which identifies the goals of a national weather modification program, and which sets forth the respective roles of the State and Federal Governments.

What are the respective roles that the administration suggests?

Mr. FRANK. We believe that because of the interstate character of a large number of weather modification activities, the Federal Government will eventually, in terms of oversight and regulation, be the preeminent entity. On the other hand, as we have also stated, activities which are local or housed in the State governments, should remain there.

We do not have a precise differentiation between those two. We would be happy to work with the subcommittee on the subject.

Senator STEVENSON. Well, if I understood you, you’ve just said that the Federal regulatory role should be preeminent, but in your written statement you said a Federal regulatory regime is premature. And of course earlier you urged us to legislate, quickly.

Now I think we deserve a little bit more guidance and advice from the administration, and at least some clarification of what I perceive to be contradictions in its advice—a preeminent Federal regulatory role, and then the statement that a Federal regulatory regime is premature.

Mr. FRANK. Part of that is an element of timing, Mr. Chairman. That is, eventually we will probably want regulation, and it may be the Federal Government which will be the preeminent regulator.

Our concern now with regulation is that it is not needed because of the extent of the activity that is presently taking place, and also because we are not sure we know, or indeed that we or Congress could know, what type of regulation would be best.

Our judgment is that such regulation ought to come when we know more about the subject matter—which means the operational research that Senator Bellmon was talking about; then we will know what we have.

I would be happy, however, to supply you with an enhanced articulation of our views as to the respective roles of the State and Federal Governments.

[The following information was subsequently received for the record:]

Although the Federal Government will have principal responsibility for regulation of the impacts of weather modification as effective technologies are developed, because of their interstate implications, comprehensive Federal legislation is not yet

necessary. The private industry is small (less than \$6 million in gross annual contracts), its operations are generally localized within state boundaries and do not create major risks, and most research field experimentation is controlled directly or indirectly through Federal funding.

States should be encouraged to voluntarily adopt an updated and improved version of the Council of State Governments' model weather modification control act, with such changes as may be necessary to adapt the model code to local circumstances. Although many states have enacted legislation in this area, standards tend to be loose and in many cases are prefatory. Enactment and implementation of the model code should assure that weather modification projects are carried out professionally, with due regard for public safety and after adequate public discussion of the risks and benefits. In addition, states should be encouraged to support research that will advance the state of scientific knowledge in the field.

At this time, the Federal role should be confined to the enactment of legislation of limited scope that can serve as the basis for a comprehensive long-term Federal research program to resolve the basic outstanding scientific issues, to the planning and conduct of such research in cooperation with States and the academic and private sector, and to collection and dissemination of information about the scope of National weather modification activities.

Federal legislation should contain a statement of National weather modification policy indicating the importance of a National program for weather resources management, identify the goals of a National program, and set forth the respective roles of the State and Federal Governments.

Federal research should take place in the context of a long-term research plan that emphasizes fundamental research on cloud microphysics and mesoscale meteorology, as well as the effect of seeding on the structure and dynamics of cloud systems. In addition, the manner in which the Federal program is conducted can contribute to improving the general level of professionalism of private sector activities. The Federal program can set an example by ensuring that the manner in which Federal projects are carried out incorporates the latest thinking about sound weather modification practices. Federal administrative actions in this regard could include active consultation with state and local authorities in areas to be affected prior to Federal field activities, development of operational guidelines for Federal projects, and followup of Federal programs by assessments of the environmental consequences of such activities.

In addition, Federal cost-sharing programs with states should be explored for evaluation of selected weather modification operations and for cooperative research and development operations. Such project evaluation support could be a cost effective way of providing more definitive information on the effects of weather modification activities. Federal programs should also be explored for Federal technical assistance (on a reimbursable basis) to, and information exchange with, interested states, communities, and private operators. The Federal program is an important repository of knowledge and information about the changing state of the art in weather modification.

Federal regulations should be amended to increase the advance notice of proposed projects now required by the reporting rules under Public Law 92-205 from at least 10 days to at least 30 days. As a matter of policy under current authorities, the Federal Government should promptly transmit copies of preproject notifications received by it to states without their own notification requirements. An increase in the current 10-day notice period would allow time for such notification.

Senator STEVENSON. You indicated that the administration felt the Advisory Board's recommendations for funding were unnecessarily large. What would an appropriate level of funding for weather modification be?

Mr. FRANK. I am authorized to say that the administration believes that increased funding is wise, and we do support increased funding. That is, more funding than is taking place now. Precisely what that funding ought to be will depend on what the 5-year plan is, and the virtue of the specific programs.

As to our views about the Weather Modification Advisory Board, our judgment is that \$40 million the first year, ending up at almost \$90 million, is more than can be absorbed, is probably more than is

necessary, and is more than ought to be allocated to this subject, considering other priorities.

Senator STEVENSON. Well, you have indicated support for legislation. Now we need to find out what the contents of that legislation are which you support. And I should think that if one purpose of the legislation was to demonstrate a commitment, then one content of the legislation should be an authorization. Do you agree?

Mr. FRANK. Yes, sir.

Senator STEVENSON. The present level of funding is about \$16 million. It should be higher than that, but lower than the Advisory Board's recommendation for the first year.

Mr. FRANK. That is correct, sir.

Senator STEVENSON. When will we get something a little bit more precise than that?

Mr. FRANK. I think we are going to be talking about two different issues. One is authorization, and the other is appropriation.

I think that the administration position on this is more oriented toward appropriations, and that we see and will support and will propose additional appropriations. I am not sure that the authorization levels which are suggested in the legislation are so far removed from those of an enhanced program—or at least what the authorization for an enhanced program ought to be.

Senator STEVENSON. S. 1644 commences with an authorization of \$30 million. It goes up in equal annual increments to \$50 million over 5 years. Any objections to that level of funding, if not support for it?

Mr. FRANK. Let me give you a tentative answer, and then give you a more definitive answer subsequent to this hearing. My tentative answer is that, as an authorization, that is not an unreasonable amount. I would not commit myself, however, to the fact that the appropriation should be at that level, but I think that the authorization is in a reasonable realm.

You are suggesting \$30 million for the first year, moving up to \$50 million. That, we believe, is certainly closer to what is needed than the figure the Weather Modification Advisory Board recommended.

As I mentioned earlier, I believe that an answer to the question of funding must await the development by a CAO subcommittee of a coordinated, multiyear Federal weather modification research program.

Senator STEVENSON. In your concluding remarks, you have asked us to forget about the past. I think that is asking a little more than is reasonable. It may shed some light on the future, and it certainly raises some questions, some of which have already been asked.

You are suggesting that a subcommittee of the Committee on Atmosphere and Oceans perform the coordinating responsibility for the weather modification program. If a subcommittee of the committee can perform this function, why hasn't the whole committee done so already?

Or to put the question slightly differently, if the committee has failed to do so—as everyone agrees—what is there to convince us that a subcommittee can perform that function effectively? Is legislation going to make the difference?

Mr. FRANK. I think, first of all, legislation will make a difference. That is, if Congress does establish a priority for weather modification, the executive branch will react quite differently than it has in the past.

I do admit that the executive branch, even without legislation, should have engaged in better coordination than it did. There have been some reasons why that has not taken place. But I think because of the stimulation of various Members of Congress, and because of the possibility now of legislation, we will move forward.

I can cite other examples where legislation has made the difference. In climate we did not have any kind of coordination of the Federal program. Once Congress passed legislation on that subject, the National Climate Program Office was established, and now that Office does have a degree of coordination which I think is working quite well. I think we will be able to judge that fully only in 1 or 2 years. But as of now, I think it is working.

In the area of pollution, the Federal Government did nothing toward coordination—in fact, we did not even have listed in one place all of the ocean pollution programs. We now have those listed, and there is a degree of coordination taking place in a form similar to the one we are recommending.

So there are examples of coordination which has worked—where legislation has provided a mechanism which significantly improved coordination.

Senator STEVENSON. Well, I do not see any reason for delay in the Congress. I know of no opposition to an effort here to make that commitment that you have referred to, but we still do not have the Secretary's report, and we still do not have the administration's advice on all of the questions, including that division of responsibility between the States and the Federal Government. And, to say the least, the suggestions with respect to funding are imprecise.

So I might have some more questions that I will submit in writing. I definitely want keep this moving. But I hope that you will give some further thought to those questions on funding, and the division of responsibility.

We understand that you want to postpone action on the responsibility for regulation. Still, I think there are some questions as between the State and the Federal responsibility that you recognize here. Our own timing, I guess, will be influenced to some extent by the cooperation we get from the administration, but this is not where the delay has been. And far from wanting to cause any delay, I sense, as we all did this morning, a good deal of impatience up here.

We could report a bill out of committee; it could be on the calendar within 3 days; and be enacted by the Senate without a vote, even without a recorded vote. But we still have some questions for which there are no answers from this administration.

I do thank you gentlemen, and also commend you for what I detect to be a new and much livelier interest in this subject than has been detectable in the past.

Mr. FRANK. Senator, may I respond to what you have just said?

Senator STEVENSON. Certainly.

Mr. FRANK. In terms of timing of passage, we would support early passage of the legislation. That is, we have no desire to see this delayed beyond this calendar year, if that is possible. We would assist you in any way possible to see that there is passage at an early time.

Second, you will have within a matter of days our report. Indeed, your staff can have sections of it before that. There are only modest changes that need to be made now in light of decisions that have just recently been made.

Third, I will let you know if our views on funding—that is, authorization funding—change, but I have indicated, at least in a tentative fashion that the figures in your bill are not necessarily so different from those we have in mind. I will let you know if our view on that is different from the one I have expressed here today.

Finally, you have specifically mentioned the difference between Federal and State regulatory responsibilities. At the same time we give you our report, we will give you something on that subject, and we will discuss it with your staff even before then.

Senator STEVENSON. Very good. Thank you, gentlemen.

Mr. FRANK. Thank you.

Let me thank you also—and if you will pass this on to Senator Bellmon—I want to reiterate that it is very important that Congress maintain the interest it has had in this subject, because I believe it is that interest which will see us move forward.

Senator STEVENSON. Well, we welcome your interest, too.

Mr. FRANK. Thank you.

[The statement follows:]

STATEMENT OF RICHARD A. FRANK, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Mr. Chairman and members of the committee, I am pleased to be here this morning to discuss National weather modification policies and research and development programs.

My testimony will cover four areas—the Department of Commerce's study of these subjects pursuant to the National Weather Modification Policy Act of 1976, the present status of National weather modification policies and programs, the activities of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) in this area, and the major outstanding issues with respect to the future direction of National weather modification policies and programs.

1. DEPARTMENT OF COMMERCE ACTIVITIES PURSUANT TO THE NATIONAL WEATHER MODIFICATION POLICY ACT OF 1976

The National Weather Modification Policy Act of 1976 directed the Secretary of Commerce to conduct a comprehensive study of the status of weather modification science and technology, and to submit to the President and the Congress a Report on the findings, conclusions, and recommendations of the study. In implementing that direction, the Department of Commerce has carried out an intensive review of the issues associated with this developing field.

In 1977, the Secretary of Commerce established a Weather Modification Advisory Board to provide independent advice on the wide range of matters required to be addressed pursuant to the Act. The 17 Advisory Board members had a wide range of backgrounds and distinguished records of service in public and private life. They were chaired by Mr. Harlan Cleveland, Director of the Program in International Affairs at the Aspen Institute for Humanistic Studies—an individual known to many members of this Committee, with a wide range of Governmental experience. The members include experts in weather modification, atmospheric science, oceanography, law, economics, international affairs, environmental studies, political science, state government, and public administration.

The Advisory Board conducted an intensive study of the issues. It retained the services of 20 consultants and 6 contractors. It met 12 times in 7 states and the District of Columbia over a one-year period, and heard testimony from over 100 individuals and groups, both from this country and abroad. Its members spent many hours reading documents, drafting statements, weighing the contributions from consultants, and discussing the issues in public sessions.

The Advisory Board's report to the Secretary was issued last year, and the members of this Committee have received copies. Mr. Cleveland and other members will be testifying during these hearings, and will summarize the report's contents. Let me say, however, that the Advisory Board issued a unique, competent, and thought-provoking report. It was remarkable not only because of its artistry, thoroughness, and balanced judgments on complex scientific and social issues, but also because it was a product of the Advisory Board members themselves rather than their staff. The members deserve the thanks of all those interested in these issues for their extensive and professional efforts.

As the next step in the preparation of the Secretary's Report, 3,000 copies of the Advisory Board's study were distributed widely in the United States and abroad for comment and study. Copies were sent to the Governors of all 50 states as well as interested members of the scientific, environmental, academic, governmental and business communities.

The Advisory Board's report and the comments we received on it were then combined with expertise in the Department of Commerce to develop a Report to the Congress and the President. This Report was subjected to an intensive review within the Executive Branch by all interested Departments and agencies. I am pleased to be able to inform the Committee that the Executive Branch clearance process has now been completed, and that the Report of the Secretary of Commerce will be formally transmitted to the Congress and the President within the next few weeks. In the course of my testimony today, I will reflect the findings, conclusions and recommendations of this Report.

2. PRESENT STATUS OF NATIONAL WEATHER MODIFICATION POLICIES AND PROGRAMS

Both the Advisory Board's study and the Secretary's Report contain a substantial amount of information on current National weather modification activities and policies. This morning, I would like to summarize briefly the most important characteristics of those policies and activities.

A. Weather modification is already taking place

First, deliberate intervention to influence the atmospheric processes and events that comprise the weather is already being carried out in a variety of ways. Cloud seeding technologies are employed commercially in this country in efforts to clear winter fog from airports, augment snowpacks in mountain regions, increase rain from summer showers, and reduce destruction from hail. In 1978, 50 operational programs were reported to the Department of Commerce pursuant to the National Weather Modification Reporting Act of 1971; these projects covered approximately 5 percent of the country's land area.

About a dozen relatively small contractors regularly furnish commercial cloud seeding services in the United States. The total weather modification business of these companies in 1977 is estimated by NOAA to have been about \$5 million. About half of this funding was appropriated by State governments, and the balance was invested by private individuals.

Private weather modification firms incorporated in the United States also conduct several millions of dollars of business operations abroad each year. Contracts have been signed with foreign governments and with foreign private associations such as farm cooperatives. Because no mandatory reporting requirement exists for such activities abroad, the full extent of these foreign commercial activities is not known accurately.

Finally, the weather is also being modified inadvertently, by cities, powerplants, and agricultural activities such as irrigation and deforestation. These unintentional effects on local and regional weather patterns can be quite dramatic. For example, the Metropolitan Meteorological Experiment, a major field investigation carried out at St. Louis in the early 1970's, showed that the St. Louis urban-industrial complex influences convective storm behavior in such a way as to increase cloudiness by 10 percent, total summer rainfall by 20 percent, and severe storm activity by 100 percent, in a localized area within 25 miles of the city center.

B. Weather modification is fully regulated in only a few States

These private weather modification activities are currently regulated at the State level rather than the Federal level. The only Federal legislation in the area is the Weather Modification Reporting Act of 1971, which requires all non-Federal attempts to modify the weather to be reported to the Department of Commerce. In 1973, Federal agencies agreed to report their weather modification activities as well, and since the NOAA has published periodic reports summarizing all weather modification activities in the United States. I have a copy of the latest summary report with me, which I will make available to the Committee.

The extent of State regulation of private weather modification varies considerably. Eighteen States have no weather modification laws. Thirty-three States have enacted statutes—but of these, only 13 require cloud seeders to obtain professional licenses, only 13 have created special weather modification regulatory boards, only 23 require either registration of projects or operational permits, and only 20 require operators to keep weather modification records or to report operational information to the agency regulating their activities.

One of the most comprehensive State statutes is the Illinois Weather Modification Act, which was adopted in 1973 and designed as a model code. It has been heavily relied on in formulating recently enacted statutes in a number of other Midwestern States. In 1977 the Council of State Governments refined the Illinois Act and published an updated model regulatory code, which represents the best formulation to date of a model regulatory code for domestic weather modification activities.

I should also note that an extensive and varied body of judicial and legislative pronouncements exists at the State level on associated issues such as water rights and liabilities for damages. No Federal law exists to allocate atmospheric water rights, and no Supreme Court decision deals with the issue. Individuals harmed by Federal weather modification activities may seek compensation under the Federal Tort Claims Act. However, such activities, particularly those of an experimental nature, may fall within the Act's exemption for "discretionary" functions. In addition, the Eighth Circuit Court of Appeals has held that the Tort Claims Act precludes class actions by persons affected by a Federal weather modification activity.

C. Current weather modification technologies are still at an early stage on development

Despite variation in the laws dealing with liability for the results of weather modification activities, in one respect the case law has been consistent—no plaintiff has been able to prove the causal relationship between seeding and effect necessary to obtain a judgment for damages. This result accurately reflects the current status of weather modification science and technology—modification of the weather is scientifically possible; much research has been done, often with promising results; but much more must be accomplished before the Federal Government can reliably intervene in complex atmospheric processes.

The Federal Government has sponsored weather modification research since cloud seeding became a reality in 1946. In general, however, the physics and mathematics of the atmosphere have turned out to be even more complex, and the scale of weather events even greater, than scientists had anticipated. The behavior of clouds and cloud systems has proved to be so variable that physical cause and effect are difficult to determine. The technologies for intervening in a predictable manner in these complex cloud processes are still at an early stage of development.

Let me briefly summarize the current state of knowledge:

Techniques for clearing supercooled fog from airport runways are now proven and in regular use.

The seeding of orographic clouds over mountainous regions to stimulate precipitation, particularly to enhance snowpack, has been one of the most actively pursued weather modification activities. Experiments have shown positive results in certain types of meteorological situations, and apparent precipitation increases as high as 20 percent have been observed.

Summer cumulus clouds are even more important than orographic clouds as producers of precipitation and generators of severe weather. The supply as much as three-fourths of the precipitation in middle-latitude agricultural areas and almost all of the precipitation in the tropics. Results of the many summer cumulus cloud precipitation enhancement projects have varied more widely than those observed during orographic experiments. Some experiments using the static seeding concept resulted in apparent decreases in precipitation; others indicated apparent precipitation increases as high as 33 percent. Most, however, were inconclusive. Those cumulus experiments using the dynamic seeding concept have demonstrated fairly

convincingly that the growth of a single cumulus cloud can be stimulated using this technique, but the question of whether predictable increases in areal precipitation will occur as a result of seeding and the subsequent growth and merger of clouds and cloud system is still open.

With respect to winter cumulus clouds, one project in Israel has established statistically convincing results—precipitation increases of about 15 percent—and is now operational. Results of seeding projects in winter convective bands in California have also been encouraging, although inconclusive.

Very little experimentation has been done on modification of severe storms. The single exception is the hurricane. Experiments to moderate hurricanes have been encouraging and in the direction predicted by preliminary numerical models. However, only three hurricanes have been seeded, and basic moderation concepts have only been tested on one hurricane. Much more research and experimentation are necessary before any firm conclusion can be drawn.

Much more work needs to be done to determine the efficacy of hail suppression and other weather modification techniques.

We must recognize, as the Advisory Board clearly did, that learning more about the atmosphere is only part of the task, even though it is the most important part. We need to know about the benefits and costs, about the specific short-term and long-term environmental and societal impacts, and about the potential for negligence and recklessness, associated with deliberate changes in the weather.

The past three decades of weather modification activity have provided a good basis for anticipating the general types of legal problem that will be created by expanding the number of weather modification research experiments and by effective operational weather modification projects. Although the precise manner of solving these problems remains to be resolved, with a few exceptions they are not novel problems. In contrast, the social and ecological implications of weather modification have not been examined nearly as extensively as the legal problems, and much more work remains to be done before these implications can be assessed as confidently.

In summary, good reasons exist to believe that weather can be modified by overt human intervention in atmospheric processes, but much more knowledge is needed to intervene in an acceptable manner in complex weather phenomena with scientifically predictable results. The Advisory Board put the matter succinctly and well: "The experimental evidence for cloud seeding has not yet reached the levels of objectivity, repeatability and predictability required to establish new knowledge and techniques. There are, nevertheless, several lines of evidence suggesting that carefully controlled seeding, using means appropriate to the aims, will result in weather modification effects of useful dimensions."

D. Modification of the weather in useful ways is scientifically possible

I want to stress that scientific uncertainties of the type I have referred to are typical of the first stages of development of new technologies. Despite such uncertainties, NOAA believes that modification of the weather in useful ways is scientifically possible. And good reasons exist to believe that a carefully constructed research and development program can supply many of the missing answers.

As I will indicate in more detail later in my testimony, the major scientific problem is to develop a substantially improved understanding of cloud systems and cloud dynamics. In recent years, striking advances have taken place in developing the research tools needed to investigate such atmospheric phenomena. Increased computer power and more effective numerical models offer much greater opportunity to address crucial questions concerning intra-cloud and cloud-environment interactions. Greatly improved remote sensing techniques provide tools for studying a variety of cloud phenomena. Aircraft and sophisticated instruments are available for airborne measurement of many essential cloud and environment variables. In addition, an adequate manpower base now exists within the U.S. scientific community to proceed with research and development programs.

An effective plan of action will be necessary to take full advantage of these new capabilities, a point I will return to shortly.

E. Reliable weather modification technologies would have substantial benefits

Our studies indicate that if reliable and effective operational weather modification technologies are developed, they will have substantial benefits that are likely to outweigh the costs by impressive amounts. Few studies of the economic benefits of weather modification have been conducted. As the Advisory Board concluded, however, "Although the evidence is not all in, the collective impact of the analyses now on record suggests that an operational weather modification capability will provide impressive economic benefits."

These studies suggest the following conclusions:

The ability to deliver more water in the right places and at the right times for farming, irrigation, hydroelectric power, and municipal and industrial water use would benefit agricultural and urban areas.

Substantial economies could be realized by the aviation sector if a reliable technology existed to dissipate warm fogs, thus avoiding cancellation of airport operations and losses to affected travelers.

The annual reduction in hurricane damage from storm surges and winds could be significant. In the United States, the annual economic losses caused by hurricanes (including accompanying floods) are about \$800 million. Three storms between 1964 and 1968 each resulted in losses of more than \$1.4 billion. Preliminary estimates place losses from this year's Hurricane Frederic well in excess of \$1 billion. We also lose nearly a hundred lives annually as a result of hurricanes. With the increasing population and industry at risk in the U.S. coastal areas, these losses are almost certain to escalate. And losses of this magnitude are not limited to the United States. In Bangladesh, a tropical cyclone killed about 200,000 persons in November 1970. The City of Darwin, Australia, was virtually wiped out by cyclone Tracy in December 1974.

Crops and property damage due to hail, which exceed \$1 billion in the United States alone, would be reduced substantially, particularly in the Great Plains region.

F. U.S. weather modification activities are of substantial international importance

United States weather modification activities are of substantial international importance. As the Advisory Board concluded, "The weather is inherently transnational." Any technologies developed to modify our weather will be applicable to other areas of the world and could play important roles in alleviating global shortages of food, water and energy and in reducing the loss of life from severe storms. At the same time, U.S. activities and technologies could be the source of future international tensions as well as benefits, unless appropriate methods of international cooperation are developed in parallel with these new technologies.

The United States has a long history of international cooperation in atmospheric activities, and in 1968 the Congress declared that U.S. policy is to cooperate with other nations in atmospheric research and development. I will discuss later in my testimony how NOAA, in concert with the Department of State, has for many years provided Federal Government leadership in connection with multinational weather modification matters.

G. Several Federal agencies conduct weather modification research

Authority and responsibility for weather modification are currently distributed among several agencies and Departments. To date, Government has preferred that weather modification research be undertaken by agencies as their respective missions dictate, and that such efforts be accompanied by interagency coordination as necessary.

The theory has been that because the understanding of weather modification is in its infancy, a diversity of approaches to the problem is the best way to achieve results. A number of past reviews within the Executive Branch have concluded that each agency charged with the responsibility for dealing with a National problem to which weather modification can be relevant should be given the latitude to seek the best approach or solution to the problem. Thus the types of scientific research conducted by Federal agencies have differed in approach, techniques, and types of equipment employed, depending on the particular weather phenomena being addressed.

As many as seven Federal agencies have been involved in weather modification activities at one time or another since 1959. Federal funding directed toward deliberate and inadvertent weather modification research has been relatively level from the 1972 fiscal year—when it totaled about \$18.6 million—to the 1980 fiscal year—when it amounted to \$16.3 million. In the area of deliberate weather modification only three agencies are pursuing active research programs in Fiscal Year 1980—NOAA, the Department of Interior's Bureau of Reclamation, and the National Science Foundation.

Based on the customary distinction between weather modification activities and other atmospheric research, the expenditures by these agencies fiscal year 1980 for weather modification research will be as follows: NOAA—\$4.3 million; Bureau of Reclamation—\$9.4 million; NSF—\$1.2 million. These projected expenditures for NOAA activities include only a pro-rate portion of the base-funded Research Flight Center, which provides aircraft for a wide variety of oceanic and atmospheric research projects.

3. NOAA WEATHER MODIFICATION ACTIVITIES

In the course of these hearings you will receive testimony from representatives of the other Federal agencies that are currently active in the weather modification field. I would like to indicate what part NOAA is playing in the Federal weather modification research effort I have just described.

NOAA has broad responsibility to provide atmospheric and oceanic services and to undertake related research and development. As the Advisory Board indicated, "NOAA regards itself and is regarded by Congress as the focal Agency for matters having to do with the atmosphere and the oceans." As such, NOAA is the repository of a substantial portion of the Federal government's activity and talent in areas related to weather modification.

A. NOAA research and development

NOAA and its predecessor agencies have conducted weather modification research since 1948. NOAA's Environmental Research Laboratories conduct a wide range of laboratory experiments and studies, field experiments, and computer modeling in atmospheric sciences that are directly relevant to the scientific questions remaining to be answered. These include the following activities:

NOAA's National Severe Storms Laboratory in Norman, Oklahoma, is dedicated to understanding the origin, structure and life history of tornadoes, thunderstorms, and other forms of severe convection. It maintains the most advanced Doppler radar for studying destructive storm systems. It is a leader in the theoretical and field analysis of mesoscale storm phenomena—the kind of weather situation so often associated with moderate or heavy precipitation.

NOAA's National Hurricane and Experimental Meteorology Laboratory in Miami, Florida, conducts theoretical and analytical work on the dynamic structure and energetics of hurricanes. It penetrates tropical hurricanes using NOAA's instrumented aircraft, measures the natural structure and variability of these storms, and seeks to develop numerical models for use in analysis as well as forecasting. This Laboratory also conducts Project Stormfury—the effort to understand the dynamics of tropical hurricanes, evaluate the potentialities of cloud seeding to ameliorate the effects of hurricanes, and conduct field experiments as appropriate. In addition, it is responsible for the Florida Area Cumulus Experiment, which I will discuss in a moment.

NOAA's Atmospheric Physics and Chemistry Laboratory in Boulder, Colorado, is devoting special attention to the numerical modeling of mesoscale meteorological phenomena, so important to precipitation. These models will aid in the understanding of the dynamics of mesoscale cloud systems. Although the effort is primarily devoted to improving our ability to forecast these phenomena, the program will have immediate applicability to certain problems of weather modification technique development. The Laboratory also carries out theoretical and experimental programs in cloud microphysics, aerosol physics and chemistry, and nucleation chemistry.

NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, is best known as the international leader in mathematical modeling of the atmosphere's general circulation. But it also pursues an active program of numerical simulation and theoretical study of the smaller scale motions related to convective processes and cloud dynamics so important to weather modification techniques.

NOAA's Research Facilities Center in Miami, Florida, provides instrumented aircraft in support of a variety of research programs. These aircraft, equipped with the latest sensing and recording systems, radar, and seeding devices, are essential to NOAA's hurricane research program and Project Stormfury and can make significant contributions to many other weather modification field experiments.

NOAA's Wave Propagation Laboratory in Boulder, Colorado, is a world leader in the development and experimental application of new methods for remote sensing of the atmosphere. Remote measuring concepts and techniques developed in this laboratory provide important opportunities to add to our basic understanding of mesoscale cloud and precipitation processes.

NOAA's Air Resources Laboratories, located at various sites around the country, provide valuable insights into the concentration and chemical character of atmospheric aerosols and small-scale air motions near the surface, both of which are important factors for evaluating the potential for and effects of intentional and inadvertent weather modification.

B. NOAA atmospheric services

NOAA is responsible for the Federal Government's civilian atmospheric services—the National Weather Service, the National Environmental Satellite Service,

and the Environmental Data and Information Service. It is thus the primary source within the Federal Government of the talents, observations, data, and information essential to weather modification field programs and evaluations.

As I indicated earlier, since 1972 NOAA has also collected and periodically reported on all weather modification activities in the United States pursuant to Public Law 92-205.

C. NOAA international activities

In addition NOAA, in concert with the Department of State, provides Federal Government leadership in connection with those multinational organizations, experiments, and negotiations involving weather modification.

NOAA's Associate Administrator, Dr. George Benton, is the United States representative to the World Meteorological Organization and a member of its Executive Committee. The WMO and its predecessor, the International Meteorological Organization, have been an active and central forum for the international discussion and coordination of atmospheric issues for more than a century. Dr. Benton and his staff keep the WMO informed regarding weather modification activities underway in the United States, and keep the U.S. research community informed about important developments elsewhere in the world. This is a major task—74 countries have used weather modification techniques at some time, and over 30 countries reported projects to the WMO in 1977.

NOAA has been the initiator or major proponent of most of the international weather and weather modification programs now being pursued by the United States, such as the Global Atmospheric Research Program and the Precipitation Enhancement Project. NOAA is the lead agency in the United States for the Global Weather Experiment, which began in late 1978 and includes contributions by many other countries. With the support of the academic research community, NOAA scientists mounted a program costing nearly \$200,000 as part of the WMO Precipitation Enhancement Project field program in Spain from March through May 1979, and has led efforts and made commitments to continue the program in 1980. Dr. Benton is the Chairman of the WMO Board overseeing this project.

Through the Department of State, NOAA has actively pursued formal negotiations with the Government of Mexico and informal discussions with representatives of the Government of Australia to conduct bilateral hurricane seeding programs.

NOAA recently organized two meetings among principals from the United States and Canada which led to a memorandum of understanding for Canadian participation in the Bureau of Reclamation's HIPLEX project in Montana beginning in July 1979.

NOAA has played a major role in the joint WMO-UNEP intergovernmental meetings on the legal aspects of weather modification.

D. Current NOAA activities

Finally, let me briefly summarize some of NOAA's recent domestic weather modification activities:

We have monitored and measured recent Atlantic hurricanes, and obtained extensive physical data to examine critically the concepts behind Project Stormfury.

We have initiated the second phase of FACE, the Florida Area Cumulus Experiment being conducted by our National Hurricane and Experimental Meteorological Laboratory. FACE-2 seeding experiments were conducted in Florida during the summer months of 1978 and 1979. FACE-2 will continue during the summer of 1980 in an effort to confirm the results of FACE-1, which indicated that dynamic seeding increased precipitation over a fixed target area in Southern Florida.

During Fiscal Year 1980 we will also be conducting the pre-experiment phase of PACE—the Precipitation Augmentation for Crops Experiment. PACE could eventually evolve into a comprehensive program to determine the potential for modifying convective precipitation in a major agricultural area in the Midwest.

As a result of the Advisory Board's report, interest by the States in cooperative evaluation projects with NOAA has increased. In 1980 we will initiate plans on a selective basis for collaboration with State operational seeding projects to help evaluate their effectiveness and to add to the research base in weather modification.

Let me note in passing that in the past the majority of NOAA's weather modification research has been conducted by its own staff. Some support activities have been contracted out, and a small percentage of its limited weather modification funds has supported focused research efforts in universities and industry. NOAA's orientation to in-house activity in the atmospheric sciences has been criticized by National Academy of Science Advisory Panels as well as by the Advisory Board. NOAA's Assistant Administrator for Research and Development, Dr. Ferris Webster, as well

as Dr. Benton and I have been among such critics, and we have taken a number of steps to remedy this situation.

The academic and research communities can provide thought and research of high quality—in some cases the best thought and research available—thus permitting NOAA and the rest of the Government to fulfill our mandates in the best possible fashion. Greater NOAA support of these communities would strengthen them and permit them to continue to provide outstanding services. And more reliance on their efforts would enable NOAA to use its limited personnel resources more effectively.

We intend to use the best available talent and facilities to conduct future weather modification research, and a significant fraction of NOAA's funding for these programs will go outside of NOAA's own laboratories. We also intend to forge a mechanism that will enable individuals knowledgeable about weather modification and its impacts to provide general guidance on NOAA initiatives and to review all new NOAA program development plans and proposals in the area—those from the external community as well as from NOAA laboratories.

4. NATIONAL WEATHER MODIFICATION POLICY AND PROGRAM ISSUES

As a result of the deliberations of the Advisory Board and the Department of Commerce's extensive consultations with other Federal agencies and with the academic, industrial, and State governmental communities, a number of central issues regarding current National weather modification policies and programs have emerged that deserve this Committee's study. I would like to briefly pose those issues this morning and summarize our views with respect to them.

A. The shape of future Federal research programs

First, as I indicated earlier, modification of the weather is scientifically possible. If it can be done reliably and with predictable results, society will benefit substantially, both economically and by savings of lives. These potential benefits justify the Federal Government in undertaking a sound research and development program built around a coherent long-term research plan to resolve the outstanding scientific issues.

As the Advisory Board concluded, "The prime requirement of a National weather modification policy is to know more about the atmosphere itself." Since most present weather modification efforts are based on the assumption that the timing or efficiency of natural cloud and precipitation processes can be manipulated, better understanding of these processes is critical to the orderly development of a practical weather modification technology. A substantially improved understanding of cloud systems and cloud dynamics is essential for development of the entire range of weather modification techniques.

Large field experiments which seek to demonstrate the efficacy of weather modification techniques by statistical analysis of observed precipitation should be the culmination, not the basis, of the Federal Government's research program. This is not to say that field programs are inappropriate. A research program built around theoretical, computer and laboratory studies is essential, but a substantially improved understanding of cloud systems and cloud dynamics cannot be achieved by these means alone. An urgent requirement exists for the careful design and execution of a field program oriented toward monitoring cloud systems and determining the impact of seeding on cloud dynamics. This will require extensive monitoring of the cloud system by remote sensing techniques, airborne measurements before and after seeding, and numerical simulation of the evolving precipitation situation designed to check the validity of theoretical concepts and physical ideas developed in the laboratory.

We believe that NOAA is well equipped to take the lead in performing the necessary fundamentally-oriented research and development. I mentioned earlier the wide variety of NOAA activities and expertise in this area. NOAA maintains a substantial remote sensing capability, using geostationary and orbiting meteorological satellites, ground-based remote sensing devices such as the superb radar facilities at the National Severe Storms Laboratory, well-equipped research aircraft, and experience in managing major field programs.

Indeed, NOAA has taken the lead in recent interagency field investigations very similar to those that will be needed in the future. For example, the recent Severe Environmental Storms and Meteorological Experiment—SESAME—was conducted by NOAA in Oklahoma this past summer. Cooperating agencies in SESAME included the Air Force, Army, Navy, Department of Energy, Federal Aviation Administration and NASA. Other participants included the National Center for Atmospheric Research, fifteen universities, and a number of state organizations. This is the kind

of cooperation that is needed if this country is to mount a research effort in weather modification which is soundly based on scientific needs, brings to bear the best available scientific capabilities, and provides the basis for new advances in weather modification techniques.

As I also indicated earlier, learning more about the atmosphere is only part of the research program needed to develop a beneficial weather modification capability. We must learn much more than we now know about the economic benefits and costs of weather modification, about the less tangible impacts on society of operational programs, and about the environmental impacts of deliberate changes in the weather.

B. The need for public involvement

In conducting research, we cannot afford to pass over lightly a basic philosophical question—whether and to what extent society, and in particular Government, should seek to control our environment, even if it is scientifically possible to do so. Many members of the public are deeply skeptical about the desirability of “tinkering” with large natural forces in a way that might produce unforeseen consequences, even if the scientific community is convinced that weather can be modified predictably and safely. The point was made succinctly in a letter I received on the Advisory Board’s study from the New Jersey Department of Environmental Protection, reporting the views of the Department’s Commissioner—“Don’t fool around with Mother Nature.”

Any National research program will require widespread public participation and scrutiny at all stages. Deliberate weather modification must be designed and carried out after full consultation with the people likely to be affected. As someone who has spent part of his career representing environmental organizations, I am particularly sensitive to these problems. But I think these concerns are widely shared, and I am committed to ensuring that the National effort is carried out in an open manner.

C. Further international progress

Because the United States has a long history of international cooperation in atmospheric scientific activities, we have a unique opportunity to achieve the benefits and minimize the tensions of weather modification science and technology as it develops. A number of actions in the international arena are now feasible and would be important steps toward eventual establishment of a comprehensive international regime for weather modification. These include:

- Adoption by the United States of a unilateral declaration of weather modification policy.

- Negotiation with Mexico and other neighboring countries of bilateral notification and consultation agreements.

- Development of an international accord on weather modification research activities.

- Promulgation through an appropriate international organization of principles of conduct for the guidance of national programs.

D. Organization of Federal weather modification programs

The Advisory Board concluded that the present Federal strategy of viewing particular weather modification efforts as one of several possible approaches to achieving various agency missions should be changed. It recommended that all civilian research and development programs be centralized in a single Federal agency, and that it be managed by an autonomous public board with direct authority over the operations of the National program.

The Administration believes that well-coordinated research and development programs carried out by a number of Federal agencies can best achieve advances in weather modification science and technology. To that end, the Administration has decided to establish a Weather Modification Subcommittee under the Committee on Atmosphere and Oceans of the Federal Coordinating Council on Science, Engineering and Technology. I am the Chairman of the Committee on Atmosphere and Oceans, and a NOAA official with chair the Subcommittee. It will be charged with developing within the next six months a five to ten-year weather modification research plan that emphasizes fundamental research on cloud microphysics and mesoscale meteorology, as well as the effect of seeding on the structure and dynamics of cloud systems. The program will include a careful analysis of required field experiments, especially with regard to effective monitoring and improved scientific and statistical design. The Subcommittee will also provide a coordinating mechanism for the conduct of this plan once approved, and will assist the Office of Management and Budget in analyzing annual agency program budget submissions for consistency with the plan.

The Administration recognizes the need for close public scrutiny and involvement in field weather modification programs, but does not believe that it is necessary or desirable for an independent board of private citizens to manage such Government programs. The Administration intends to establish a committee of individuals knowledgeable in the field of weather modification, whose members represent diverse viewpoints, to act as a special advisory board to the Subcommittee. The Administration has successfully established similar advisory committees on other national research and development programs in the past under existing authorities, and believes that such a committee can provide valuable scrutiny of the planning and conduct of the Federal program as it is carried forward.

E. Weather modification legislation

I believe that the Counsel of State Governments' model weather modification control act, supplemented in certain respects, should be adopted and implemented by all States in which weather modification activities are conducted, with such modifications as may be necessary to adapt the model code to local circumstances. Voluntary enactment of this model code by States should assure that weather modification projects are carried out professionally, with due regard for public safety and after adequate public discussion of the risks and benefits. It would also assure reporting of information that will be a useful source of data for scientists, project designers, and government agencies in evaluating the impacts of such projects.

The Advisory Board concluded that legislation at the Federal level was also desirable, both in order to license private weather modification operators and to establish the framework for a National weather modification policy and program. The Administration agrees that legislation is desirable but does not believe that such legislation should establish a comprehensive regulatory scheme.

As effective technologies are developed, the Federal Government will have the principal responsibility for regulation of the impacts of weather modification because of its interstate implications. However, the Administration strongly believes that comprehensive Federal regulation is not yet necessary in view of the relatively small levels and limited impacts of non-Federal weather modification activities.

Any licensing scheme involves setting standards to renew and revoke licenses as well as monitoring performance—activities little different from those under a comprehensive system of regulation of operations. The advantages of Federal licensing at this time are small—non-Federal activities can be regulated by any State that chooses to do so to protect its citizens; and because weather modification operations are currently conducted on a small scale, a State's failure to do so would impact only its own citizens. On balance, any small advantages of a Federal licensing system are outweighed by the associated costs.

Although the Administration believes that enactment of a Federal regulatory regime is premature, the Administration does support enactment of legislation which states clearly the National interest in weather resources management, identifies the goals of a National weather modification program, and sets forth the respective roles of the State and Federal Governments.

F. Funding for weather modification research and development

The Advisory Board concluded that major increases in the levels of Federal funding will be required to support a National weather modification research and development program. The Administration does not believe that funding increases of that magnitude are necessary. The Administration supports modest budget initiatives in the area, especially for basic research, but believes that specific plans to carry out the new, coordinated Federal research program must first be developed by the CAO Subcommittee. Any such increases should also include provisions for cost-sharing by the States when the research programs have major payoffs in particular areas or the findings will be of use primarily to small areas or types of operation.

The Administration recognizes that a continuing effort is necessary for research in this field, and its preparation of annual Federal budgets will include a review of funding requirements to assure that sustained program requirements are met.

In conclusion, Mr. Chairman, the Department of Commerce's extensive study regarding National weather modification policies and programs has indicated that modification of the weather in useful ways is scientifically possible, and that prudent steps need to be taken now to enhance activities designed to investigate those possibilities. The Federal Government must develop a coherent, long-term research program and organize seriously for a longer term effort. We look forward to working with the Congress to achieve those goals. We will submit specific legislative recommendations to the Committee shortly.

Thank you Mr. Chairman. I will be pleased to respond to any questions the Committee may have at this time.

Senator STEVENSON. I will ask the representatives of the other agencies to all come forward, if we have room. In the interest of saving some time, we will hear from all of them first and then return to all of them with questions.

They are: R. Keith Higginson, Commissioner of the Bureau of Reclamation; Dr. Edward P. Todd, Acting Assistant Director for Astronomical, Atmospheric, Earth, and Ocean Sciences of the National Science Foundation; and Dr. Anthony J. Calio, Associate Administrator for Space and Terrestrial Applications of NASA.

Mr. Higginson?

STATEMENTS OF R. KEITH HIGGINSON, COMMISSIONER, BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR; ACCOMPANIED BY BERNARD A. SILVERMAN, ACTING CHIEF, OFFICE OF ATMOSPHERIC RESOURCES MANAGEMENT, ENGINEERING AND RESEARCH CENTER, DENVER, COLO; DR. EDWARD P. TODD, ACTING ASSISTANT DIRECTOR FOR ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES, NATIONAL SCIENCE FOUNDATION; AND DR. ANTHONY J. CALIO, ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. HIGGINSON. Thank you, Mr. Chairman.

I have with me here today Dr. Bernard Silverman, who is the Acting Chief of our Office of Atmospheric Resources Management, who is available to answer questions if you should desire.

I appreciate this opportunity to present this committee our comments on the proposed legislation, as well as to provide you with some information about our Atmospheric Water Resources Management Program, which is also known as "Project Skywater."

A brief history of how the Bureau of Reclamation came to conduct weather modification research may be appropriate. In 1962, the late Senator Francis Case of South Dakota was interested in having some Federal agency take an engineering approach to rain-making development.

When he came to this Bureau, former Commissioner Floyd Dominy had both the vision and the courage to accept the challenge, and the Congress appropriated to the Bureau \$100,000 to "be used for research on increasing rainfall by cloud seeding."

From the very beginning, two principles guided the research: First, an applied research approach would be taken; and second, scientific expertise and interests would be sought out and employed wherever located.

From this small beginning 17 years ago, the program has continued and grown with direction and increased funding provided by the Congress. Some of these congressional directives are, as quoted from the various appropriation documents:

In 1965: "Emphasis is to be placed on actual water production and the exploration and research are to include application of existing weather modification methods."

In 1966: "Determine the best and most economic methods of augmenting water supplies for reclamation projects by weather modification."

In 1968: "Expand the budget program for atmospheric water resources research and initiate the planned nationwide program."

In 1969: "Initiate pilot weather modification projects."

In 1978: "Prepare plans for the Colorado River Augmentation Demonstration Program."

In 1979: "Initiate a high-altitude downwind seeding effects research effort."

And finally in 1979: "Conduct rain augmentation research in the Southwest in areas where drought patterns are developing."

The Bureau's program is now the largest weather modification research program in the Nation, if not in the world. To date we have spent \$78.6 million—all on developing techniques to increase water supplies by cloud seeding, and the equally important socioeconomic, environmental, and legal issues associated with it.

Emergency drought-relief seeding projects have also been conducted with the Bureau's assistance in nine states. Expenditures in fiscal year 1980 will top \$10 million in this program, making it the largest by far of its type in the Nation.

I am proud of the achievements of this research program, especially since it has been accomplished in a very scientifically complex and controversial field. It has been responsive to the repeated confidence and increasing resources given it by the Congress.

Many of the current operational application cloud seeding programs sponsored by States and local interests can be directly attributed to the scientific results of Project Skywater. Cooperative research through the Bureau has fostered local expertise that has made their responsible initiation and management possible.

In addition to the scientific advances and technology transfer resulting from the Bureau's research, I am also proud to point out that many of the scientists now in this field—even in other Federal agencies—got their education and experience by participation in this program.

Most of the program funds—over 78 percent—are spent outside the Bureau. It is divided approximately as follows: 40 percent of the funds to universities; 21 percent in private firms; 11 percent through State agencies; and 6 percent through other Federal agencies.

This contracting out approach has established many important precedents for Federal-State-local cooperation, cost sharing, and joint operations in weather modification.

The Bureau also cooperates in international development and application of weather modification technology. This has generally been through interagency agreements involving the Department of State and, where appropriate, consultation with other Federal agencies.

The Bureau presently has an agreement with the Canadian Atmospheric Environmental Service and the National Research Council of Canada for them to be an active partner with the Bureau in providing research aircraft and scientific personnel to participate in the Bureau's HIPLEX program at Miles City, Mont.

We also have an agreement with the Spanish Director General of Hydraulic Works to direct the technical initiation of a cloud seeding project in the Canary Islands. The Bureau to date has provided scientific assistance on weather modification to 10 foreign nations. Bureau contractors are encouraged to share their expertise internationally, and foreign consultants also are involved in the Bureau programs.

Now there is a need for a better directed, stable, and focused weather modification research program. Consequently, there is a need for a statement of national policy in this regard.

Moreover, coupled with a need for policy direction is a requirement for a commitment to continue scientifically sound experimentation. Research in the atmosphere must be conducted over a period of years to get meaningful results.

A commitment to stability of funding for continued research with some modest increases, especially in basic research, is the primary concern of almost everyone involved in weather modification.

We do not believe that centralization of all research into one agency such as the Department of Commerce, NOAA, as in S. 1644, or in NASA as in S. 829, is desirable. We support the strengthening of the CAO coordinating mechanism.

We believe it is premature to provide for Federal licensing of operators, or to revise existing tort claims provisions concerning the exercise of discretionary functions by subjecting weather modification activities to liability under the Federal Tort Claims Act.

S. 829 also proposes the development within a specified period of time of a set of sound weather resources management practices. The concept of a long-range need is recognized, but more needs to be known or else such a set of standards will likely become so general as to be worthless or unduly restrictive and costly.

Too much personal judgment would be required at this state of weather modification development to allow effective compliance monitoring.

Mr. Chairman, that concludes my statement. We would be pleased to try to answer any of your questions.

Senator STEVENSON. Thank you, Commissioner.

Dr. Todd?

Dr. TODD. Thank you, Mr. Chairman.

I have a prepared statement, which I will submit for the record, and in the interest of time I will make just a few general remarks to illustrate the National Science Foundation's rather long-term involvement in the problems related to weather modification.

Senator STEVENSON. Please do. Thank you. It will be entered in the record.

Dr. TODD. The Foundation of course generally endorses the administration position so ably presented by Dr. Frank. I would like to mention that the Foundation has been involved with issues of weather modification since the passage of Public Law 85-510 in 1958 which directed the Foundation to support basic and applied research in this area.

It is interesting to note that for the following 10 years until the repeal of that act in 1968, weather modification was the sole area in which the Foundation had authority to support applied research.

In 1968, the Foundation's authority to support applied research was broadened somewhat and some of the responsibilities we had under the earlier legislation were at that time transferred to NOAA.

Rather than repeat elements of my testimony, I would like to comment very briefly on four experiments which the Foundation has supported during its 20-year involvement in weather modification research.

One of the very first experiments attempted to demonstrate the potential cloud seeding may have to increase precipitation in the Midwest—principally in south central Missouri. That was "Project Whitetop" led by scientists, principally Dr. Roscoe Braham of the University of Chicago. This was a very interesting and pioneering experiment in the early 1960's. As is typical of almost all weather modification experiments, the results provide tremendous opportunity for argument on the part of statisticians for years afterward.

The general practice of arguing about the significance and the results of these experiments was certainly continued in the Whitetop case. In general, I fear that some people feel that our model of "Mother Nature" was oversimplified, and that the results of the experiment, if anything, probably resulted in a decrease in precipitation.

Another experiment, which I regard as one of the classics of weather modification, was led by a Colorado State University scientist, Dr. L. Grant, in the Colorado Mountains. It was intended, through cloud seeding, to enhance the winter snowpack with obvious benefits in the following season from the increased runoff. This experiment is one of the best and, to my mind, demonstrated that with a proper understanding of the physics, chemistry, and dynamics of atmospheric systems, one can probably increase winter mountain snowpack.

Somewhat to my dismay, however, I understand that more recently the statistical validity of some of the conclusions of this experiment are also being brought into question.

The third experiment of considerable interest to me centered around the St. Louis metropolitan area, and was known as "MET-ROMEX." It was an attempt to demonstrate whether or not the existence of a major metropolitan center affected the average weather and the frequency of strong weather events such as thunderstorms downwind.

The METROMEX experiment, in which the Foundation had cooperation from NOAA, the Bureau of Reclamation, and other agencies, demonstrated rather convincingly that metropolitan areas do indeed change the weather downwind to some extent.

The last experiment I'll mention, a very interesting one, was the national hail research experiment, operated for the NSF by the National Center for Atmospheric Research, in Boulder, Colo. This experiment was intended to develop an understanding of some of the severe storm mechanisms that lead to hail, and, hopefully, to demonstrate an ability to reduce hail in such storm systems.

It was intended to operate for a number of years, but the first 2 or 3 years of operation convincingly demonstrated that our understanding of the complexities of the storm systems which produce hail was woefully inadequate; that our model was grossly oversim-

plified; and that rather than being ready to suppress hail, we really needed to know a great deal more about the mechanics of such storms before we could design such a system.

These experiments, with the attendant complexities of interpreting the results in effect have convinced the National Science Foundation that we need to go back to the research drawing board. As a result, we have established a stronger program of experimental meteorology and weather modification in our Division of Atmospheric Sciences. Dr. Richard Dircks, Program Director for that program, is with me this morning.

In addition to that program, we support major programs in atmospheric chemistry and meteorology, climate dynamics, and upper atmosphere physics.

The National Science Foundation feels that there is a great deal of useful work to be done. We think that the report of the Weather Modification Advisory Board is a considerable help because, although a number of us were discouraged at the progress of weather modification, we think that their rather hardnosed analysis does indeed generate room for a little bit of enthusiasm and encouragement.

One point they do make, one which I think is exceedingly important, is that the great lure of weather modification has resulted continually from an oversimplification of our concept of how Mother Nature works.

In many experiments we've been boobytrapped by Mother Nature pointing out that she's a much more complex lady than we had imagined. The Weather Modification Advisory Board has taken a hardnosed look at this problem, and one of the significant points that they have made is: To properly understand the natural systems and to develop techniques for beneficially influencing them takes, on the part of both individuals and supporting government, a strong and steady long-range commitment.

Thank you, Mr. Chairman.

Senator STEVENSON. Thank you, sir.

[The statement follows:]

STATEMENT OF DR. EDWARD P. TODD, ACTING ASSISTANT DIRECTOR FOR ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES, NATIONAL SCIENCE FOUNDATION

Mr. Chairman, members of the subcommittee; it is a pleasure for me to be able to describe for you the National Science Foundation's progress in and experience with weather modification research.

I. HISTORY OF NSF INVOLVEMENT IN WEATHER MODIFICATION RESEARCH

In July 1958, the National Science Foundation was directed by Public Law 85-510 to initiate and support a program of study, research and evaluation in the field of weather modification. Since then the Foundation has supported a granted program with universities and other research groups that encompasses a full range of theoretical, laboratory and field experimental studies.

During this 20 year period several key field experiments were supported by the Foundation. Cloud seeding to increase snowfall from winter orographic clouds was conceptually one of the simplest and most promising areas of weather modification. Randomized experiments were conducted in the Rocky Mountains near Climax, Colorado in 1960-65 and repeated during 1965-70 by Colorado State University scientists. This work demonstrated a significant increase in snowfall of about 15 percent from clouds whose temperatures were not too cold. These results formed the basis for attempts by others to rapidly develop a technology of snow pack enhance-

ment through weather modification. Recently, however the statistical basis of the Colorado experiments has been seriously questioned.

During the 1960's the Foundation also supported Project Whitetop a randomized test of seeding summertime convective clouds over the Great Plains. This experiment was conducted by scientists of the University of Chicago. It was the first large seeding effort to be carried out in parallel with extensive physical studies of clouds. Statistical results suggested a net decrease in rainfall. Physical studies in Project Whitetop contributed to the understanding of natural convective cloud and precipitation processes.

Beginning in 1959 the Interdepartmental Committee for Atmospheric Sciences (ICAS) served as a forum and coordinator for Federal atmospheric research program activities. In 1965 this committee recommended that the National Science Foundation, in consultation with other interested Government agencies, develop a national plan for hail suppression research. The early enthusiasm for this experiment stemmed largely from the reported successes of hail suppression in the Soviet Union. Based on an exhaustive two year study by a National Hail Research Steering Committee a plan was presented to ICAS in 1968. As a result a National Hail Research Experiment (NHRE) was initiated in 1970 under the direction of the National Center for Atmospheric Research (NCAR). In addition to a 5 year randomized seeding program this experiment encompassed a wide range of physical experiments that included pioneering research with new observational techniques. These physical observations soon demonstrated that the physical hypothesis of the experiment was not valid. This finding, together with discouraging preliminary statistical evidence, resulted in a termination of the randomized seeding experiment after only 3 years although field observations continued through 1976. Although the experiment was not successful in demonstrating a suppression of hail, significant scientific advances were made in the understanding of hailstorm processes from the physical experiments. The physical experiments have provided a model for subsequent research on a variety of weather systems.

A major field project on unintentional weather modification by urban areas was conducted in the St. Louis, Missouri area from 1970 to 1975. This project, named METROMEX, was jointly funded by the National Science Foundation, the Energy Research and Development Administration, the Environmental Protection Agency and the State of Illinois. This project was directed by scientists from midwest universities and included participation by scientists from government laboratories and private industry. Results indicated increases of up to 20 percent in summer precipitation downwind of the city and larger increases in severe weather events such as thunderstorms and hail. These results demonstrated a capability for modification of summer precipitation over the central U.S. during summer but did not distinguish the affect as being due to any specific cause such as aerosol particulates, changes in surface radiation or evapotranspiration.

In July 1968 the signing of Public Law 90-407 repealed Public Law 85-510 of 1958, changing some of the authority and responsibilities of the NSF in weather modification research. The Foundation, however, continued to have authority to support basic research in the sciences related to weather modification. The NSF also was assigned new authority for support of applied research.

Based on the apparent success of the Colorado winter orographic experiments and the optimism in hail suppression at that time, the NSF weather modification research program was transferred to the Research Applied to National Needs (RANN) Directorate in 1972. Weather modification was viewed by many as a technology ripe for application. Subsequently, the mounting evidence from the National Hail Research Experiment and other experiments suggested that applications of weather modification technology were premature and that much basic research needed to be done. Thus, in the NSF/RANN reorganization of 1978, weather modification activities at the NSF were reassigned to the basic research directorate dealing with atmospheric sciences. The research has now again established its basic research orientation and we feel that this is appropriate.

II. CURRENT ACTIVITIES

The current NSF basic research in support of weather modification is based broadly in both deliberate and inadvertent modification projects. We seek to support promising research opportunities, particularly interests outside of mission agency programs or interests that help build the scientific base for mission agency programs. The NSF historically has provided this research base and seeks to continue in this role. The Weather Modification Advisory Board (WMAB) Report, developed under the National Weather Modification Policy Act of 1976, has clearly emphasized

the continuing need for basic research in support of weather modification. The NSF recognizes its continuing national responsibilities in this area.

The following partial list exemplifies the scope of our current activities and shows how they relate to the ideas in the WMAB Report.

- (1) Inadvertent modification studies.
- (2) Development of analysis techniques and conduct of physical studies within current mission agency programs.
- (3) Developing and testing new statistical evaluation methods.
- (4) Improving the design and evaluation techniques for operations projects.
- (5) Physical and statistical studies of long-range effects of cloud seeding.
- (6) Basic studies of cloud and precipitation processes.
- (7) Exploratory studies of stratus cloud clearing for solar energy and of the effects of contrail cirrus clouds.
- (8) Joint support (with NOAA) of the U.S. research contribution to the World Meteorological Organization weather modification experiment in Spain.

Research segments of the National Hail Research Experiment staff at NCAR have now been formed into a Convective Storms Division. This group will continue to pursue the physical experimental studies initiated during the hail suppression experiment. There are presently plans for a joint University-NCAR-Bureau of Reclamation field study of physical processes in convective clouds in Montana during the summer of 1981.

III. STATUS OF WEATHER MODIFICATION

The most convincing evidence for weather modification remains in areas where physical observations alone are able to provide the verification of effects. These areas include dissipation of fog, clearing areas in stratus clouds and triggering explosive vertical growth of individual cumulus clouds. Man's unintentional modification of local weather by urbanization, industrialization and changing land use has been documented by statistical evidence in a few places. It is not clear, however, that the inadvertent effects are produced by processes that can be readily utilized in deliberate modification experiments.

Statistically based cloud seeding experiments, designed to increase precipitation locally, have generally been inconclusive or weakly supported on statistical grounds. This is primarily because of the large natural variability of precipitation and the complexity of the natural precipitation process. A very large number of events must be sampled to test for a cloud seeding effect. Simple designs of experiments are generally inadequate. It now appears that weather modification to alter precipitation may be effective in only a small number of events; these situations however, may produce substantial changes. What is needed is a systematic research approach examining the steps in the physical processes that produce precipitation; from this a clearer definition of treatable events should emerge. This is clearly a long term basic research problem.

IV. SUMMARY COMMENTS

Since 1959 the NSF has played a major role in intentional weather modification research and a pioneering role in inadvertent weather modification research. This is particularly important since the university research community provides significant scientific expertise in the field of weather modification. Furthermore, university research projects are the principal source of new scientists who are needed to build and strengthen cloud physics and basic weather modification research.

The WMAB Report emphasizes the need for basic research in weather modification and specifically endorses a strengthened NSF research program in weather modification. The NSF seeks to retain its research activities in support of weather modification. We believe that our role as an important source of support for basic research needed to undergird the activities in this field should continue.

Weather modification research will require stable long-term funding. Field programs and modern facilities require funding stability. Demonstration projects require adequate preparation time and long-term funding continuity to carry them out. The nature of the problem, that is dealing statistically with events that have large natural variability, demands years of careful observation and measurements.

Even though informal coordination at present is reasonably good, formal inter-agency coordination of Federal programs in weather modification could be strengthened. Prior to 1978 the ICAS acted as a coordinating body; weather modification topics frequented the Committee meeting agenda. Overall responsibilities for inter-agency coordination are vested in the Committee on Atmosphere and Oceans (CAO) of the Federal Coordinating Council for Science, Engineering and Technology. The

NSF believes that within CAO a separate subcommittee or panel should be set up just for weather modification.

In summary, we recognize the importance of a national policy on weather modification and support the concept of a more coordinated national program in weather modification, built on a commitment for stable funding of related research. We believe strongly that such a national program must emphasize basic research on atmospheric processes relevant to weather modification. This program also should include research on unintentional weather modification. Because of its long standing interests, the NSF is prepared to build on its program in these areas.

That concludes my statement, Mr. Chairman. I will be pleased to respond to any questions the Subcommittee may have.

Senator STEVENSON. Dr. Calio.

Dr. CALIO. Good morning, Mr. Chairman. It is indeed a pleasure to be here.

I would like to submit my formal prepared statement for the record, if I may.

Senator STEVENSON. It will be entered in the record.

Dr. CALIO. I will highlight a few sections of my prepared testimony. It is a privilege to present NASA's comments on bills S. 829 and S. 1644, and to describe some of our ongoing activities in meteorological research.

Although NASA's charter as set forth in the Space Act of 1958 does not specifically include weather modification, we have been involved in meteorological research for over two decades. This research is centered primarily around remote sensing of the environment from space. Our research and technology activities are aimed at providing a better understanding of atmospheric processes and improving weather forecasts on all scales. In a broad sense, results of NASA's research indirectly contribute to weather modification research by providing an improved understanding of fundamental processes in the atmosphere.

Much of NASA's current research is particularly applicable to weather modification studies. High quality, high spatial, and temporal resolution observations of the atmosphere, which can validate research models of cloud physics and dynamic processes, are important initial prerequisites for disciplined weather modification research. Implementation of remote sensing techniques from space can contribute some of this information.

NASA is developing advanced remote sensing techniques to measure atmospheric wind, temperature, pressure, and moisture profiles with unprecedented spatial resolution using both passive and active infrared and microwave techniques. The development of a new instrument called the VAS (Visible-Infrared Spin Scan Radiometer Atmospheric Sounder) to be placed on the NOAA Geosynchronous Operational Environmental Satellite (GEOS-D), which will be launched in 1980 and operated by the National Oceanic and Atmospheric Administration, will provide meteorologists with frequent temperature soundings to observe how certain weather phenomena develop. However, remote sensing from space can measure only certain of the required parameters; others must be measured by in-situ instruments or through ground-based techniques.

NASA is also developing an Atmospheric Cloud Physics Laboratory which will utilize the low-gravity environment of Earth orbit during Spacelab flights onboard the Space Shuttle in the early 1980's, to conduct very precise experiments on droplet and ice crystal growth and interaction, free from convective air motions

and particle sedimentation. This laboratory is expected to produce new information not the basic processes occurring in clouds, which is fundamental to the understanding of how to solve many meteorological problems. Knowledge to be gained from the Atmospheric Cloud Physics Laboratory includes processes driving cloud convection, dynamics, and electrification.

NASA also supports extensive meteorological modeling research. Emphasis of course is given to those models which utilize space-derived observations to initialize and update the models. Space observations of the atmosphere are also utilized to verify the model forecasts. The development and testing of mesoscale, subsynoptic scale, and large scale models are ongoing activities aimed at understanding and predicting those various scales of weather phenomena. NASA also supports modeling activities on the microphysical scale in connection with the Atmospheric Cloud Physics Laboratory, but does not conduct dynamic cloud scale modeling at the present time.

In addition, NASA is heavily involved in the areas of data processing and analysis, especially applied to the solution of meteorological problems. Space observations impose severe demands upon data processing requirements because remote sensing permits collection of vast amounts of observational data on an economical scale. NASA has supported many new developments in data processing and analysis, including man-computer interactive systems to display, manipulate, and analyze data rapidly. Significant progress has also been made in rapid image processing and display techniques.

Thus it is clear that although NASA is not engaged directly in weather modification research and development and does not possess the mandate to do so, many of the NASA developed meteorological capabilities may assist in weather modification research and development efforts.

My prepared statement discusses several of those capabilities.

NASA views present claims of weather modification as optimistic, and to assume that we may be able to manage this weather with a great deal of control in the near future is also little optimistic. A well-defined effort is required which combines strengthened basic research and a long-term commitment to funding and study.

Since weather phenomena are not confined to State and local boundaries, some form of Federal regulation may have to be considered when the technologies have been developed. We strongly do not believe that NASA should have such a regulatory function. Mr. Chairman, NASA is a research and development organization which supports operational users. NASA's charter and mission mandate neither a regulatory role nor activities directly be required to manage a national weather modification program.

Long-term planning, selected experimental programs, as well as ongoing research and development are essential for carrying out a sound weather modification program. Attention to legal, social, economic, international, and environmental concerns is also needed.

NASA will continue to participate in weather modification research from a space science research and applications perspective. However, we feel it would be inappropriate in light of NASA's

mission to assign it a lead agency responsibility or regulatory role in this effort. On these issues, we defer to the Department of Commerce's National Oceanic and Atmospheric Administration's views.

As Mr. Frank pointed out in his testimony, the Committee on Atmosphere and Oceans, of which I am the NASA member, coordinates Federal activities such as weather modification very closely. Also, Dr. Frosch, the Administrator of NASA, is the NASA member for the Federal Coordinating Council on Science, Engineering, and Technology, which assures active participation in weather research with our sister organization, NOAA.

That concludes my statement, Mr. Chairman. I will be very happy to answer any questions you may have.

[The statement follows:]

STATEMENT OF DR. ANTHONY J. CALIO, ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the subcommittee, I am pleased to appear today to present NASA's comments on bills S. 829 and S. 1644. I would like first to describe for you NSAS's ongoing activities in meteorological research, and then discuss the manner in which those activities might contribute weather modification research and development.

While NASA's charter, as set forth in the Space Act of 1958, does not specifically include weather modification, we have been involved in meteorological research for over two decades, centered on the use of remote sensing from space. These research and technology activities are aimed at providing a better understanding of atmospheric processes and improving weather forecasts on all scales. In a broad sense, the results of NASA's research indirectly contribute to weather modification research by providing an improved understanding of fundamental processes in the atmosphere.

Much of NASA's current research is particularly applicable to weather modification studies. High quality, high spatial and temporal resolution observations of the atmosphere, which can validate research models of cloud physics and dynamic process, are absolutely important as initial prerequisites for disciplined weather modification research. Implementation of remote sensing techniques from space can contribute some of this information.

NASA is developing advanced remote sensing techniques to measure atmospheric wind, temperature, pressure, and moisture profiles with unprecedented spatial resolution using both passive and active infrared and microwave techniques. The deployment of the VAS (Visible-Infrared Spin Scan Radiometer Atmospheric Sounder) instrument on the GOES-D satellite, to be launched in 1980 and operated by the National Oceanic and Atmospheric Administration (NOAA), will provide meteorologists with frequent temperature soundings to observe how certain weather phenomena develop. However, remote sensing from space can measure only certain of the required parameters; others must be measured by in-situ instruments or through ground-based techniques.

NASA is also developing the Atmospheric Cloud Physics Laboratory (ACPL), which will utilize the low-gravity environment of earth orbit, during Spacelab flights on-board the Space Shuttle in the early 1980's, to conduct very precise experiments on droplet and ice crystal growth and interaction, free from convective air motions and particle sedimentation. ACPL is expected to produce new information on the basic processes occurring in clouds, which is fundamental to understanding many meteorological problems. Knowledge to be gained from ACPL includes processes driving cloud convection, dynamics and electrification.

NASA also supports extensive meteorological modeling research. Emphasis, of course, is given to those models which utilize space-derived observations to initialize and update the models. Space observations of the atmosphere are also utilized to verify the model forecasts. The development and testing of mesoscale, subsynoptic scale, and large scale models are ongoing activities aimed at understanding and predicting these various scales of weather phenomena. NASA also supports modeling activities on the microphysical scale in connection with the ACPL, but does not conduct dynamic cloud scale modeling at the present time.

In addition, NASA is heavily involved in the areas of data processing and analysis, especially for meteorological problems. Space observations impose severe demands upon data processing requirements because remote sensing permits collection of vast amounts of observation data on a very economical scale. NASA has supported many new developments in data processing and analysis, including man-computer interactive systems to display, manipulate, and analyze data rapidly. Significant progress has also been made in rapid image processing and display techniques.

Thus, it is clear that although NASA is not engaged directly in weather modification research and development, and does not possess the mandate to do so, many of NASA-developed meteorological capabilities might assist in weather modification research and development efforts. Among these capabilities are the following:

Visible and infrared cloud imagery from the NOAA-operated GOES satellite is useful for weather modification activities to determine the extent of fog and clouds and cloud top temperature. Such imagery depicts, in real time, those clouds which are amenable to seeding. In combination with other conventional data, the satellite data are useful in determining whether physical conditions of the clouds meet the preset requirements of the modification experiment. The satellite data are also useful in assessing, after the fact, whether the seeding has had any measurable effect (though cloud growth and decay, expanding anvils, etc.) and what the downstream effects might be.

NASA uses high altitude aircraft specially equipped with remote sensors to measure cloud top temperature, cloud particle phase, cloud top pressure height, cloud optical thickness, rainfall rate, and moisture content. These sensors are capable of delineating supercooled cloud tops susceptible to ice nucleation seeding from ice crystal clouds which are not amenable to seeding. Such instrumentation could be used to measure cloud growth which, along with cloud height, is critical in the physical/statistical cloud classification used to control and analyze weather modification experiments.

Visible sensors on the GOES and Landsat satellites permit observation of the aerosol loading in the troposphere. From these data, the genesis, growth, movement and decay of dust clouds can be monitored. Dust can serve as condensation nuclei and thereby modify the weather. It can also alter the long-term balance of radiation which affects the climate.

Visible imagery from NOAA-operated GOES has also been used to monitor the movement of "hazy blobs" which are associated with air pollution episodes. The high concentrations of sulfates in these stagnant air masses can serve as condensation nuclei where sufficient moisture is present and are a significant factor in the production of acid rain.

NASA has developed new microwave techniques to measure water vapor, cloud liquid water, and precipitation in the atmosphere. When trained on tropical storms, these sensors can provide very useful information regarding the location and timing of weather modification attempts.

There is some evidence that anomalous changes in the sea-surface temperature of certain regions in the North Pacific Ocean are related to the unusually cold winters experienced by the eastern U.S. for the past two years. NASA has developed improved infrared and microwave techniques to observe these anomalies with greater precision than even before possible from space.

The cloud microphysics laboratory at NASA's Marshall Space Flight Center is conducting studies to understand why in developing cumulus clouds there are more ice needles formed than there are ice nuclei present. These studies are expected to explain how nature produces a multiplication effect on the ice needles. Other studies, conducted in aircraft-borne chambers in zero-gravity trajectories, involve the growth rates of crystals, and the variations in crystalline patterns to support the development of the Atmospheric Cloud Physics Laboratory. Still other experiments use electrostatic forces to suspend cloud droplets in cloud chambers where the effects of electric charge on their growth rates can be examined.

NASA is studying the utility of a new high speed vector processor (computer) which would have 10 times the capacity of machines currently used for weather modeling research. This increased capability would permit us to improve our models on the mesoscale and global scale and to initiate cloud scale modeling. Cloud scale models require enormous computing power to handle the complex processes which occur in clouds. The models would simulate cloud particle growth and decay, phase change, electrostatic charge effect, drag, buoyancy, etc. and their interactions in the flow dynamics of the cloud and its environment.

NASA is using the perspective from space to observe land use patterns. These affect the albedo, and such hydrological parameters as runoff and ground water

storage. Changes in albedo can cause regional effects weather modification. Similarly, the local effects of cities (heat island and aerosol), the effects of volcanoes, forest fires, and cut and burn farming can also be observed from space. All of these phenomena are forms of inadvertent weather modification.

To understand the long range effects of clouds on climate, we are studying the parameterization of clouds in the climate models. In this case, a very important chain of events that progresses from small (microscopic) particles to cloud droplets, to clouds, to albedo changes, to radiation balance change and to climate change can be of paramount importance.

One of the most important sources of cloud nuclei is the sea salt. Salt is introduced into the atmosphere from the action of the wind on the sea surface. The scatterometer, a broad-beam active radar, flown aboard NASA's Seasat, proved capable of measuring surface wind speeds up to fifteen meters per second. An operational instrument of this type will be a valuable aid in determining the effects of sea salt.

It may be too optimistic to assume that weather may soon be managed. A well-defined effort requires strengthened basic research, as well as a long-term commitment to funding and study. Since weather phenomena are not confined to state or local boundaries, some form of Federal regulation may have to be considered when the technologies have been developed. We strongly do not believe that NASA should have such a regulatory function. Moreover, the international implications of weather modification also would have to be considered.

Mr. Chairman, NASA is a research and development organization which supports operational users. NASA's charter and mission mandate neither a regulatory role nor activities directly required to manage a national weather modification program. Long-term planning, selected experimental programs, as well as ongoing research and development are essential for carrying out a sound weather modification program. Attention to legal, social, economic, international and environmental concerns is also needed. NASA will continue to participate in weather modification research from a space science research and applications perspective. However, it would be inappropriate, in light of NASA's mission, to assign it a lead agency or regulatory role in this effort. On these issues, we defer to the Department of Commerce's National Oceanic and Atmospheric Administration views.

That concludes my statement, Mr. Chairman. We will try to answer any questions that you might have.

Senator STEVENSON. Thank you, Dr. Calio.

You heard Mr. Frank say that an operational role was not contemplated, nor Federal regulation. That being so, why would NASA not be appropriate? All the administration seems to contemplate is an R. & D. program. And as Senator Bellmon pointed out—and I'm sure you don't deny this—NASA has a reputation for successful management of large scientific enterprises.

Dr. CALIO. Of a research and development nature.

Senator STEVENSON. Of a research and development nature.

Dr. CALIO. We feel that we do not have the necessary skills and expertise in the weather modification operational area; that we can best contribute to the solution of this national and global problem by providing supporting research from the space perspective.

Senator STEVENSON. But operations are not contemplated.

Dr. CALIO. Pardon me, sir?

Senator STEVENSON. It is not an operational program. It is not operations; it's R. & D., a research and development program.

Dr. CALIO. We would be prepared to assist our sister agencies in carrying out that research and development program, but we feel it would be more appropriate to have the Department of Commerce as the lead agency in the conduct of weather modification research and development which may in time lead to operations.

Senator STEVENSON. Dr. Todd, do you think the Advisory Board was overly optimistic about the potential for weather modification?

Dr. TODD. I am generally pleased with the Advisory Board's report, although they're more optimistic than I am. I have been impressed during the years of my involvement with the atmospheric sciences by the strong lure of weather modification. The potential benefits of even a modest ability to manipulate the weather are indeed impressive. The cost of a generator to waft silver iodide particles into the atmosphere is indeed low. The combination of these two factors is such an irresistible lure that many times we find it difficult to amass the patience and the costs, the funds to properly measure and understand the weather systems we are trying to influence in sufficient detail so that we are absolutely certain what we are doing.

I believe it can be done, but I do acknowledge that the job is of such immensity that it is difficult for governments to have sufficient patience.

Senator STEVENSON. And what about funds? Do you have an opinion on an appropriate level of funding?

Dr. TODD. I generally support Mr. Frank's response to that question. The question of assessing to what extent you are investing money in weather modification research versus atmospheric research in general is very difficult to understand.

I personally believe that a great deal of the research that the several Federal agencies are doing in the atmospheric sciences generally also contributes to our eventual ability to control or manipulate weather systems.

I tend to consider large fractions of the Federal Government's more than \$200 million a year investment in atmospheric research generally—all the way from weather predictions to upper atmosphere physics—as having a long-range impact on our weather modification ability. And to separate that research into research that's purely weather modification on the one hand, and research not related to weather modification on the other, I think gets us into very great semantic difficulties. I doubt if any two scientists would make the same division of atmospheric research projects into the same two categories of weather modification and others.

I think no two scientists would divide atmospheric research into equal-sized piles regarding that.

Senator STEVENSON. Commissioner, how successful have the Bureau's drought relief programs been?

Mr. HIGGINSON. Mr. Chairman, we are very pleased at the results of the program and feel that we have some very satisfactory results from both the winter and the summertime experiments.

With regard to the earlier comment, I would just like to interject one item. That is, that depending on your definition of operational, you could consider essentially the entire program of the Bureau as an operational program. A very small amount of that would be what you would call basic research.

With regard to what Mr. Frank said concerning the proposal of the administration, it is clearly pointed out on pages 32 and 33 that there would be prepared a 5- to 10-year research plan which, as indicated on the top of page 33, will include a careful analysis of required field experiments, and that would be included in the program and be part of the budgeting then of the various agencies that would conduct that activity.

Senator STEVENSON. Well, field experiments are being carried out now.

Mr. HIGGINSON. Yes.

Senator STEVENSON. But as I understood it, he said operations were expected to be carried out in the private sector.

Mr. HIGGINSON. Yes. And I would like to come back to your question and ask, if I could, to have Dr. Silverman give you his view concerning how successful we have been.

Senator STEVENSON. Thank you.

Dr. SILVERMAN. We believe our program has been quite successful. We are using the basic approach of developing a firm physical understanding of the effects of cloud seeding, which we believe to be essential if we are ever going to transfer the result that you get from one place to another.

We have been instrumental in developing some of the more modern meteorological investigating tools which are required in order to get to the root of the problem, and feel that on the basis of the development of those tools we are on a new threshold of development in this area where we can provide physical understanding in areas which have been quite difficult to get at before. That has been a fundamental part of our program.

Senator STEVENSON. Dr. Todd, you stated in your written testimony that the ICAS was the coordinating body for Federal weather modification activities from 1959 to 1978. How is ICAS similar or different from the Committee on Atmosphere and Oceans and its proposed Subcommittee for Weather Modification?

Dr. TODD. The Interdepartmental Committee for Atmospheric Sciences, ICAS, was one of several disciplinary oriented committees under the former Federal Council for Science and Technology.

In 1978, shortly after the FCST was reorganized into the Federal Coordinating Council for Science, Engineering, and Technology, the ICAS and one or two other committees were abolished and their functions taken over by the new Committee on Atmosphere and Oceans which Mr. Frank chairs. So that in effect the ICAS functions were absorbed into the CAO set of responsibilities.

Senator STEVENSON. Thank you very much, gentlemen. We may have a few more questions. If so, we will take the liberty of furnishing them in writing. We are very grateful.

I will invite the remaining witnesses to come forward as a panel. They are: Mr. Harlan Cleveland, of the Aspen Institute for Humanistic Studies, who also headed up the Weather Modification Advisory Board; Dr. Louis J. Battan, Director of the Institute of Atmospheric Physics of the University of Arizona; and Dr. Robert M. White, Administrator of the National Research Council of the National Academy of Sciences.

Once again, if you can summarize, the full statements will be entered in the record.

Mr. Cleveland, can we begin with you, sir?

STATEMENTS OF HARLAN CLEVELAND, DIRECTOR, PROGRAM IN INTERNATIONAL AFFAIRS, ASPEN INSTITUTE FOR HUMANISTIC STUDIES; LOUIS J. BATTAN, DIRECTOR, INSTITUTE OF ATMOSPHERIC PHYSICS, UNIVERSITY OF ARIZONA; AND ROBERT M. WHITE, ADMINISTRATOR, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES

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

As a part of my prepared statement, I have included the text of the summary and recommendations of the report. Since it is rather full and a rather carefully drafted summary of the whole report, you might want to have it be part of the record of these proceedings here.

Senator STEVENSON. That will be entered in the record.

Mr. CLEVELAND. I will not further dwell on the administrative history of the report, since it has been referred to a number of times, or the 3 years and 11 days that have passed since Public Law 49-490.

I think it is fair to say that our unanimous report is the most comprehensive policy analysis on this subject that is now available, and I would like very briefly to highlight the key findings—not quite in the order in which they are in the report—just to have them available for discussion here this morning.

First, as several people have already said, the benefits look to be wholly out of proportion to the probable costs of getting a dependable weather modification capability.

Second, the prime requirement of a national policy is to learn more about the atmosphere itself. Again, that repeats what a number of people have already said here. The Board did make the judgment, as the result of a great deal of discussion, that the first breakthrough was likely to be in the understanding required for regionally important increases in mountain snowpack. That ought to be by the early 1980's, if we get on with it. Then we should be able dependably to produce increased rainfall in areas like the High Plains in the late 1980's, and reduced hurricane winds and hail damage by the 1990's.

The scientific uncertainties are real, but they are not a reason for the Federal Government to freeze in hand-wringing inaction. They are also not a reason for the scientific community to acquiesce in inaction.

The key to such an effort, as we have said, is basic research on the physics and dynamics of the atmosphere itself, and I think there is very wide support for that proposition in the community.

Third, there is already a substantial operational weather management activity, in this country and at various times in 74 countries around the world. We felt that the Federal Government, working with the States, has to assume a general responsibility for what you might call quality control, both of the operations and of the people that conduct it.

Fourth, as you know most of the so-called weather modification has really been the unintentional result of civilization—urbanization, power production, cropping patterns, deforestation, irrigation, and the like. Learning more about these unintended consequences is an essential part of learning how to do things deliberately and with benefit to the atmosphere.

Fifth, more and more Americans are moving into places where they will be at risk from hurricanes. One piece of testimony we had was that another storm like Camille (which was just 10 years ago now), moving up the sea-level delta from Galveston to Houston, could cost 10,000 lives on very favorable assumptions about evacuation and warning, and inundate two-thirds of the U.S. petrochemical industry, in a few hours. A sustained U.S. research effort and a sensitive framework of international cooperation—especially to facilitate experiments on real hurricanes in the Western Pacific Ocean—seems essential. The amount of costs involved in such a research and experimentation program really are peanuts, compared to the enormous damage that we've already seen twice this year on or near our own coasts.

Sixth, weather resources management is of course an environmental impact, on purpose. Environmental considerations have to be part of the plan, not a sort of environmental impact statement afterthought, but part of the plan in every case. So do the analysis of economic costs and benefits, and arrangements for making sure that the affected public knows what is planned and have a chance to help decide what is going to be done. We go into these social, economic, and environmental issues in considerable detail in our report. In that sense our report is a very deep and broad piece of technology assessment, to use the current terminology.

Seventh, to carry out the broad responsibility we think the Federal Government inherently has for human intervention in weather systems that do not respect State or indeed national frontiers, we think some things need to be done. We did not propose what Mr. Frank called, earlier this morning, a comprehensive regulatory system; quite the contrary. We did not propose to lay a very heavy regulatory glove on this still tiny industry. But we did, and I do, think that whoever is going to try to modify the weather ought to be qualified, and that means some kind of licensing system. I think that the case for Federal licenses for the individuals involved is at least as strong as the case for a Federal license for every pilot, even if he is only flying around in his own county in a Piper Cub.

We also thought the Federal Government should take responsibility for issuing continuously updated, environmentally sensitive, Sound Weather Resources Management practices, as we call them—in effect, advisories to the whole community. The advice would be mandatory, obviously, for the Federal experiments, but would be advisory reports to State regulators, to weather managers, to users, and others involved.

The community of the concerned should also have available a technical assistance capability in the Federal Government.

And we thought that, better early than late, the Government should make clear that the Federal Government's own experiments in weather management (and perhaps later Federal weather management operations) are subject to claims for damage under the Federal Tort Claims Act.

Eighth, the United States should actively promote international consultation and cooperation in the field of weather modification. The case for doing so is really two-way. It's not just that we want to help other people increase their own food and water and energy supplies and limit the weather damage. It is also that we want to

make sure that our own programs benefit from the discoveries and experiments of others. As we keep finding out, Americans don't have all the world's wisdom.

Ninth, we recommended a sustained, 20-year program of research and development. I will not further describe it. It is described and detailed in the report and summarized in my prepared testimony. But it does start with basic research as point No. 1. Our recommended effort would have called for \$37 million in the first year. This would have been a little over twice the total amount appropriated for weather modification in 1977 that total figure has become slightly slenderer since), and would have risen to about \$90 million in the fifth year.

And tenth, the Advisory Board recommended the consolidation of everything that the Federal Government does in this field in one organization, and enough autonomy for that organization to produce, defend, and carry out a serious and consistent long-term program of research and development, and also to handle the minimal regulatory functions.

Now, Mr. Chairman, the 17 members of this Board were not born yesterday. We knew how difficult it is in our big Government to get it all together, how vigorously defended is every square inch of existing bureaucratic turf, and how hard it is in every field of public policy to sell integrated and purposeful action to constituencies which perceive a stake in fragmented action programs. But we were asked to propose a national policy and program, and we were unanimous in concluding that a consolidated program is a must.

We looked at the record of lead agencies in the Government and concluded that the lead agency formula generally means telling one part of the executive establishment to take charge, without placing the tools for leadership in its hands.

I might say, this same conclusion applies in spades to the notion of coordination by a subcommittee. I am touched by the faith in interagency coordinating committees that I have heard this morning, but as a veteran of a good many of them I am not sure what the confidence is based on.

Our proposal, which was deliberately unusual, was to establish a small executive board with a life of its own in an existing agency, and with its own executive director; and to bring into that board's purview—either as its own staff or through contractual arrangements—everything that is done about weather modification by the Federal Government for the next couple of decades.

That does not mean that other agencies would not be in the weather modification business. For example, an experiment like the Bureau of Reclamation's HIPLEX [High Plains Experiment] would logically be contracted out, entrusted to the Bureau of Reclamation to manage within the framework of policy and standards established by our proposed board.

Our consensus proposal, a year ago, was that this function should be allocated to NOAA—although some members of the Advisory Board would even then have opted for NASA or even NSF as the host agency.

The delay in reacting to our report, I must say it frankly, raises serious questions about the capacity of NOAA to take the kind of vigorous lead that would be required. My own feeling—the Board

has disbanded and I can't speak for its membership—is that the earlier consolidation of oceanic and atmospheric functions in one agency was an enormous step forward in organizing the Federal Government for sensible management of resources in these very special global environments.

If NOAA is not yet the effective center of initiative, not yet the enterprising and innovative agency it will have to become if it is going to serve our national interest, the proper remedy is to energize its management, not to start stripping it of oceanic and atmospheric functions.

Meanwhile, as we said in our report, we are still tackling 20-year problems with 5-year projects staffed by short-term contracts and funded by 1-year appropriations. It is not good enough.

I think that is essentially the state of affairs today, and I am delighted that this subcommittee is moving toward a legislative initiative. I have included in my statement, but I will not rehearse them here unless you want to go into more detail, some comments on the two bills, and a comparison between them on a number of points.

The main thing is that our proposed executive board and its director, or the program's director in the two bills before you, should have clear responsibility for developing and pushing an integrated, rolling, 5-year program, and the management and allocation of the financial resources which are placed at the disposal of the effort; and should also give unremitting attention to quality control in both Federal and non-Federal weather modification.

I do urge the subcommittee not to allocate to a lead agency leadership responsibilities without the administrative authority and the budgetary tools to do the job.

In conclusion, Mr. Chairman, let me repeat something that I said in my transmittal letter to Secretary of Commerce Juanita Kreps when we gave her the report summer before last:

The history of our time is sprinkled with instances of new technologies running ahead of the social, economic, environmental, international, and institutional thinking that should accompany them. Precisely because the science and technology of weather resources management are still at such an early stage, there is an excellent chance in this field to do things right—that is, for policy to be made and institutions to be built in parallel with the scientific discoveries and technological innovations.

For reasons spelled out in our report, we were unanimous in recommending that the time was then. We think even more the time is now.

Thank you, Mr. Chairman.

[The statement and material referred to follows:]

STATEMENT OF HARLAN CLEVELAND, CHAIRMAN OF THE WEATHER MODIFICATION
ADVISORY BOARD

THE MANAGEMENT OF WEATHER RESOURCES: OUR NEED FOR A POLICY IS NOW

I

In the National Weather Modification Policy Act of 1976 (P.L. 94-490 of October 13, 1976), Congress called on the Secretary of Commerce to "conduct a comprehensive investigation and study of the state of scientific knowledge concerning weather modification technology, the problems impeding effective implementation of weath-

er modification technology, and other related matters." The study was "to develop a comprehensive and coordinated national weather modification policy and a national program of weather modification research and development." Congress asked for a final report in one year.

It is now three years and eleven days later. A part of that time—a little more than a year of it—was occupied by the work of the Weather Modification Advisory Board, which was appointed by Secretary of Commerce Juanita Kreps in April 1977, held twelve public hearings and working meetings in various parts of the United States, consulted with experts from many other countries, and submitted its final report to the Secretary on July 12, 1978.

This report, entitled "The Management of Weather Resources: Proposals for a National Policy and Program," has of course been available to the Congress as well, but the Executive Branch had not until this hearing reacted to the report or expressed itself on the need for a national policy about efforts to change the weather at human command. Meanwhile two bills to establish a national policy and authorize a national program have been introduced, S.1644 by Senator Adlai Stevenson and S.829 by Senator Bellmon.

You have asked me, as Chairman of the now-disestablished Weather Modification Advisory Board, to discuss these bills, without advance notice of the position if any, of the Executive Branch.

The Advisory Board's report contains a rather full Summary and Recommendations. That section of the report was reproduced in full in the October 1978 issue of the "Bulletin of the American Meteorological Society," together with a foreword in which I summarized the brief but intensive administrative history of the Advisory Board and identified its members. A reprint of this material is attached to my testimony. Rather than burden my direct testimony by rehearsing in detail the arguments and conclusions in our Report. I would hope that the Subcommittee would be willing to include in the record of its hearing the text of this reprint.

II

I think it is fair to say that the unanimous report of our Advisory Board is the most comprehensive policy analysis now available on the subject of weather modification—or weather resources management, as we preferred to call it. It may be helpful to highlight our key findings and proposals.

First. The benefits likely to be derived from management of weather resources—for the distribution of water, the growing of food and fiber, the production and conservation of energy, and the warding off of some of the severest storms—are out of all proportion to what it will cost to learn enough about the atmosphere to modify the weather purposefully and prudently.

Second. The prime requirement of a national policy in this field is to learn more about the atmosphere itself. But we know enough already to guess that a much intensified and steady program of scientific inquiry and field experiments over the next two decades will yield regionally important increases in mountain snowpack in the early 1980's, increased rainfall in areas like our High Plains in the late 1980's, and reduced hurricane winds and hail damage by the 1990's.

The scientific uncertainties are real. But they are not a reason for the Federal Government to freeze in hand-wringing inaction. They are also not a reason for the scientific community to acquiesce in inaction. If they were, uncertainty would have ruled out the experiments of Galileo, the explorations of Columbus, and even the speculations of Heisenberg on uncertainty. The proper attitude toward scientific uncertainties that stand in the way of large potential benefits to farmers, city people and dwellers on hurricane-prone coastlines is to get on with a serious research and development effort that matches the scale and complexity of the problem. And the key to such an effort, as we said in our report, is basic research on the physics and dynamics of the atmosphere itself.

Third. The main weather modification technology, cloud seeding (usually with silver iodide), has been used operationally in 74 countries and is regularly practiced in the United States. In 1977 clouds were seeded in 88 projects in 23 states, covering more than a quarter of a million square miles of U.S. territory. The Federal Government, working with the states, has to assume responsibility for making sure that quality standards and qualified people are the rule in weather resources management.

Fourth. Most "weather modification" so far has been unintended, the product of urbanization, power production, cropping patterns, deforestation and irrigation. Learning more about the unintended consequences of modern industrial civilization is an essential part of learning how to change weather on purpose in ways that benefit people.

Fifth. More and more Americans are moving into hurricane paths; the U.S. migration to the Sunbelt has enormously increased the populations, property and productive industry at risk. Even on favorable assumptions about warning times, another storm like 1969's Camille, moving up the sea level delta from Galveston to Houston, could cost 10,000 lives and inundate two-thirds of the U.S. petrochemical industry in a few hours.

Hurricanes are a triple threat—from wind, storm surge and flooding. There is an intriguing but not yet proven theory for moderation of their wind speeds, but it needs a sustained U.S. research effort and a sensitive framework of international cooperation, especially to facilitate experiments on real hurricanes in the Western Pacific.

The Weather Modification Advisory Board last year proposed a 10-year test of hurricane moderation, which might cost \$8 to \$15 million a year. The recommendation is still resting in an Executive pigeonhole. Do we really need to have a couple of billion-dollar, kilodeath storms to spur us into doing our scientific and technical homework on the most devastating kinds of weather?

Sixth. Weather resources management is, in effect, a deliberate "environmental impact," so environmental considerations have to be part of the planning of every weather modification try. So does the analysis of economic costs and benefits. And so do arrangements for making sure the affected publics know what is planned, and have a chance to help decide what will be done. As our report says, "There is no area of public affairs where a policy of official candor is more integral to the success of a Government-sponsored research-and-development program."

Seventh. The Federal Government has broad responsibility for human intervention in weather systems that do not respect state, or indeed national, frontiers. But weather resources management is still a very small industry, and we did not propose to lay a heavy regulatory glove on it. We did make these suggestions:

(a) Each weather management operator should have a Federal license, as aircraft pilots do.

(b) The Federal Government should take responsibility for issuing continuously updated, environmentally sensitive "Sound Weather Resources Management Practices," based on state-of-the-art technology. These would serve both as a standard to which all Federal field experiments would be held, and as guidance for state regulators, weather resource managers, user organizations such as farm groups, courts and arbitrators.

(c) The Federal Government should arrange to provide technical assistance in weather resources management to states, local authorities, and private users and operators.

(d) The Federal Government should make clear that its own operations are subject to claims for damage under the Federal Tort Claims Act.

Eighth. The United States should actively promote international consultation and cooperation in the field of weather modification. The benefits of close and candid consultation are two-way. We want to make sure that our own programs benefit from the discoveries, insights and experiments of others. And we want to assist other countries to increase their food, water and energy supplies and limit their weather damage. To make clear that the U.S. intent is to promote the peaceful uses of weather modification, our Advisory Board also recommended the early ratification of the Environmental Modification Convention, a treaty already signed by the U.S.

Ninth. We recommended a sustained 20-year program of research and development, including basic research; refinement of cloud seeding technique; experiments in the dissipation of stratus; a special effort to learn more about warm fog; the study of atmospheric responses to land use, farm practices, industrial processes and urban life; a special push to develop techniques for reducing peak winds in hurricanes; support for the first international cloud-seeding experiment, now being actively planned; research on ways other than cloud seeding to modify local weather; research on impacts—environmental, economic, and social—of weather resource management; and a cooperative Federal/State/local effort to garner maximum scientific knowledge from selected operational cloud-seeding projects.

The recommended R. & D. effort, containing all elements, would call for Federal appropriations of \$37 million in the first program year (roughly twice the 1977 total of Federal agency spending for comparable purposes), and increases to \$90 million in the fifth year.

Tenth. The Advisory Board recommended the consolidation of all the Federal Government's weather modification work in one organization and sufficient autonomy for that organization to produce, defend, and carry out a serious and consistent

long-term program of research and development—and handle the minimal regulatory functions in a highly professional way.

III

The members of the Advisory Board were not born yesterday. We knew how difficult it is in our big government to "get it all together," how vigorously defended is every square inch of existing bureaucratic turf, and how hard it is in every field of public policy to sell integrated and purposeful action to constituencies which perceive a stake in fragmented action programs. But we were asked to propose a national policy and program, and we were unanimous in concluding that a consolidated program is a must.

I hear tell that even some of the most vigorous supporters of a serious weather modification effort are now prepared to settle for a pattern of continued fragmentation, with some limited national planning and coordination attempted through a "lead agency." I believe that this would be a mistake. "Lead agency" in U.S. federal experience is a euphemism for not getting things organized so they are going to work, yet pretending to do so. "In practice," we said in our report, "a lead agency generally means telling one part of the Executive establishment to take charge without placing in its hands the tools required for leadership."

Our proposal, a deliberately unusual one, was to establish a small executive board with "a life of its own" in an existing agency, and an executive director to carry out the national policy to be enunciated by Congress; and to bring into the new board's purview, as its own staff or through contractual relationships, all the Federal Government's existing and future weather modification programs. This central organization could and should delegate particular projects to the agencies best able to carry them out; for example, an experiment such as the Bureau of Reclamation's HIPLEX would logically be entrusted to the Bureau of Reclamation to manage, within the framework of policy and standards established by the national program office.

Our consensus proposal a year ago was that this function should be allocated to the National Oceanic and Atmospheric Administration (NOAA)—although some members of the Advisory Board would even then have opted for NASA or even NSF as the host agency. The delay in reacting to our report raises—let us say it frankly—serious questions about the capacity of NOAA to take the kind of vigorous lead that would be required to get a national weather management program pulled together and up to speed.

My own feeling—the Board has disbanded and I cannot speak for its membership—is that the earlier consolidation of oceanic and atmospheric functions in one agency was an enormous step forward in organizing the Federal Government for sensible management of resources in these very special global environments. If NOAA is not yet the effective center of initiative, not yet the enterprising and innovative agency it will have to become if it is to serve our national interest, the proper remedy is to modify its management, not start stripping it of oceanic and atmospheric functions.

IV

Meanwhile, in the field of weather resources management, we are still "tackling 20-year problems with 5-year projects staffed by short-term contracts and funded by one-year appropriations. It is not good enough." That is what we said to the Executive Branch more than a year ago, and that I believe, is still essentially the state of affairs today. I am therefore delighted that this subcommittee is moving toward a legislative initiative.

Either of the bills you are considering would represent a very large step forward from where we are. But as the committee writes a bill to present to the Senate, you may wish to combine elements of both bills in the final draft.

S.829, for example, contains in its "Findings" a rather fuller analysis of the present situation, and its "Policy" section is closer to the recommendations of the Weather Modification Advisory Board, than the comparable formulations in S.1644.

I would hope that the concept of Federal "Sound Weather Resources Practices" could be a part of the final draft; the professional quality of weather resources management is what will make it possible to reap large benefits without running large risks.

The role of the States, and the need for Federal/State/local cooperation, seems to me an essential ingredient of a national policy and program; this emphasis is lacking in S.1644 and perhaps not pointed enough in S.829.

The licensing of weather modifiers is provided for in S.1644 but not in S.829; I would strongly recommend that such a requirement be retained in the final bill, as an essential part of quality control.

Both bills provide for a board, but in both cases it is advisory; I still think a small executive board, in which a few outstanding people could find a vocation in nursing this potentially important field of weather resources management from infancy through adolescence during the next two or three decades, is an idea worthy of serious consideration.

Even if the board were to be advisory, I would opt for the smaller number of members (6 as against 15) and the longer terms of appointment (6 years rather than 3), for reasons which do not need to be explained to any committee of experienced political leaders.

The key functions of our proposed executive board and its director, or of the Program's Director in the two bills before you, should be the development of an integrated, rolling five-year program, the management and allocation of the financial resources which are placed at the disposal of the national weather modification effort, and unremitting attention to quality control in both Federal and nonfederal weather modification. I do urge the subcommittee not to allocate to a "lead agency" leadership responsibilities without the administrative authority and budgetary tools to do the job.

V

In my letter transmitting to the Secretary of Commerce the report of the Weather Modification Advisory Board, in the early summer of 1978, I made one comment that may bear repeating now that your subcommittee is moving toward action.

The history of our time is sprinkled with instances of new technologies running ahead of the social, economic, environmental, international and institutional thinking that should accompany them. Precisely because the science and technology of weather resources management are still at such an early stage, there is an excellent chance in this field to do things right—that is, for policy to be made and institutions to be built in parallel with the scientific discoveries and technological innovations.

The United States of America does not have a national policy for the management of weather resources. For reasons spelled out in our report, our Advisory Board (which was created in response to a Congressional initiative) was unanimous in recommending that the time for adopting a legislative policy stance, backing it with a coherent executive program, and organizing seriously for a longer term effort, is now.

public policy affairs

"The Management of Weather Resources—Proposals for a National Policy and Program"

Foreword

Harlan Cleveland¹

Chairman, Weather Modification Advisory Board

With the National Weather Modification Policy Act of 1976 (Public Law 94-490 of 13 October 1976) Congress mandated that the Secretary of Commerce "conduct a comprehensive investigation and study of the state of scientific knowledge concerning weather modification technology, the problems impeding effective implementation of weather modification technology, and other related matters." This study was "to develop a comprehensive and coordinated national weather modification policy and a national program of weather modification research and development. . . ."

The 1976 election was only weeks away, but as a nonpartisan activity, plans were laid even before the change of Administrations to carry out the intent of Congress by establishing an external Advisory Board to provide independent advice to the Secretary of Commerce and assist in developing the mandated study and report. The board's charter was in fact approved two days before President Jimmy Carter's inauguration. In April 1977 the new Secretary of Commerce, Juanita M. Kreps, invited the following persons to constitute the Weather Modification Advisory Board:

Chairman,
Harlan Cleveland

Executive Secretary,
Edward S. Epstein

Members

D. Ray Booker
Roscoe R. Braham, Jr.
Stanley A. Changnon, Jr.
Abram Chayes
John P. Craven
James A. Crutchfield, Jr.
Robert D. Elliott
John W. Firor

T. Keith Glennan
Thomas L. Kimball
Thomas F. Malone
Martha A. McNnis
Herman Pollack
Wallace N. Robinson III
Joanne Simpson
S. Bryce Streibel

The board members quickly agreed that they should

not serve as specialists or constituency representatives but rather as advisors on the broad public interest in prudent and effective weather modification. They constituted a balanced group with broad experience in the relevant disciplines and in government. Nine members came from scientific or engineering backgrounds, including the first Administrator of NASA, the Executive Director of NCAR, two full-time academic scientists, a research scientist working with a state water survey, a scientist with broad international experience, a university dean of marine programs, and two scientists with direct experience with operational weather modification. Two persons were active in the environmental movement and two were practicing farmers with governmental experience at the state level. There was also an economist with both academic and government experience, a former Foreign Service officer with long experience in public administration and technological cooperation, and a professor of law with high-level experience in government. My qualifications as Chairman included involvement with the development of the original proposal for the World Weather Watch in the early 1960s and my noninvolvement in the history of tensions and rivalries in the field of weather modification.

Working with a \$430 000 appropriation from Congress, the board held 12 meetings throughout the United States during its term: 3 in Washington, D.C., 2 each in Colorado and Illinois, and 1 each in California, Georgia, North Dakota, Oklahoma, and Virginia. Each meeting was announced ahead of time in the *Federal Register*, all were open to the public, and provision was made for oral and written statements to the board. Copies of the meeting notices were sent to a mailing list of interested individuals and observers. In this manner, the views of state and local agencies, private firms, colleges and universities, and other interested persons and organizations were solicited and considered.

¹ Aspen Institute for Humanistic Studies, Princeton, N.J. 08540.

We also consulted separately with Canadian, British, Mexican, Australian, and Israeli experts and held a two-day seminar with European experts at the headquarters of the World Meteorological Organization in Geneva.

Early in our work, in October 1977, the board published a rather full "Discussion Paper" as "a preliminary assessment of the board's thinking, while its members were still in mid-passage in their assignment." That paper, entitled "A U.S. Policy to Enhance the Atmospheric Environment," received wide distribution and was excerpted in several periodicals.

Of the several studies commissioned by the board and conducted through consultants or contractors, one was deemed so distinct and useful that it warranted publication as a document separate from the board's report. It appears, in Volume 2, as "The Role of Statistics in Weather Resources Management" (Report of the Sta-

tistical Task Force to the Weather Modification Advisory Board). This technical annex to the board's report reviews the issues associated with statistical design, analysis, and evaluation of weather modification experiments and considers the published results from nine recent experiments. The Task Force consisted of David R. Brillinger, Lyle V. Jones, and John W. Tukey (Chairman).

The Subcommittee on the Environment and the Atmosphere of the House Committee on Science and Technology held two hearings to review the board's progress, on 26 October 1977 and 25 May 1978. The final report of the Weather Modification Advisory Board was presented to Juanita Kreps, on 12 July 1978 (see photos).

The board feels that its product is "no ordinary report." It is a multidisciplinary approach to a highly complex scientific and social problem and provides an integrated framework for developing and containing



(Opposite) Secretary of Commerce Juanita Kreps receives the report of the Weather Modification Advisory Board from Chairman Harlan Cleveland (center) and NOAA Administrator Richard Frank.

(Below) Secretary Kreps, Board Chairman Cleveland, and Administrator Frank (center, background) discuss the Weather Modification Advisory Board's just-presented report with members of the board.



the growth of weather management technology, while in its early stages of learning.

What follows is the Summary and Recommendations of the board's final report titled "The Management of Weather Resources." A limited supply of the report is available from NOAA (RD-Z, Science and Academic Affairs, Rockville, Md. 20852; tel: 301-443-8108).

In transmitting our report to Secretary Kreps, I made some summary comments that may be worth repeating here:

We conclude that it will soon be technically possible to manage some kinds of weather resources in a variety of ways on a significant scale—and that the human benefits of doing so with prudence are likely to be very great. But a national policy of weather resources management must start by learning much more about the atmosphere. The centerpiece of our recommendations is

therefore a 20-year research and development effort, the dimensions and probable outcomes of which are set forth in this Report. Meanwhile, even while the promising technologies are being tested, efforts by interested citizens to improve their weather are growing and need help to do the prudent best they can within the state of the art.

The history of our time is sprinkled with instances of new technologies running ahead of the social, economic, environmental, international and institutional thinking that should accompany them. Precisely because the science and technology of weather resources management are still at such an early stage, there is an excellent chance in this field to do things right—that is, for policy to be made and institutions to be built in parallel with the scientific discoveries and technological innovations.

The Federal Government does not have a policy in this field. For reasons spelled out in our Report, we are unanimous in believing that the time for adopting a policy stance, backing it with a coherent program, and organizing seriously for a longer term effort, is now.

Summary and Recommendations¹

I.

Weather is important. It deeply affects the costs and conveniences of living. It is a prime factor in determining the food and fiber that can be grown, the amount and distribution of usable water, and the consumption and production of energy. It also does very great damage to lives and property.

People have learned to live with the weather; but there is growing public awareness of its dangers and variabilities. If the weather can be changed to their benefit, most people will want to try.

It will soon be possible to influence the weather more reliably and in a much greater variety of ways; how soon depends on how hard men and women work at developing a body of knowledge that is still only a generation old, and testing unproved technologies in field experiments.

II.

The guesses of 20 years ago that certain kinds of precipitation could be increased have been generally supported by experience. Striking advances in the technologies of measurement, computer simulation, and data handling make much better field experiments possible. Enough first-rate scientists and other specialists are available in this and related fields to start a considerably more vigorous program of research and development.

It seems probable that a much intensified and steady program of scientific inquiry over the next two decades will yield regionally important increases in mountain

snowpack in the 1980s, increased rainfall in areas like our High Plains and Midwest by the late 1980s, [and] reduced hurricane winds and hail damage by the 1990s. The margins of man-produced seasonal weather change would be 10% to 30% increases for snow and rain. Some hurricane winds would be reduced by 10% to 20% (with much greater reductions in wind damage). Hail would be reduced up to 60% in some kinds of storms.

The case for hastening progress along these lines is very strong. The economic benefits of delivering more water in the right places—for farming, for irrigated crops, for hydroelectric power, and for municipal and industrial water use—seem very likely to outweigh the costs by impressive amounts. Large benefits, especially to aviation, can come from dissipating fog on command. Population growth and migration are multiplying the people at risk from hurricanes and other severe storms; if the damage from the weather's occasional fury can be mitigated, the people at risk will insist that the effort be made.

The public interest requires that deliberate changes in the atmosphere be designed and carried out with environmental prudence and after consultation with the people likely to be most affected. The air and the clouds are a public good, belonging to no one. The size and power of atmospheric systems are such that sensible policy must start with Federal responsibility for weather resources management—and a network of international arrangements as well.

III.

The prime requirement of a national weather modification policy is to learn more about the atmosphere itself.

¹ Reprinted from "The Management of Weather Resources, Volume 1, Proposals for a National Policy and Program," Weather Modification Advisory Board, 1978, pp. 3-16.

Weather change can be induced by injecting energy by "brute force" (direct heat, mechanical mixing); by triggering and intensifying the atmosphere's natural energies (so far, with chemical seeding agents such as dry ice or silver iodide); or in more exotic ways—for example, by altering the land or water surface to change its natural interaction with the lower boundary of the atmosphere.

The first of these methods has been used at a few airports, in the United States and abroad, to dissipate warm fog. The third method, a cluster of ideas we have called "beyond cloud seeding," may be very important in the long run because the scale of effects might be much larger than what can now be foreseen for cloud seeding.

But it is the second method, cloud seeding, that presents the most near-term opportunities for intensified research and field experimentation, is the basis for a small operational business in the United States, and accounts for numerous weather modification efforts elsewhere, especially in the larger nations.

IV.

What we know about the physics of cloud seeding, and a judgment about the main field experiments conducted so far, are summarized in some detail in this Report. We know that:

- Supercooled fog and stratus can be seeded to improve visibility.
- Holes can be opened in winter stratus clouds to increase the amount of solar radiation that reaches the ground.
- Snowpack, and thus the spring runoff, can be increased by seeding wintertime clouds rising over some mountain barriers.
- Rain can be induced from some types of summer cumulus clouds, and their potential for precipitation can apparently be increased by increasing the size of the clouds ("dynamic seeding").
- Rainfall is increased in Israel by seeding winter cumulus clouds; seeding convective rain bands in winter cyclonic storms over California (the nearest analog to the successful Israel experiments) also suggests positive results.
- Hail suppression is attempted in many countries, with claims of up to 80% success in the Soviet Union. U.S. experiments have provided no convincing evidence, but evaluations of several projects suggest that hail damage from some kinds of storms can be reduced.
- There is no evidence that increases in rain or snow in one area decreases them in nearby areas.

V.

Experiments on the atmosphere must be done in the atmosphere; mathematical modeling and small chambers are helpful to a point, but they cannot match the dynamic complications of real clouds in a real sky. The necessary field experiments typically require five years

or more; lack of continuity and multiyear funding has inhibited weather modification research. Moreover, the need to go promptly into the field requires an early focus on environmental, economic, and social impacts.

Evaluating field experiments depends partly on statistical inferences, especially as long as so little is yet known about what goes on inside each cloud and how clouds interact with their surroundings. The Weather Modification Advisory Board (WMAB) commissioned a critique of the statistical aspects of the more recently conducted experiments in weather modification by three outstanding scholars—John Tukey, Lyle Jones and David Brillinger. Their report to the Board, which contains excellent advice on how future experiments should be conducted, is reflected in Chapter 2 of our Report and also forms a separate volume.

VI.

Meanwhile, people with interests at stake have been investing in operational cloud seeding without awaiting scientific demonstration. Most of the cloud seeding in the 74 countries that have tried it has been direct attempts to increase rain or suppress hail with no prior scientific experimentation. In the United States, cloud seeding is still a small industry (\$4 to \$6 million a year), with a dozen companies working for private groups, local authorities, and overseas clients. But in 1977 clouds were seeded in 88 projects in 23 States, over 673,000 square kilometers (about 260,000 square miles) of the United States. Use of the technology is growing.

The Federal Government, as part of its research and development (R & D) effort in weather resources management, can get more science out of some well-designed operational cloud-seeding projects by sharing costs with them. The Government should also develop quality standards for operational projects, covering both environmental impacts and state-of-the-art technology. The professional community would do well to help upgrade standards by certifying weather modification experts to examine operational projects and make public reports (as Certified Public Accountants do in financial matters).

When drought threatens, public and political pressure builds up for emergency cloud seeding. But these are the least useful times to seed because there are fewer clouds; attempts to use weather modification are not encouraged. Weather modification techniques can best be used, with much longer range planning, to help increase the stores of water available to tide over the times of excessive dryness.

VII.

The most widespread "weather modification" arises from man's unintentional impacts on the atmospheric environment. Cities, power plants, cropping patterns, deforestation, and irrigation do demonstrably modify the local weather.

East of the Mississippi River, the effects of urban and industrial growth are such that large parts of the region are cloudier and rainier than they used to be. There is

evidence that, in the Northern Hemisphere, urbanization produces 10% to 15% more snow and rain, 15% more thunderstorms, 60% more fog—and 1,000% more contaminants—than are found in otherwise comparable rural areas.

Learning more about this unintentional weather is an essential part of a national policy for weather resources management—and, more broadly, for future land-use planning.

VIII.

Because the population of hurricane-prone coasts and islands has grown so rapidly, any possibility of moderating hurricane winds assumes great importance. Even a 15% decrease in wind velocity can mean a 30% or more decrease in wind damage.

A theory about how to moderate hurricane force, by seeding, has been tried in three cases since 1961; the results are encouraging, but much more research is needed, both on these violent storms themselves and on the effect seeding strategies have on their behavior. Some methods "beyond cloud seeding" are also theoretically promising; if, for example, ways can be found to cool the ocean surface in a hurricane's path, it is highly probable that the storm would subside.

So far, field experiments have been possible only in the North Atlantic, in a zone safely away from land. This arrangement yields too few test cases. A current negotiation with Mexico may make it possible to work on tropical storms in the Eastern Pacific, where they typically blow out to sea rather than onto populated coasts. But the largest supply of hurricanes is in the Western Pacific. There, a U.S. plan to seed typhoons was shelved after objections from nations in the region. We recommend another effort, this time starting with a research program in which the nations most affected could be full partners.

IX.

Learning more about the atmosphere is only part of—even if it is the condition precedent to—beneficial management of weather resources. *It is also important that we learn much more than we now know about benefits and costs, about wider impacts on society and politics, and about the environmental impacts of manmade (as well as unintentional) changes in the weather.*

Each major field experiment in the national R & D program—and similar interventions in the weather that may be sponsored by State and local authorities—should always include, as an integral part of program design, definitions of impact data required, and procedures to collect and analyze it for these purposes.

Managing the weather to serve human needs is in itself an "environmental impact." Designing a prudent plan for intervening in the atmosphere by altering weather patterns is the same process as trying to assess in advance the impact of that intervention. "Environmental considerations" cannot be an afterthought; they have to be part of the planning.

In the management of weather resources, it will not be enough to guess in advance at future impacts. This is required by the National Environment Policy Act (NEPA) for all Federally supported activities—which in the immediate future will be predominantly R & D experiments. *When it comes to weather resources management, we recommend two other requirements:*

- An ongoing monitoring or assessment that observes environmental effects during the project.
- A post-assessment to validate (or otherwise) the earlier predictions about environmental effects, for which NEPA makes no provision, and also to detect any unpredicted ecological changes.

X.

Economic analysis, too, should be built from the outset into the planning of weather resources management, including field experiments.

In the short run, it may well be that other methods of getting water to farmers or of increasing farm output with nonwater inputs may be more attractive than weather modification—in the present state of the science. But over a 20-year time horizon, the outlook for food and fiber production clearly calls for expanded effort in all directions. Though it seems likely that weather modification will not make revolutionary additions to usable water supplies or reductions in hail damage, *the potential appears great enough to judge that weather modification is one of the promising research tracks now remaining to be aimed at expansion of agricultural output in the United States and abroad.*

The research-and-development effort to realize the economic benefits will not be inexpensive, and not all the capabilities can be guaranteed. But the potential benefits are so great that it seems a better bet than much public spending and many business investments. One thing is clear: continuation of the present low level of spending on weather management R & D, which makes substantial, sustained field experiments impossible, is quite unlikely to be productive and is a poor investment.

"Social impact" is the prevailing euphemism for public controversy. By and large, the Board has found that controversy about weather modification has been more publicized than widespread. *Efforts to modify the weather are better accepted when they are openly explained to the affected publics ahead of time, and the affected publics have a chance to participate in the process by which decisions are made to authorize and conduct them.* There is no area of public affairs where a policy of official candor is more integral to the success of a Government-supported research-and-development program.

XI.

It is clear enough that the Federal Government has a broad responsibility for human intervention in weather systems that do not respect State (or indeed national)

frontiers. But responsibility does not necessarily require detailed regulation and control.

If our recommendations are carried into action, a substantial Federal R & D program will be the main event in weather resources management during the next decade or more. The rest of cloud-seeding activity is so small that State regulation, tort law, and a professional community actively interested in standards of quality are—for the time being—preferable to a premature rigidity of national regulations.

As technologies for weather modification are proven, the scale and scope of efforts to improve the weather will become more extensive. The Federal authority we propose to nurse this early stage science and technology to maturity should keep developments under careful review.

We do recommend that the Federal authority take direct responsibility for five functions:

- Weather management operators should have a Federal license (as pilots of all kinds do), and no modification project should be permitted without the onsite supervision of a licensed operator.
- The Federal Government should conduct an open consultation in areas and with groups likely to be substantially affected by a Federally sponsored field experiment. The opinion of State governments should especially be taken into account, though the Federal authority would inherently have the right to go ahead even over a State objection, after a public hearing on the record, if it found a compelling national interest in doing so.
- The Federal Government should issue continuously updated, environmentally sensitive "Sound Weather Resources Management Practices," based on state-of-the-art technology. These would serve both as a standard to which Federal field experiments would be held, and as guidance for State regulators, weather modifiers, user organizations, courts, and arbitrators.
- The Federal Government should arrange to provide technical assistance in weather resources management to State, local authorities, and private users and operators.
- The Federal Government should make clear that its own operations are subject to claims for damage under the Federal Tort Claims Act.

XII.

Weather is transnational. Around the world, efforts to modify it have been widespread, sporadic, and mostly operational. The United States is far from having a monopoly of the best thinking and the best field work in weather resources management.

Emerging technologies promise help in extending resource limits worldwide. But they will also lead to conflict if international cooperation does not become a habit early.

International cooperation in weather forecasting and

research is, so far, a bright spot in international relations, and in the exercise of U.S. leadership. *We believe it would be premature to seek now a comprehensive international agreement on weather modification. The United States should, however, try hard to keep the institution-building in step with the emerging science and technology by:*

- Unilaterally offering to consult in advance with any nation likely to be affected by U.S. efforts to manage weather resources—which should reduce suspicion, avoid unnecessary conflict, and establish a U.S. right to consult about what others are doing.
- Working through the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) to form a standing international panel of experts to provide technical help and assist in avoiding or resolving international disputes.
- Pressing for international cooperation in scientific research, in ways ranging from the involvement of more non-Americans in U.S. experiments to an eventual integrated research institution for the study of weather resources management. Meanwhile, the United States should give solid support to the first international cloud-seeding experiment, WMO's Precipitation Enhancement Project (PEP) in Spain.

The purpose of all this cooperation is to make sure that our own weather resources management program benefits from the discoveries, insights, and experiments of others—as well as to assist other countries to increase their food, water, and energy supplies and limit their weather damage.

The United States should make as explicit as possible that the U.S. intent is to promote the peaceful uses of weather modification. As a minimal first step, we recommend the ratification of the Environmental Modification Convention, already signed by the U.S. and the U.S.S.R. but not yet sent to the U.S. Senate for advice and consent.

XIII.

Three kinds of Federal actions are needed to organize for the tasks described in this Report. One is a *first Congressional statement of national policy*. Another is a Federal R & D strategy with a clear focus on learning more about how to modify weather both predictably and prudently. A third is to bring together in an integrated program the scattered elements of the ineffective existing effort.

The policy statement can be brief. Here is the kind of language that might help fill the present Federal policy vacuum:

(The Congress finds) that it may soon be possible to manage weather resources in a variety of ways; that very great benefits may accrue from a vigorous and prudent use of emerging technologies for weather resources management; that an intensified and

steady program of scientific inquiry gives promise of realizing this potential over the next two decades; that the public interest requires that deliberate changes in the atmosphere be designed and carried out with environmental prudence and after consultation with the people likely to be affected; and that weather resources management can best be developed in close cooperation with other peoples with whom we share the Earth's atmosphere. The atmosphere is a public resource belonging to no person or interest. Within the United States, the Federal Government has a supervening responsibility for its management. This responsibility, to be exercised in partnership with the States, should use to the maximum the talent and initiative of local public authorities, university scientists, user groups, and private weather management operators.

XIV.

The central emphasis of a Federal effort to enhance the atmospheric environment has to be cloud seeding, to make more rain and snow in the right places at the right times; it is this aspect of weather modification that is best understood, and is nearly ready for large-scale application.

The aim of the national program of action should therefore be to achieve a comprehensive understanding of those combinations of cloud-environment conditions and seeding methods that lead to useful weather changes in a reliable and predictable manner. This will require a balanced and coordinated mix of quantitative theory, laboratory studies, and field studies controlled primarily with a view to what can be learned from them.

The national program in this field will need to maintain very close coordination with the National Climate Program, the national energy authorities, and other groups active in natural resources management.

The broad research-and-development effort in weather resources management should not, at this stage, be oriented primarily to user constituencies—though every opportunity should be taken to be responsive to user needs, to transfer scientific guidance and seeding technology to user groups and operational weather modifiers, and to make sure that whatever operations are conducted are as close as possible to the state of the art.

In sum, the 20-year program of action we recommend would emphasize the following elements:

1. Basic research in all relevant sciences to provide the scientific and engineering foundation for all forms of enhancement of the atmospheric environment—including the creation of several dedicated laboratories at universities across the country.
2. A focused effort to refine existing techniques and develop new ones for increasing precipitation through cloud seeding. The two areas of highest priority are snowpack augmentation from winter mountain clouds and rain enhancement from convective clouds in agricultural regions during grow-

ing seasons. An effort to increase our knowledge of hail processes, and of how to moderate severe thunderstorms, should be associated with the projects primarily designed to make more rain.

3. Increased efforts to dissipate stratus and learn more about warm fog.
4. Studies of "unintended weather modification"—that is, research on atmospheric responses to urbanization, industrialization, agricultural and land-use practices, and other human activities, with emphasis upon responses in time scales of hours and days, as opposed to years and decades. (The latter, which are also important, will be part of current plans for the National Climate Program.)
5. An effort to develop techniques for reducing peak winds in hurricanes, and possibly other damaging characteristics of hurricanes, through cloud seeding.
6. Create a growing pattern of international research cooperation and play our part in the first international cloud-seeding program.
7. Research on methods other than cloud seeding to modify the weather.
8. Research on impacts—environmental, economic, and social—of weather resources management.
9. A cooperative Federal/State/local effort to garner the maximum scientific knowledge from selected operational cloud-seeding projects.

The recommended R & D effort calls for Federal appropriations of \$37 million (twice the current rate) in the first program year, and increases to \$90 million in the fifth year.

XV.

Weather modification has never attained a critical mass or momentum in Federal organization. The small pockets of interested activity (the largest being 38 persons among the National Oceanic and Atmospheric Administration's 13,000 employees, and 32 of the Bureau of Reclamation's 7,000) are vulnerable to on-again-off-again budgets, bureaucratic rivalries, and the pluralism of Congressional jurisdictions. Funds for an activity of growing potential have actually been declining in recent years. As things stand, *we are tackling 20-year problems with 5-year projects staffed by short-term contracts and funded by 1-year appropriations. It is not good enough.*

The need for better focused Federal leadership is hardly an original theme. It has been played by every committee, of Congress, the Executive, and the National Academy of Sciences, that has examined the field of weather modification for more than a decade.

The problem here is how to build into the structure of the Federal Government effective leadership for so comparatively small a spending program. Our proposal is deliberately unusual: that the Congress create and the President appoint a small commission, the National Weather Resources Management Board (NWRMB), with the Executive authority—and funding—to nurse through

adolescence the science and practice of weather modification.

We have considered and rejected the often suggested formula of designating a "lead agency." That would leave things more or less the way they are. In practice, setting up a lead agency generally means telling one part of the Executive establishment to take charge without placing in its hands the tools required for leadership.

In our proposal, *the key management concepts are the consolidation of all the Federal Government's weather modification work in one organization and sufficient autonomy for that organization to produce, defend, and carry out a serious and consistent long-term program of research and development.* The same organization could readily handle the licensing of weather modification operators and the formulation of guidelines for operational weather modification.

The new Board would appoint its own executive director with the concurrence of the head of the host agency. It would construct, and defend through the chain of Executive and Congressional review, a national budget covering all civilian Federal weather modification activities; the only exception would be basic research funded by the National Science Foundation as part of its general mandate to strengthen the Nation's scientific underpinnings.

The National Weather Resources Management Board would bring into its purview, as its own staff or through contractual relationships, all the Federal Government's

existing weather modification activities. The new Board would carry on existing projects that fit the proposed R & D strategy; new major field experiments would be planned by the Board. It should be mandated by Congress to use in its work the services of universities, expert panels, State and local authorities, and private enterprises. It would render an annual report—a summation of performance, problems, and prospects, with recommended action, in the field of deliberate [and] unintended weather change.

If President Carter presents a reorganization plan that combines some of the Department of the Interior's functions with those of the National Oceanic and Atmospheric Administration, the Water Resources Council, and related Federal activities, a new National Weather Resources Management Board obviously belongs in that Department.

Meanwhile, *the problem is to make sure that the newly consolidated agency has a "life of its own" within an existing Federal Agency.* We have considered and analyzed the options. In consequence, we recommend that the weather modification function should be associated with the National Oceanic and Atmospheric Administration in the Department of Commerce. We strongly urge that the principles of organization proposed in this Report, to which the Administrator of NOAA has told us he is committed, become the framework for a genuinely new start in the management of weather resources. •

Senator STEVENSON. Thank you, sir.

Dr. Battan?

Dr. BATTAN. Mr. Chairman, thank you for your invitation to the National Advisory Committee on Oceans and Atmosphere. Dr. Evelyn Murphy, the chairwoman of the committee, asked me to appear on behalf of the committee. Dr. James Almazan, the staff meteorologist of the committee who participated in the preparation of this testimony, is here with me today.

We have submitted a statement, and I would like to make some summary remarks.

Senator STEVENSON. Your full statement will be entered in the record.

Dr. BATTAN. By profession I am a cloud physicist who has been closely associated with weather modification research for many years. For example, I directed a 7-year cloud seeding research program, have been a member of several delegations to the U.S.S.R. to discuss this subject, and have been a member and chairman of the Committee on Atmospheric Sciences of the National Academy of Sciences when it issued reports on this subject.

There is widespread agreement with the Weather Modification Advisory Board on where we stand in the development of a weather modification technology.

First, supercooled clouds and fogs can be cleared by seeding them with ice crystal nuclei such as ice, dry ice, and silver iodide. This technique is being used on an operational basis in various countries of the world.

Second, the evidence indicates that in some special circumstances precipitation can be substantially increased or, in different circumstances, can be decreased by means of ice nuclei seeding. In most circumstances, the results of cloud seeding on precipitation are unpredictable. A reliable precipitation modification technology does not yet exist, but the prospects are good for developing one that is effective in certain areas of the United States.

Third, notwithstanding claims by Soviet scientists that they have developed cost-effective hail reduction techniques, those claims have not been verified by independent tests. Furthermore, hail-storm research in the United States and elsewhere raises serious doubts about the effectiveness of the Soviet seeding procedures. Nevertheless, it appears to be physically plausible to develop a hail-suppression technology.

Fourth, there is some evidence to suggest that it might be possible to reduce the peak wind speeds in hurricanes, but the evidence is weak in character and small in quantity.

We concur with the Board and other groups that have looked at this problem, that in order to achieve useful weather modification technologies, the following steps should be taken:

First, there should be major continuing programs of fundamental research on natural mechanisms of cloud and precipitation formation.

Second, in order to achieve precipitation modification and severe-storm mitigation technologies at an early date, carefully designed, randomized cloud seeding programs should be conducted in different climatological areas of the United States.

Third, there should be continuing studies on the societal impacts of an effective weather modification technology.

We believe that the major impediments to progress in purposeful weather modification at this time are not organizational, but rather are attributable to the following factors: First a funding has been inadequate and unstable. In fiscal year 1972 the Federal budget for weather modification research and development was about \$18 million. In fiscal year 1975 it had dropped to \$12 million. In fiscal year 1978 it was back up to about \$14 million. With this type of funding—which is low and unstable—it is very difficult to carry out long-term cloud-seeding experiments and programs of fundamental research that give us the answers we are looking for.

The second impediment to progress, in our judgment, is inadequate planning and coordination of Federal programs. Before essentially all weather modification activities are centralized in a single agency, that agency should demonstrate the following attributes: A conviction of the worth of the program; a competency to do the job—competency in scientific affairs and in the management of a science and technology development program and a broad view of the problems involved. It should have competence to marshal the expertise in other Government agencies, in the universities and the private sector toward the achievement of the goals that most of us agree on.

And third, we think the agency should demonstrate a readiness to work aggressively to do a job. It is not enough to say, "If you ask me to do it and give us the funds, we'll be happy to take on the responsibility."

We do not believe that NOAA or any other Federal agency has shown that it meets these criteria for assuming management of the national weather modification program.

We recommend that, to make progress in weather modification, we should take the following steps:

First, seek improved planning and coordination through a National Weather Modification Coordinating Committee made up of representatives from government, universities, and the private sector. Such a committee should be under the direction of the Office of Science and Technology Policy. It does not seem to be possible in the Washington scene today for a single agency to be effectively plan and coordinate activities of other agencies.

Second, we believe that funding for a weather modification program should be increased by a factor of 2 to a level of about \$30 million a year, as proposed in your bill, and that a 5-year funding commitment should be made.

We believe that it is premature at this time to establish a system of licensing and permitting at the Federal level. Various States have such provisions and the States at this time should be allowed to continue to do this, if they feel they are needed.

We believe that at this stage of development licensing and the establishment of permits would lead to an unnecessary amount of restriction on research and development programs.

We are conscious of the following problem, however. It is possible for a large, promising, expensive research program in one area—let's say the State of Kansas—to be jeopardized by a cloud seeding program which is carried out in the State of Colorado by some

independent operator who seeds every day. Such an operation could introduce, into the upwind region of the experimental area, seeding materials in such a way that the experiment is jeopardized. This is a serious problem, but we are informed that it has been dealt with in recent years. Federal rules require the reporting of intentions to carry out a seeding program before the start of the program, in order that existing cloud seeding experiments particularly the Federal Government supported programs—have the time to take action to prevent the interference from taking place.

On the question of reporting, NOAA currently is charged with the responsibility of maintaining reports of existing and planned weather modification programs, and we think that should be continued.

In summary, then, Mr. Chairman, I would like to make the following remarks:

The Weather Modification Advisory Board made up of a wide spectrum of interests concluded that a weather modification program is a good national investment. We agree.

We believe that legislation is needed to establish a national policy and a national program in weather modification.

We urge that there be substantially increased and more stable funding.

We believe that the concentration of all weather modification programs in one agency is not in the national interest at this time. It might lead to better administration, but probably would not lead to rapid advances in science and technology. At this stage of development, we need a high degree of imagination, talent, and competitiveness. Theoretical laboratory and field experiments should be attacking the problems from many points of view with particular emphasis on the fundamental nature of clouds, precipitation, and storms.

Better coordination should be more effective at the level of the Office of Science and Technology Policy than it can be at the departmental level. Experts in universities and the private sector must be brought into the planning and budgeting process. As technologies for precipitation augmentation and severe-storm mitigation are developed, it may become more important to centralize authority and institute systems of licenses and permits.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF LOUIS J. BATTAN, MEMBER, NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE

I am Louis J. Battan, member of the National Advisory Committee on Oceans and Atmosphere (NACOA) and Director of the Institute of Atmospheric Physics at the University of Arizona. I also am former chairman of the Committee on Atmospheric Sciences of the National Academy of Sciences and former President of the American Meteorological Society. My testimony concerning S. 1644, the Weather Modification Management Act of 1979, and S. 829, the Weather Resources Management Act of 1979, is as a member of NACOA.

PART I—GENERAL COMMENTS ON WEATHER MODIFICATION

A major objective of weather modification research over the past three decades has been to develop cloud-seeding technology for increasing precipitation. Such a technology would help to meet the growing water demands of agriculture, industry, and urban centers. Throughout history the problem of inadequate water supplies

has plagued the Great Plains and the southwestern part of the United States; however, in recent years, even the more humid regions of the central and eastern sections of the country have been experiencing major water resource management and conservation problems, almost on an annual basis. It is essential to investigate all techniques for augmenting the Nation's water supplies. Cloud seeding has the potential to increase valuable water supplies at little expense to the Nation. Advances over the past decade encourage us to believe that an effective technology for increasing rain and snow is within reach.

Weather modification by design

About three decades ago, both V. Schaefer in 1946 and B. Vonnegut in 1947 demonstrated that supercooled clouds, that is, those clouds composed of water droplets having temperatures below 0° C., can be altered dramatically by introducing into them small pellets of dry ice or finely divided silver iodide. These seeding materials convert a supercooled cloud to ice crystals and snowflakes that grow and fall out of the cloud. This sequence of events can be explained theoretically and has been repeated often enough that it is no longer in doubt. Supercooled fogs over airports are regularly cleared by seeding them with ice-crystal-producing substances.

It is tempting to extrapolate the results just noted to conclude that if thin supercooled clouds can be caused to produce falling ice crystals and snowflakes, the same could be done with thick clouds to yield substantial quantities of rain and snow over many regions of the United States. Unfortunately, such a result has not yet been demonstrated to the satisfaction of most atmospheric scientists.

Nevertheless, farmers and power companies in many countries facing severe losses from water shortages or threats of hail to crops have been using the services of private cloud-seeding companies. A measure of the willingness to gamble on the likely success of cloud seeding to obtain additional water is indicated by the fact that in 1977 cloud seeding was done over about 7 percent of the land area in the United States. Regrettably, in the absence of adequate experimental controls, it is not possible to assess the actual effects of cloud seeding programs.

Many governmental and private groups have surveyed the state of weather modification research and application. A distinguished Weather Modification Advisory Board, chaired by Harlan Cleveland, produced the most recent study, "The Management of Weather Resources, Volumes I and II."¹ This study of the status of weather modification and its potential in the United States was legislated by an interested Congress and signed into law in October 1976 as the National Weather Modification Policy Act of 1976 (Public Law 94-990). The purpose of this Act was, *inter alia*: "To develop a comprehensive and coordinated national weather modification policy and a national program of weather modification research and development . . ." The Act called upon the Secretary of Commerce to conduct a comprehensive study and review of the economic, funding, international, regulatory, scientific, social, and technical characteristics of weather modification.

As was the case with earlier reports by the Committee on Atmospheric Sciences² and the Board on Agriculture and Renewable Resources³ of the National Academy of Sciences, this new analysis by the Weather Modification Advisory Board supported the following general conclusions:

1. Supercooled clouds and fogs can be cleared by seeding them with ice-crystal nuclei, such as dry ice and silver iodide.
 2. Evidence indicates that in some special circumstances precipitation can be substantially increased, or in different circumstances, decreased, by means of ice-nuclei seeding. In most circumstances, the results of cloud seeding on precipitation are unprecipitable. A reliable precipitation modification technology does not yet exist, but the prospects are good for developing one that is effective in certain areas of the United States.
 3. Soviet scientists claim that they have developed cost-effective hail reduction technologies; however, independent tests do not verify those claims. Furthermore, hailstorm research in the United States and elsewhere raises serious doubts about the effectiveness of the Soviet seeding techniques. Nevertheless, it appears to be plausible physically to develop a hail suppression technology.
 4. Some evidence suggests that it might be possible to reduce the peak wind speeds in hurricanes, but the evidence is weak in character and small in quantity.
- The report by the Weather Modification Advisory Board noted the opportunities and potential benefits of effective weather modification technologies. It also recog-

¹ Published in 1978 by the Superintendent of Documents, Washington, D.C.

² "Weather and Climate Modification: Problems and Progress," 1973. National Academy of Sciences, Washington, D.C.

³ "Climate and Food," 1976. National Academy of Sciences, Washington, D.C.

nized the scientific and societal problems and difficulties. As did earlier reports by groups organized by the National Academy of Sciences, the Board called for a major long-range, national commitment to the development and application of effective weather modification procedures. Specifically, the report of the Board states that: "The aim . . . of the national program of action should therefore be to achieve a comprehensive understanding of those combinations of cloud-environment conditions and seeding methods that lead to useful weather changes in a reliable and predictable manner." The National Advisory Committee on Oceans and Atmosphere (NACOA) endorses this approach toward the development of a weather modification technology and recognizes that it requires well-conceived, theoretical laboratory and field investigations, carried out over many years. This will necessitate a joint effort by cloud physicists, cloud dynamicists, mesoscale dynamicists, statisticians, ecologists, and social scientists.

There are various reasons why there has not been greater progress in the development of a weather modification technology. The primary reason, in the view of many atmospheric scientists, is an inadequate understanding of the nature of clouds and precipitation systems.

The second major reason is that there has yet to be, in the United States, a carefully designed and executed seeding project conducted over a sufficiently long period of time to demonstrate conclusively that cloud seeding can increase precipitation by economically significant amounts. The highly variable nature of precipitation makes it difficult to identify seeding effects that are relatively small. To obtain conclusive statistical results for any seeding program, experimental bias must be minimized by incorporating a randomization procedure for deciding which clouds or cloud systems are to be seeded. This randomization requirement demands that a seeding program be carried out over a period long enough to accumulate sufficient data to allow meaningful analyses.

Another major impediment to progress that has influenced all the others has been the prevalence of inadequate and short-term funding. The report of the Weather Modification Advisory Board states: "We are tackling 20-year problems with 5-year projects staffed by short-term contracts and funded by 1-year appropriations. It is not good enough."

Recommendations

The Committee urges that the U.S. Government adopt a comprehensive, national weather modification policy and a national program of weather modification research and development. Scientific and technical developments of the recent past lead us to conclude that an economically feasible weather modification technology can be developed. New doppler radar and satellite techniques, coupled with more conventional observational methods and further developments in three-dimensional cloud and mesoscale models, offer promising opportunities for advancing our fundamental understanding and for facilitating the conduct of conclusive cloud-seeding experiments.

In pursuing the scientific aspects of such a national program, the Committee offers the following recommendations:

There should be major continuing programs of fundamental research on natural mechanisms of cloud and precipitation formation.

Until more is known about natural processes, experimental cloud-seeding programs will have to be based on limited knowledge and the likelihood of success will not be optimum. By means of experimental and theoretical studies, much more needs to be learned about ice-crystal formation in natural and seeded clouds. It is essential to develop a better understanding of the interactions of clouds and their environments, with particular concern on how these interactions affect cloud and precipitation development.

To achieve precipitation modification and severe storm mitigation technologies at an early date, carefully designed, randomized cloud-seeding programs should be conducted in different climatological areas of the United States.

Available scientific and statistical evidence supports the hypothesis that ice-nuclei seeding of winter storms over the mountains of the western United States could increase snowfall by 10 to 30 percent. This hypothesis must be tested conclusively by means of a cloud seeding program that incorporates sound physical and statistical concepts in its design, execution, and analysis.

Research over the past two decades strongly suggests that rainfall can be increased from summer convective clouds of the type so crucial for agriculture. At least two major cloud-seeding research projects can be justified at this time. One project would deal with summer convective clouds over the humid eastern or midwestern regions of the United States. A second project should concentrate on convective clouds over the drier Great Plains.

Every cloud-seeding experiment should be viewed as a research program having two major objectives:

1. An experiment for testing one or more scientific weather modification hypotheses.
2. An observational and experimental investigation for learning about the fundamental nature of cloud and precipitation formation processes.

Before engaging in a major hailstorm seeding program, more needs to be known about natural storms and hail-formation process to formulate a feasible seeding hypothesis.

There should be continuing studies on the societal impacts of an effective weather modification technology. This includes analyses of the environmental impacts of weather modification operations. Over the past three decades, weather modification programs have raised a variety of legal and economic issues that have not yet been resolved. Some of them are international in nature. For example, procedures must be developed to resolve conflicts that can arise when attempts are made to modify storms, such as hurricanes, that can affect more than one nation. In addition, the use of weather modification techniques for hostile purposes needs to be understood better and controlled.

Federal organization for weather modification

The Weather Modification Advisory Board recommended that a semiautonomous body be established within the National Oceanic and Atmospheric Administration (NOAA) that was charged with major responsibility and authority for carrying out a national weather modification program. All Federal activity, except basic research responsibilities assigned to the National Science Foundation (NSF), would be transferred to a proposed National Weather Resources Management Program within NOAA.

A 1973 report of the Committee on Atmospheric Sciences of the National Academy of Sciences had recommended that NOAA be assigned lead-agency responsibility for Federal programs in weather modification.

These recommendations seem appropriate, because weather modification problems are mostly meteorological in nature, and NOAA is the Federal agency broadly charged with dealing with meteorological matters.

Unfortunately, NOAA has not pursued with conviction, vigor, and effectiveness, a national program in weather modification research, development, and management. The Weather Modification Advisory Board issued its report in July 1978. We anticipated that the Secretary of Commerce would issue shortly thereafter, a report to the President and Congress leading to the introduction of legislation prescribing a national policy and plan for weather modification activities; this has not happened yet.

We note that most of the weather modification community believes that at this time it would not be in the national interest to assign to NOAA principal responsibility for the development and management of a national program in weather modification. NACOA shares this view.

We conclude that the best course of action, at this time, is to maintain existing weather modification research programs in NOAA, the Bureau of Reclamation, the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF); however, we must establish a stronger planning and coordination mechanism and substantially increase the funding to a level that is more nearly commensurate with the needs.

To deal with the national interests rather than those of a particular agency, planning and coordination should be at the level of the Office of Science and Technology Policy (OSTP) and should include representatives from *government, universities, and the private sector* in developing plans.

The principal participating agencies in the National Weather Modification Program would continue to be NOAA, the Bureau of Reclamation, NASA, and NSF. Because of the widely recognized fact that progress in the development of an effective weather modification technology depends strongly on the development of greater understanding of the fundamental nature of clouds and precipitation, it is particularly important that NSF play a major role in this program. Its budget for weather modification activities needs to be increased substantially. NSF should, in particular, play a major role in the OSTP planning and coordination of the national program.

Section 2. Findings

We agree with these findings, but have some reservations about how this Act proposes to regulate weather modification activities. The discussion of Section 6 addresses this matter.

Section 3. Policy

We concur with the provisions for a national weather modification policy outlined in Section 3, but recommend that there be an additional provision:

(1) Weather modification techniques will be used for peaceful purposes and for advancing human welfare in the United States and all other nations.

The purpose of this statement is to emphasize that the United States, as a matter of policy, does not intend to use weather modification techniques as weapons of war. To ensure the peaceful use of weather modification, the General Assembly of the United Nations adopted and opened for signature on May 18, 1977, the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques. At that time, the United States and 33 other nations signed the document; the U.S. Senate has not yet ratified it.

Section 4. Purposes

We agree with the purposes of this Act, but have reservations about Item (2) that deals with the licensing of weather modification activities. The discussion of Section 6 addresses this point.

Section 5. Definitions

The definitions given in this Section are satisfactory.

Section 6. National Weather Modification Management program

Because NOAA is the Federal agency charged with the responsibility of dealing with weather and climate research, development, and application, it is reasonable to look to NOAA for leadership in a national weather modification program. Unfortunately, NOAA has not supplied that leadership. Over the past 15 months, since the publication of the final report of the Weather Modification Advisory Board in July 1978, NOAA has not shown that it wishes to pursue aggressively an effective program of weather modification research, development, and application.

It would not be in the national interest, at this time, to assign to NOAA or any other agency the primary responsibility for managing a national weather modification program unless that agency demonstrates a conviction of the worth of the program, competence to do the job, and readiness to work aggressively to make the program succeed.

We do not believe that any Federal agency has shown that it meets these criteria for designation as a lead agency for weather modification. For this reason, NACOA recommends that no agency be so designated. Instead, we recommend a National Weather Modification Coordinating Committee be established under the overall responsibility of the Office of Science and Technology Policy (OSTP) to plan and coordinate the activities of those agencies currently involved in weather modification activities. This includes NOAA, Bureau of Reclamation, NASA, and NSF. For an effective weather modification technology to be developed, we need a greater understanding of the fundamental nature of clouds and precipitation. NSF should play a major role in the planning and coordination of a national program, which will require a substantial increase in its budget for weather modification activities.

The Weather Modification Coordinating Committee could take on a structure and responsibilities somewhat similar to those specified for the Weather Modification Advisory Council noted in Section 6, Paragraph (d)(3) and described in Section 7, except that the Committee would report to OSTP rather than the Secretary of Commerce.

We believe that such an arrangement falls short of the optimum, i.e., a well-funded, highly qualified, and highly motivated lead agency. At the same time, we are convinced that our proposal is the most practical one at this time and should inject those ingredients needed to stimulate progress. It should be regarded as a temporary measure subject to review after a few years. In the long term, as the program progresses, the lead agency concept can be instituted.

Section 6(b). Program elements

We concur with the list of program elements except for Item (7) that deals with licensing.

Section 6(c). Director and 6(d). Duties and Sec. 7. Weather Modification Advisory Council

If it is decided to follow the recommendations made under our comments to Sec. 6(a), Sections 6(c), 6(d), Section 7 of the act would no longer apply.

Section 8. Licenses for weather modification operations

Because weather modification is mostly in the research and experimental stage, we believe it is premature to establish "a system for licensing all individuals having responsibility to design or perform any weather modification activity . . ." We believe the costs involved in licensing all such individuals would exceed the benefits.

Undoubtedly, there are few "meteorological quacks" peddling worthless weather modification schemes, but this alone is inadequate to justify an elaborate, all-encompassing Federal licensing program. In view of the undeveloped state of the relevant science and technology and the uncertainty of the results of cloud seeding, the licensing provisions would have to be loose. We suspect that most weather modification activities conducted in the United States over the past few years have been carried out by individuals who would qualify for a Federal license.

It would appear, in view of the very substantial uncertainties about the effects of cloud seeding, that the Federal Government should not establish a licensing program until some widely accepted, significant weather modification techniques have been developed. Individual States could be allowed to adopt licensing systems if they are deemed necessary.

Notwithstanding our belief that Federal licensing would be premature, we are convinced that steps must be taken to protect federally funded scientific experiments from interference introduced by other nearby weather modification experiments or operations. Some observers suggest that this could be done by requiring Federal permits for all weather modification activities. The resulting criteria, rules, procedures, and enforcement provisions would probably lead to excessive restrictions and impediments at a time when we need innovation, experimentation, and free enterprise. It would appear to be more reasonable at this time to continue to require the reporting and publication of the place, time, intent, and other details of all weather modification activities before the start of any project, so that an existing or planned experimental program can be stopped before it can cause unreasonable interference.

Section 9. Reporting of weather modification activities

We believe that the Secretary of Commerce should continue to be responsible for maintaining a record of weather modification activities and for publishing an annual summary in the manner prescribed in Section 9.

To deal with the problem we discussed under Section 8, the person primarily responsible for a weather modification activity should be required to report and publish, at least 10 days in advance of any attempts to modify the weather, the information listed under Sec. 9(c), except that 9(c)(1) should be the scheduled dates of the initiation and conclusion of the proposed seeding activity. We believe that such a reporting requirement is currently in effect.

Prior publications of planned activity would allow individuals and organizations that believe the planned activity would be detrimental to seek injunctive or other relief measures.

Section 10. Biennial report

We favor such a report but if our suggestions under Section 6(a) are accepted, the Office of Science and Technology Policy would prepare and submit it.

Section 11. Contract and grant authority

The intents of this Section are satisfactory, but the applications would depend on the organizational structure of the national weather modification program.

Section 12. Administrative provisions

If our suggestions under Section 6(a) are accepted, there would be no transfer of these responsibilities to the Secretary of Commerce.

Section 13. Miscellaneous provisions

The intents of Sections 13(a) and 13(b) are satisfactory, but the applications would depend on the organizational structure of the national weather modification program.

Sections 13(c) and 13(d) are reasonable ones if this Bill is enacted.

Section 14. Authorizations of appropriations

We believe the funding authorized in this section is reasonable and adequate to carry out a successful program of research and development.

We believe that, at this time, the greatest impediment to progress of weather modification is not organizational in nature, but rather is attributable to inadequate and unstable funding, particularly for basic research and field experimentation. A long-term Congressional commitment of the kind outlined in Section 14 would go a long way towards achieving the objective listed in Section 3 of S. 1644.

COMMENTS ON S. 829 (SENATOR BELLMON'S BILL)

In our discussion of S. 1644, we have already commented about the substance of a national weather modification policy and program. Most of our comments also can be applied to S. 829.

We should note explicitly that we do not believe that the National Aeronautics and Space Administration (NASA) should be charged with principal responsibility for a national weather modification program.

It is widely acknowledged that NASA has done a magnificent job in developing the hardware needed for satellite technology and exploration. It also is well-known that these accomplishments have been made at costs that dwarf the budgets of most atmospheric science programs and make our national weather modification program look miniscule.

The problems in weather modification are of a scientific nature involving a high level of expertise in the nature of atmospheric aerosols, clouds and precipitation, and storm systems and their interactions with the surroundings. NASA does not have the broad-based meteorological expertise to deal successfully with a national weather modification of the scale visualized in both S. 829 and S. 1644.

We are particularly concerned that S. 829 does not include a strong program of fundamental research on weather modification problems within the National Science Foundation.

Senator STEVENSON. Thank you, sir.

Dr. White.

Dr. WHITE. Mr. Chairman, members of the committee, I welcome this opportunity to present my views on S. 1644 and S. 829, the Weather Modification Act of 1979, and its companion the Weather Resources Management Act of 1979.

To one who has witnessed a decade of floundering on this important subject, it is encouraging to me to see action by this committee to establish a national policy and program in weather modification. It is long overdue.

I first became involved in our national weather modification programs when I became Chief of the U.S. Weather Bureau in 1963. One of my great disappointments, after 15 years in Government, including the last 7 as Administrator of the National Oceanic and Atmospheric Administration, was the failure to develop a productive national effort. It was not that we did not try—we tried over and over again. The weather modification effort of our Government has now been endlessly studied, but the submarginal and fractionated effort has persisted.

It was therefore with great enthusiasm that I welcomed the initiative of this committee more than 3 years ago when, as a result of its efforts, the Congress enacted the National Weather Modification Policy Act of 1976, which directed the Secretary of Commerce to develop a comprehensive and coordinated national policy on weather modification and a national program of weather modification research and development.

I was deeply involved at that time with the appointment of what has become known as the "Cleveland Weather Modification Advisory Committee." The concept was to have a select group of individuals outside the Federal Government make a careful appraisal of

the Nation's needs and opportunities in the field of weather modification.

That committee has issued an excellent report. It has set forth some national goals and a framework for action. Both S. 1644 and S. 829 draw heavily on the recommendations of that report.

I believe that S. 1644 comes closer to the Cleveland recommendations, and I would favor it as a basis for legislative action. The findings, policy, and purposes of sections 2, 3, and 4, catch my views well. Sections 6 and 7 of the act, which address matters of organization and management, however, are at its heart. It is on the provisions of these sections that I would like to dwell.

The proposal outlined in the act could work well. It conforms to the recommendations of many studies, to establish NOAA as a focal agency for the program. There are differences from the recommendations of the Cleveland committee, principally in the degree of autonomy granted the weather modifications program within the Department of Commerce. I should think that NOAA would embrace the act. I support its enactment.

As S. 1644 is now drawn, it grants the necessary broad authority to NOAA, the NSF, and other agencies to establish a national weather modification program.

The purposes of the act could, however, be implemented in many different ways. It is my belief that success will be closely tied to how it is implemented. Therefore I would like to suggest some approaches that the committee may wish to consider for inclusion in the act, or a part of its legislative history.

If we ask why progress over the past two decades has sputtered, why funding has been marginal, and why no effective management arrangement for the national effort exists, we may clarify what needs to be done.

At the core of our predicament have been the uncertainties about the scientific validity of much weather modification research, and those that surround the practicability of weather modification.

The uncertainties stem in part from a lack of basic understanding of basic atmospheric physical processes, and in part from the difficulty in determining whether the interference in these processes has actually resulted in postulated weather changes.

The great natural variability of the weather can easily obscure the effects of weather modification efforts. One has only to recall how variable rainfall can be from one place to another to realize how difficult the problem of evaluation is.

Because of this, results of field experiments conducted in less than a scientifically rigorous way are suspect. In spite of these uncertainties, there has gradually emerged a sense that limited success in rainfall enhancement, fog dispersal, and snowfall augmentation under certain conditions has been achieved.

A cautious endorsement of the reality of these results by various scientific groups, including those assembled by the National Academy of Sciences in 1963 and in 1973, has in some cases led to unrealistic expectations.

In extreme weather situations such as drought, desperate people seek remedies, however unreliable, if they offer any hope of relief.

Weather modification has been viewed by some as such a remedy. We should not be surprised, therefore, that farmers or

others dependent on adequate water supplies, when confronted with disaster, should seek action through State and National Legislatures to explore and foster the use of weather modification techniques to stave off crop failures or water supply shortages, even though the probability of success is low.

We should also not be surprised that scientists generally have been reluctant to endorse the use of weather modification techniques under such conditions because of the unwarranted expectations.

Just as nature abhors a vacuum, our political system abhors unmet needs of important segments of our society. As a result, our weather modification programs took hold in parts of the Federal bureaucracy that were willing to meet these needs, and once they had taken hold, a well planned and coordinated program became difficult to organize.

In a succession of administrations, the weather modification cake was not regarded as worth the political candle. It was a small program, and attempts to change it evoked such intense congressional, agency, and constituency reactions that the gains that could be achieved were regarded as hardly worth the pain to be endured.

As a result, we contented ourselves with the status quo—submarginal efforts, scattered in several agencies, each proceeding in response to its constituency needs, and nobody considering weather modification in all of its ramifications as an important objective in itself.

This experience of the last two decades leads me to suggest the following:

The management of the research and associated parts of the national weather modification program, with the possible exception of hurricanes, must be placed in a credible scientific environment reasonably isolated from bureaucratic strains.

The National Science Foundation, NASA, the Department of Energy, and other Government agencies have used many university arrangements—centers, institutes, and consortia—to achieve such a goal.

A possible university framework for major parts of the weather modification program already exists. It has been in existence for 20 years. I am speaking of the University Corporation for Atmospheric Research, funded by the National Science Foundation to manage the affairs of the National Center for Atmospheric Research in Boulder, Colo. This is a consortium of 49 universities involved in the atmospheric sciences. It can provide a mechanism for entraining the participation of the university community in a comprehensive national effort in weather modification. Appropriate laboratories of the Federal agencies could also participate.

I should indicate to this committee that I am not unbiased in this matter. I am a member of the board of trustees of UCAR.

The universities through UCAR could be asked to take on the responsibilities for major parts of the research experiments, the assistance to non-Federal entities, and the investigation of nontechnological effects called for in the act.

The universities of the University Corporation for Atmospheric Research are based throughout the country. Because of this, groups

of them could undertake long-term weather modification research and field experiments in different parts of the country.

The National Center for Atmospheric Research, with its incomparable facilities, could give such a program strong participation and support.

The universities would also be in a position to provide advice and assistance, based on the best available scientific knowledge, and technological capabilities to States, local governments, and others interested in conducting weather modification for operational purposes.

Such an entity could be funded by the National Oceanic and Atmospheric Administration, the National Science Foundation, or jointly by several interested agencies.

Its responsiveness to national needs would be assured by the management oversight of the Federal agencies. It could start modestly, building on one or two central experiments. Present weather modification research efforts need not be disrupted. They could be continued to their logical conclusion under their present sponsors, or transferred from management and conclusion to UCAR if the sponsoring agencies felt this desirable.

Over several years we could build the kind of focus that I think the Nation needs, without serious disruption to present efforts. In a sense, this might achieve some of the objectives of the semiautonomous Weather Resources Management Board advocated by the Cleveland committee.

We can expect that operational weather modification will be conducted willy-nilly. Operational weather modification will be carried out or sponsored by other Federal agencies to meet their mission needs, by State and local governments, and by private groups.

Our goal should be to insure that, whenever possible, they be carried out in accordance with the best available scientific knowledge, and that they yield useful data for evaluation.

The act provides for assistance to State or local governments or other entities. While the intent seems to be the support of weather modification research and demonstration efforts, it is not restricted to them.

If assistance to carefully selected operational projects is conditioned on making such undertakings yield useful data for evaluation and for research purposes, we will have taken a major step forward in building our base of knowledge about the efficacy of weather modification.

NOAA is the logical agency to be responsible for all Federal regulations, licensing, monitoring, and reporting of weather modification activities to the extent that they are necessary. This would be quite in line with many of NOAA's other environmental management responsibilities in the field of ocean resources and the coastal zone.

A critical element of any program will be in the evaluation of the results of weather modification efforts in the field. In my opinion, neither bill stresses this matter sufficiently.

What will be needed is an evaluation effort conducted by an impartial institution. I am, as you know, the Administrator of the National Research Council of the National Academy of Sciences

and so, once again, I must indicate a bias. But it seems to me that the Academy offers the kind of environment in which a scientifically credible evaluation could be undertaken.

If the approach suggested here or one similar to it were adopted, we would have achieved the following:

We would have established the kind of long-range sustained research effort called for in the Cleveland report under the management of the scientific community and within the context of the university groups who have the interest, capability, and scientific knowledge to carry out a sound program.

We would have gone a long way toward eliminating many of the bureaucratic problems that for so long have stalled a comprehensive national weather modification effort.

We would introduce an effective means of providing assistance to those who need it. In a sense, we would be establishing a weather modification extension service. In this case the assistance would be to State and local governments who want to be apprised of the latest scientific approaches to weather modification. It would have the added value of encouraging the organization of operational weather modification activities so that the data might be useful for scientific assessment purposes.

We would have separated regulatory and licensing activities from research and operational weather modification.

Mr. Chairman, for the most part these suggestions can be accommodated under the authorities in the act, but some modification would be necessary. I hope the committee will find them of some value.

Thank you.

Senator STEVENSON. Thank you, sir.

Dr. White, you said that NOAA is the logical agency to be responsible for all Federal regulations, licensing, monitoring, and reporting weather modification activities, to the extent they are necessary.

To what extent are Federal regulation and licensing necessary?

Dr. WHITE. My view on the regulation is that I would agree with Harlan Cleveland and with Dr. Battan. We want to go very lightly. But I do think that some Federal regulatory authority will be needed to prevent interference—the problem that Dr. Battan mentioned. I am not quite sure how one goes about preventing interference unless some regulatory authority is available for that purpose.

But I would only introduce regulatory authorities to the extent that they are demonstrated to be actually necessary. I believe that is one that is actually necessary.

Senator STEVENSON. And that goes for licensing, too?

Dr. WHITE. I would agree with the Cleveland report that Federal licensing is desirable.

Senator STEVENSON. It is desirable?

Dr. WHITE. I would say so.

Senator STEVENSON. That is demonstrably necessary, now, in your view?

Dr. WHITE. In my view, I think that we should insist that people who are going to go out and modify the weather meet certain minimum requirements. Now there are State licensing activities, but I think they should be uniform across the country.

Senator STEVENSON. Mr. Cleveland, how do you respond to Dr. White's suggestion, and in particular his suggestion for organizing this enterprise?

Mr. CLEVELAND. I must say, I think that it is a very creative notion. I think that it would help to pull together in one place a comprehensive research and development effort.

I like our proposal better, but if it won't fly I think I would fall back first to Dr. White's.

Senator STEVENSON. You mentioned your experience with inter-agency efforts. What experience have we with board-managed efforts that gives you more confidence in that formulation? It's management by committee, isn't it?

Mr. CLEVELAND. I'll tell you how we came to this particular idea in the report. It was as a result of looking at the record, in the very early stages of aviation in this country, of the National Advisory Committee on Aeronautics. That was a small, very distinguished board of people who were not otherwise involved in the Federal Government, and which for several decades nursed what started (in 1915, I think it was, that the NACA was authorized) as a rather infant industry, nursed the quality control of that industry so that American aviation became the extraordinary success story that it did become.

This was done by a collective executive which had its own full-time executive staff, but the small board consisted of people who spent quite a lot of their time on what you might call "aviation strategy."

Now weather modification will never be the monster industry that aviation now is. But there is a somewhat comparable situation here. You have an infant industry. You have a lot of uncertainties, scientific and also social, which require concentrated thinking across a very wide spectrum of subject matter—some "strategic thinking," if you will.

I think that you could attract to that task four or five first-rate people who would spend some considerable part of their time worrying about this subject over the next decade or two, and that that would provide a kind of intellectual and, if you will, moral focus for this effort. It would enable us to do, as I indicated, what we usually don't do, which is to develop the economic and social ideas and the institutions in parallel with the development of hardware—rather than developing a technology and then scratching our heads and saying, "Oh, look, we've split the atom, and here's the bomb, and now let's think about arms control," which is our normal procedure.

The setup we suggested would be unusual. But it would be a positive benefit to establish something unusual, so that everybody would know that it was supposed to be unusual.

Senator STEVENSON. Dr. Battan, I was going to say that you are in the minority, but if it is you and the administration, then it is about evenly divided at the moment.

Do you want to respond?

Dr. BATTAN. Yes. I might say, Senator, that we did not have any notion of what the administration's position was until this morning. We were as much in the clouds—

Senator STEVENSON. Do you want to change your position?

Dr. BATTAN. No, I just want to make it clear that we weren't in cahoots.

On the question of licensing, let me say, that at this stage, there is a fundamental difference I think between licensing someone who has the intention of changing the weather, and licensing an airplane pilot.

We know that if someone takes off in an airplane and lands in the middle of Chicago, the consequences are going to be disastrous. At this stage in the weather modification development business, we are not sure what will happen if you seed clouds. There is great question as to whether or not we can make any change at all, other than dissipating clouds. There are still many questions about whether or not we can produce more rain or reduce the amount of hail.

So we would be licensing people to do that which we are not sure they can do. We would be licensing "intentions," rather than "acts." That is not to say that there are not some quacks in this business, there are. There are weather modification quacks just like there are medical quacks, and it would be desirable if somehow they could be put out of business—and licensing would do it—but there are so few of them around, it is not worth the effort.

I suspect, as we mentioned in our prepared testimony, that, if you set up licensing provisions they would have to be fairly loose in view of the looseness of the subject. As a consequence, I would guess that most of the people who are seeding clouds in the United States today, and who account for this 5 or 7 percent of the land area being under a cloud seeding program, would be licensed anyway—largely because there is no reason for not giving them licenses.

So it seems to me that, as in the aviation business, and as in the automobile business, you have to allow room for a certain degree of freedom of action to find out whether or not you can make weather modification technology that can fly, and whether or not you can make a technology that can put the "horse" out of business.

In this case, we need freedom of action for research, imagination, daring, a time to find out whether a precipitation technology can be developed, and if so, what it is.

Now on the second question with organization, I am concerned about the proposal that Bob White has just made. I have been involved with UCAR, the University Corporation for Atmospheric Research, as a result of our university's affiliation with it, and I have reservations about its ability to put together a team that could manage the national weather modification program.

I think that UCAR can be effective if you could cut out a part of the problem, as we did about 10 years ago—the National Hail Research Experiment was put together to deal with the problem of hail modification. Specifically, the program came about because we learned that the Soviets had been making extravagant claims, spectacular claims that they could reduce hail damage by 60 to 90 percent on a consistent basis. We subsequently have grave reservations about those claims, but nevertheless the Soviet Government has put a great deal of resources into that endeavor, and that inspired us to look at this question of can you reduce the fall of damaging hail. A National Hail Research Experiment was put

together under the auspices of the National Center for Atmospheric Research (NCAR), which is managed by UCAR.

Now I think that in theory, if you could define a task that well, the University Corporation for Atmospheric Research, could put together a program involving scientists at NCAR and the the universities to deal with that specific program.

But to expect UCAR to manage the whole program I think is to expect too much. My guess is that if one has a problem coordinating five or six Federal agencies all of which are getting support from the Federal Government and all of which are answering to the same President, to try to get together even a part of the 49 universities that comprise UCAR for a single position on weather modification would be much more difficult.

No, I do not think that UCAR would be effective in managing the whole program. But admittedly Bob sprung that one on us just recently and we haven't really had a chance to analyze all the pros and the cons.

Senator STEVENSON. Well, Dr. White, as a former NOAA administrator, you seem to have more confidence in NOAA's ability to manage this research enterprise than Dr. Battan does. Why don't you have even more confidence? You seem to feel pretty strongly that the responsibility for the management of the research element ought to be outside of NOAA. Why is that, Dr. White?

Dr. WHITE. The execution. The ultimate management has to remain in the Federal agency which acquires the resources, and this is a standard mode of operation among Federal agencies.

Senator STEVENSON. But would it be standard for the Congress to dictate the mode of execution? We place the responsibility on an agency—dictating which consortium or university or other agency to execute? Is that the thrust?

Dr. WHITE. No, I indicated that I think the authorities in the act are adequate for NOAA or any other agency to deploy their funds in any way they wish.

I am suggesting that the problem is in the implementation, of the programs after you have given the funds to an agency to implement it in accordance with policies set down by legislation. It seems to me that if the intent of the Congress could be indicated in the legislative history, because you certainly do not wish to tie the hands of the Federal agency once you have given them the authority. I think it would be unwise to do so.

Dr. BATTAN. Senator, I don't think NOAA should manage the national program, either. My feeling is—the point I tried to make, and it is made in more detail in the prepared statement—is that the national program should be under the guidance of a committee under the Office of Science and Technology Policy. It might end up to be the CAO that Mr. Richard Frank talked about earlier, with a crucial difference in the way it operates from how ICAS operated earlier.

First of all, Congress should instruct the committee under OSTP to plan and coordinate and seek adequate funding for a national weather modification program.

Second, Congress would mandate that OSTP call on university and private-sector experts for participation in planning and budgeting.

I think the disinclination to include non-government experts in the planning and coordination process was one of the flaws of ICAS. ICAS served many useful functions. It did not serve an effective coordinating function, and I think one of the reasons is because it was an "all government" club.

Dr. WHITE. Mr. Chairman, could I comment on the point made by Dr. Battan?

Senator STEVENSON. Yes, by all means.

Dr. WHITE. He and I seem to be disagreeing today.

I have a sense of *deja vu*, when I hear the proposal that the way to move ahead with the weather modification program is another coordinating committee. Wherever you locate it it will have little effect. In the past 15 years we have had coordinating committees for weather modification not only located in ICAS, but in the White House in the Domestic Council.

The problem is not "coordination"; the program is coordinated to death. Representatives of the agencies meet all the time; they put out reports; we have stacks of them.

What we need to be able to do is make decisions—which means granting authority to some central place—which can move the national weather modification forward as a coherent program rather than to have it, as we've had it up until now, as a fractionated effort.

Now there is a rationale for the kind of fractionated effort we have had in the past. That is, that weather modification is indeed merely a technology to be used by any agency to further its mission. Therefore, there is no need for any kind of sort of centralized approach to it.

One can argue that case. The point made by the Cleveland report, as I understand it, is that: It's time we took a look at weather modification as a mission in and of itself. And if you do that, then the present management arrangements are not suitable for that kind of an approach.

It seems to me that we have to decide on that basic philosophical principle first. If we decide that we want to advance the science and technology of weather modification broadly, then it seems to me you must move closer to a centralized approach than we have had to date.

Senator STEVENSON. Mr. Cleveland?

Mr. CLEVELAND. If I may make one more comment on that, Mr. Chairman, I think that Dr. White has said it very well. The key to the clout of the coordinator is always what his relationship is to the money that the agencies are spending and are going to spend. It doesn't surprise me at all that in a meeting chaired by OMB that OMB would rule that none of the Government witnesses should come out here for a coordinating arrangement that would have the money attached to it.

You'll notice that all of the proposals for coordinating committees don't have any fund allocation function. The fund allocation function would remain in OMB. That's always the hardest thing to get delegated in the executive branch, these pieces of money that would otherwise be coordinated by OMB.

Whatever is done here, it seems to me that there is a very strong case for authorizing and appropriating the funds to be adminis-

tered by whoever is supposed to be taking the leadership role. And if something is done short of that, I'll guarantee you that there won't be very much leadership.

Senator STEVENSON. Dr. Battan, it strikes me that what Mr. Cleveland says makes some sense, and that neither OSTP nor FCCSET have the experience, the staff resources, nor the capacity for management, as opposed to coordinating. They are coordinating the agencies. OSTP derives some authority as a coordinator from the President, but it is difficult for me to conceive of it becoming a manager. Would we appropriate funds to it? I don't think the OSTP itself would want the kind of role that I sense you are envisioning for it—which goes a little bit beyond its typical role of coordinator. Or do you just disagree with what Mr. Cleveland and Dr. White have said about the need for centralizing authority and putting some of the money where the authority is?

Dr. BATTAN. No, in principle I certainly agree with them, that it would make sense if it were possible to put together a package within NOAA where NOAA had the conviction that it was worth doing. The thing that I am concerned with, Mr. Chairman, is that I am troubled, as have other people been troubled—Senator Bellmon was troubled—by the fact that NOAA has not demonstrated it wants to do the job.

Now if it is possible somehow by legislation, or some other mechanism, to convince NOAA that it is worth doing, I would be much more inclined to a proposal whereby NOAA was given principal responsibility, providing that other mission-oriented agencies that have responsibilities in areas which involve weather modification are permitted to carry out those specific programs that affect their own mission.

But I am concerned that the actions of the current NOAA administrators over the last 3 years shows they do not want the job.

Now how could one vest in any organization, whether it is NOAA or any other organization, a responsibility to do a job which they don't want to do? It has been demonstrated that they don't want to do it, not only by the testimony we heard this morning, but by the actions of the last 3 years.

Therefore, you are forced to say, "Where do we go from here?" NOAA doesn't want to do it. I don't think NASA is the agency to do it. As far as I know, the Bureau of Reclamation doesn't want to do it. The National Science Foundation doesn't want to do it. So you say to yourself, "Is that the only course of action I have?"

Now Bob says he gets a feeling of *deja vu*. So do I. I have been around this business. I have seen this thing waffle back and forth. Faced with the realities of the situation at this time, it seems to me that to vest responsibility in NOAA will not move us down the road of developing a weather modification technology.

This morning we have heard mostly from the administrators. From the point of view of the people doing the research, I think you will hear that the problems which are impeding research and development in weather modification today are not primarily organizational. The problems are primarily ones of inadequate and unstable funding. If better organization can take care of that, that's great; that's what we should do.

Senator STEVENSON. We could take care of that problem in a variety of ways. You just don't believe in the forgiveness of sin. NOAA says it's seen the light.

Dr. BATTAN. Yes, but I believe in confession, first.

Senator STEVENSON. It's turning a new leaf. It could get the money. What about an analogy to the climate program? What if NOAA had a lead role and OSTP has, in that case, had a coordinating role? That's worked out pretty well, hasn't it?

Dr. BATTAN. Well, we heard from—Richard Frank thinks it's working out all right. Other people think it's not working out as well as it should.

Senator STEVENSON. Well, they'll always believe that; it won't always be true.

Dr. BATTAN. I view this proposal of ours as a short-range solution to a very pressing problem. I think the field of weather modification now is barely alive. The budget was \$18 to \$20 million—7, or 8, or 10 years ago; it is now down to \$14 million, without inflation. It is barely alive. And I would like to see legislation which does the minimum of authorizing funding at the level of \$30 million escalating, and a mechanism whereby we can coordinate what we are doing at the moment.

Senator STEVENSON. Should we give some consideration to NOAA as lead agency with an advisory board, to try to keep the pressure on, to bring ideas in from outside, and to help with the execution, keeping alive the kind of possibilities that Dr. White was suggesting? Not "keeping them alive," but building a legislative history to support any reaction as to that possibility?

Dr. BATTAN. I might say, my concern with the "lead agency" concept is that, if it meets with the other agencies and they all agree on a course of action, then everything works well. But if they disagree on particular issues, then there is no way for the Department of Commerce to convince the Department of Interior to change its position that is the reason why we proposed that the coordination be done at a level above the departmental level.

Mr. CLEVELAND. Well, there is no reason for other agencies to agree unless the funds are gathered together in the first instance in one place, and then allocated out.

Senator STEVENSON. Well, that is what we do in S. 1644.

Mr. CLEVELAND. Yes, that is exactly what you are proposing to do in S. 1644. The only difference really is that your board is advisory. I have a feeling that our executive board isn't going to fly, but I would like to see somebody try it.

Dr. WHITE. I think an advisory board of some kind, however the program is established, whatever shape it takes, some outside advisory board will be essential.

The powers that you have given the Weather Modification Advisory Council in S. 1644 seems to me to be the kinds of things that a Weather Modification Advisory Board would want to engage in.

So I think it would be essential to have one of some kind.

Senator STEVENSON. We thank you all.

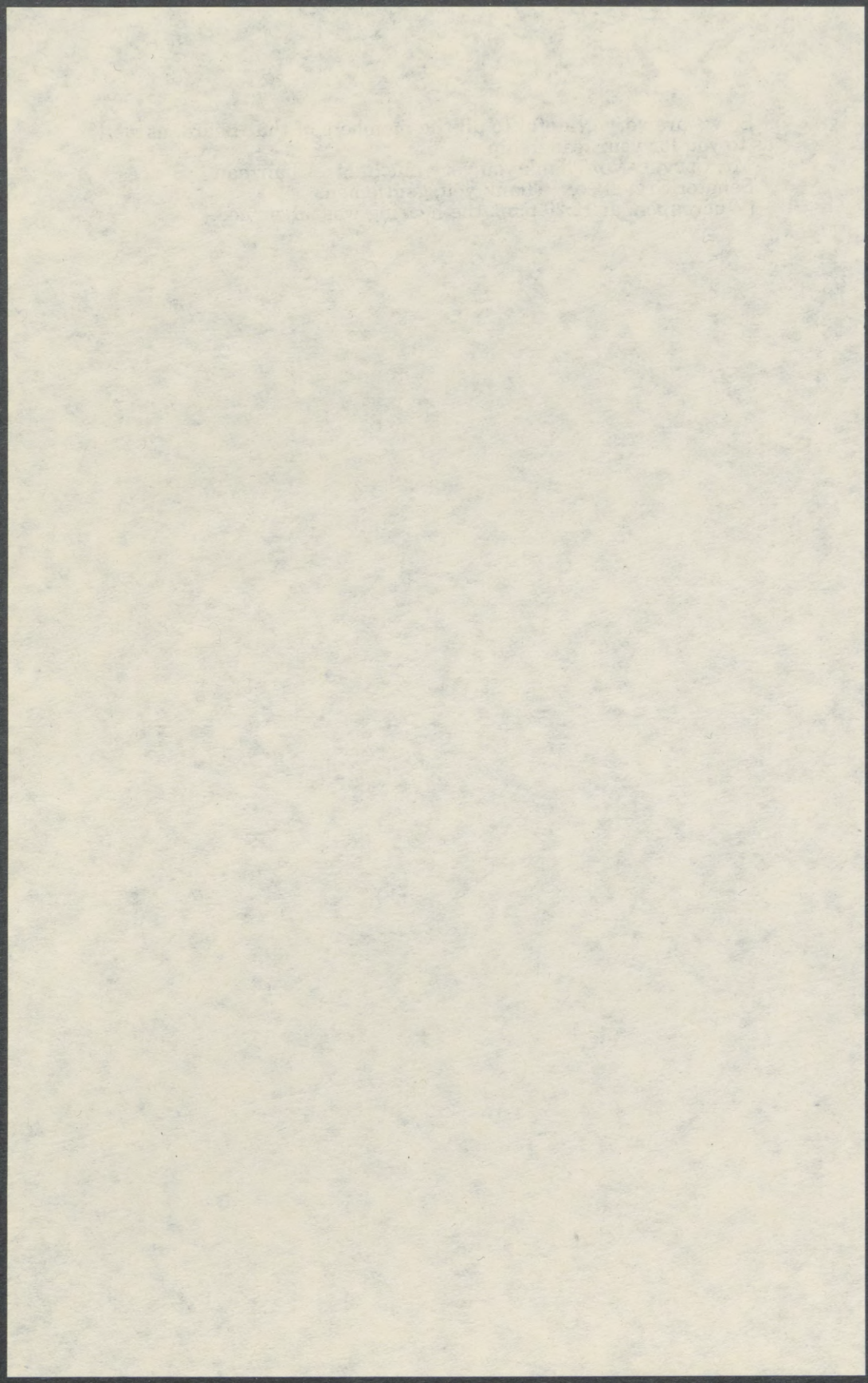
Mr. Cleveland, we thank you and the Board which you ably headed for an extraordinary job. It was a comprehensive carefully done piece of work without which we wouldn't be here today.

So we are very grateful to all the members of that Board, as well as to you for your leadership.

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

Senator STEVENSON. Thank you, gentlemen.

[Whereupon, at 12:20 p.m., the hearing was adjourned.]



WEATHER MODIFICATION

FRIDAY, OCTOBER 26, 1979

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:34 a.m., in room 235, Russell Senate Office Building, Hon. Howell T. Heflin, presiding.

OPENING STATEMENT BY SENATOR HEFLIN

Senator HEFLIN. The subcommittee will come to order.

Today we resume hearings on S. 829, the Weather Resource Management Act introduced by Senator Henry Bellmon, and S. 1644, the Weather Modification Management Act, introduced by Senator Stevenson.

Senator Stevenson, the chairman of this subcommittee, regrets that he is unable to preside over today's hearing. He has to be out of the city today. Both he and I feel that this is an important subject, and I am interested particularly in hurricane modification, especially after Hurricane Frederick caused more than \$1 billion damage in my home State of Alabama, the city of Mobile, the entire gulf coast section of Alabama, and many parts of the gulf coast of Mississippi and Florida were particularly hard hit.

On Wednesday the subcommittee heard testimony from administration witnesses and a distinguished group of individuals associated with advisory groups. From that testimony we found out that the administration is prepared finally to issue the Commerce Secretary's report on weather modification.

We heard the administration position, and we found that several witnesses disagreed with that recommendation. I expect that this will also be the case today.

The need to improve the Federal effort in weather modification is clear. The legislation we are considering represents two approaches. We seek the candid views of witnesses on the two approaches and, specifically, as to the scope of the Federal program, how it should be managed at the level of financial resources that is needed.

I invite the witnesses who are appearing today to come forward as a panel and to summarize their prepared statements.

The prepared statements will be entered in their full text in the hearing record.

And if you will, the witnesses will come forward. I believe we have Dr. Donald L. Veal, head of the Department of Atmospheric Sciences, University of Wyoming; Dr. Barbara C. Farhar; Prof. Ray

J. Davis, College of Law, University of Arizona; Dr. D. Ray Booker, president, Aeromet Inc.; and Paul C. Summers, cloud seeding program coordinator, Division of Water Resources, State of Utah.

We are delighted to hear from all of you. Our first witness will be Dr. Veal.

STATEMENTS OF DONALD L. VEAL, HEAD, DEPARTMENT OF ATMOSPHERIC SCIENCES, UNIVERSITY OF WYOMING; BARBARA C. FARHAR, BOULDER, COLO.; RAY J. DAVIS, COLLEGE OF LAW, UNIVERSITY OF ARIZONA; DR. D. RAY BOOKER, PRESIDENT, AEROMET, INC.; AND PAUL C. SUMMERS, CLOUD SEEDING PROGRAM COORDINATOR, DIVISION OF WATER RESOURCES, SALT LAKE CITY, UTAH

Dr. VEAL. Mr. Chairman, I am here today to speak as a representative of the faculty of the Department of Atmospheric Sciences, University of Wyoming, and as one of the four non-Federal members of the American Meteorological Society Committee on Weather Modification.

We are encouraged that there is interest at the national level at this time in developing a national program policy for weather modification research and development.

Man can and does modify the weather, both deliberately and unintentionally. There is accumulating evidence that suggests that, one, certain local weather conditions can in some areas be significantly altered by means of carefully controlled cloud seeding; and, two, human activity and land-use changes result in modification of the weather.

Most of the evidence available to scientists today concerning weather modification, however, is based on statistical indications which do not yet have the necessary physical support to explain and verify the suggested effects.

Thus, one is forced to conclude that the science of weather modification, both deliberate and inadvertent, is largely still in the stage of exploratory research and experimentation.

Weather modification science is a relatively new discipline, but can be viewed as integral to climate and meteorological research efforts in general. Many of the scientific problems that are barriers to understanding weather modification are also barriers in such areas as climate prediction, weather forecasting, disaster warnings, and so forth.

The oversimplified expectations of early weather modification enthusiasts have been replaced by realization of the problem's true complexity and the scope of scientific inquiry which will be required to develop promising concepts into verified technology.

During the last decade, the most significant progress has been in the advancement of experimental measurement capabilities. Newly developed instrumentation systems, observational platforms, and data processing facilities make certain vital physical observations of cloud systems available for the first time.

With these observations, it is now possible to approach the evaluation of weather modification experiments by carefully documenting the hypothesized chain of physical events and to extend this knowledge with the aid of numerical stimulation models.

Understanding the atmospheric processes involved in weather modification is also essential if the findings of a particular research project are to be reliably transferred to another area.

The views of the four non-Federal members of the AMS committee on weather modification, which I shall now present, are our own and should certainly not be construed as an official statement of the AMS.

We feel that a major problem in advancing weather modification research is, and has been, the lack of stability of funding.

Programs with long-range objectives are too often attempted on very short time scales, and frequently start, stop, or get significantly reduced before any firm conclusions are reached.

The report of the Weather Modification Board and the bills now introduced by Senators Bellmon and Stevenson refer to the same problem when they suggest that a focused national program could be helpful in developing a significant and sustained commitment to weather modification research.

We agree that a focused national program would perhaps be helpful and desirable from this point of view.

Stability of funding is only one aspect of a focused national program. The merit of a focused national program must also be examined from the perspective of scientific programs.

The central issue in such an examination is an assessment of the present state of knowledge, because different degrees of focus should be considered, depending on whether one accepted the view that we were on the verge of putting into practice a useful new technology, or if one recognized that important scientific uncertainties still existed.

We believe that the existing scientific uncertainties dictate an organizational approach which allows different scientists and scientific groups to attack the problems independently, though not in isolation, so that the full benefits of diversity of ideas and capabilities may be realized.

The scientific and technological base does exist and, in fact, is being used to support weather modification research efforts. There is a potential to further address important scientific objectives with the tools and expertise presently available but, increases in the national effort will require commensurate investments in new facilities such as instrumented aircraft, radar, satellites, automated meteorological networks, and so forth.

We also believe that at our present state of understanding large-scale weather modification programs with the simple objective of producing more water on the ground is not now appropriate.

Instead, there are a number of testable ideas which need confirmation and there are opportunities to initiate experimentation designed to enhance scientific understanding.

We believe that such research is certainly worth pursuing now, as it holds the key to future progress.

It is the view of the four authors of this statement that channeling all effort through a single governmental agency or office is not desirable even though that may be the most direct way of assuring stable funding. Centralization of organization and points of view are disturbing dangers in a field with scientific uncertainties such as weather modification.

Careful consideration must be given to such dangers when organizational structures are developed, and we believe compromises away from centralization is the appropriate way to go now.

We have reviewed the bills introduced by Senator Bellmon, S. 829, and Senator Stevenson, S. 1644. The policy and findings statements in these bills focus attention on several aspects which are important factors in the development of a national posture.

It is indeed encouraging that both bills recognize the importance of a sustained basic and applied research program in order to understand the atmospheric processes relative to weather modification.

Both bills also require the formation of an advisory board and the development of a 5-year comprehensive plan with annual updates, which are positive steps forward.

Both bills provide for the consolidation of the responsibility and management of all weather modification activities now in various Federal agencies with the exception of the National Science Foundation and the Department of Defense in the case of S. 1644.

As was stated earlier, we believe compromises away from the concept of consolidation or centralization is more appropriate at this time.

It is our view that the programs now being conducted by the Federal agencies are appropriate attacks on the problem and should be continued.

Further, it seems to us that agencies who will ultimately apply weather modification technology should be involved in its development.

In summary, the four non-Federal members of the committee believe that considerable progress has been made in weather modification, but weather modification is currently in the research phase and that the Nation by a national policy should foster a diversity of scientific inquiry and do all it can to encourage new scientific talent into the field in order that weather modification can be investigated on as broad a front as resources permit.

Finally, we strongly believe that the national benefits to society make the national investment in weather modification worthwhile.

The faculty of the Department of Atmospheric Science at our university agree with the principles that have been set forth; that is, one, weather modification is currently in the research phase and that a diversity of points of view and attacks on the problem are required; two, compromises away from consolidation or centralization within a single governmental office is desirable; and, three, the potential benefits to society are great, and the national investment in weather modification is worthwhile.

The faculty, in their review of the bills introduced by Senators Bellmon and Stevenson agree that the policy and findings statements in these bills focus attention on several aspects which are important factors in the development of a national posture.

The recognition of the importance of a sustained basic and applied research program and the development of a 5-year comprehensive plan are certainly positive steps forward.

Regarding the reinforcement and better organization of the national effort for weather modification, it is their view that channel-

ing all efforts through a single governmental agency or office is not desirable.

They hold the view that much more basic research is needed and should be the heart of the national effort.

The faculty also believes that the primary program considerations of any national weather modification program should be to adopt an organizational structure which would, one, foster the development of the necessary scientific understanding; two, utilize to as great an extent as possible many different investigators, wherever they are, holding many different points of view, to investigate the important scientific uncertainties; three, develop a spirit of close cooperation and coordination among all agencies and organizations, be they Federal, State, or local, and; four, advance the education and training in atmospheric and associated sciences in order provide the necessary new talent to advance weather modification specifically and atmospheric science in general.

In order to develop a national posture for weather modification research, the faculty believes it appropriate at this time to form a task force with representatives from the appropriate Federal agencies. This task force should be given the responsibility of fostering weather modification research by presenting a national plan to Congress.

We envisage this plan to be basically a coordination of the research programs proposed by the individual agencies so that Congress can view the various aspects of the national weather modification research effort in their entirety. Such a procedure could eliminate unnecessary duplication and would facilitate support of weather modification research on a rational and stable basis.

Because progress in weather modification will come primarily from research, it seems especially important to strengthen research programs related to weather modification within the National Science Foundation.

In conclusion, the faculty recommends that the national effort in weather modification be built on the concept of a multi-faceted and broadly based research program, with a Federal task force over-viewing and presenting that program for Congress' consideration.

Thank you very much.

[The statements follow:]

STATEMENT OF THE FACULTY OF THE DEPARTMENT OF ATMOSPHERIC SCIENCE,
UNIVERSITY OF WYOMING

The views presented herein are those of the faculty of the Department of Atmospheric Science, University of Wyoming. These views are based on background developed through involvement in weather modification research at various levels over the past decade. Our research efforts have focused primarily on physical observations, and on laboratory simulations of various atmospheric processes related to weather modification. This focus of research was based on our conviction that a better understanding of fundamental atmospheric processes was required for weather modification specifically and for atmospheric science in general.

We do believe that the development of a national policy for establishment of a comprehensive national program of weather modification research and development is very important, thus, we are indeed encouraged to see the current interest at the national level in the topic.

It is quite well established that man can and does modify the weather, both unintentionally and deliberately. There is now strong evidence indicating that human activity and land-use changes result in modifications of the weather. There is also accumulating evidence that suggests that certain local weather conditions

can, in some areas, be significantly altered by means of carefully-controlled cloud seeding. Most of the evidence, however, still lacks the physical support necessary to explain and verify the suggested effects, or to predict future trends. This science of weather modification, both deliberate and inadvertent, has many fundamental uncertainties and is therefore, largely still in the stage of exploratory research and experimentation.

Modern weather modification science is a relatively new discipline, but weather modification research can be viewed as integral to climate and meteorological research efforts in general. Many of the scientific problems that are barriers to understanding weather modification are also barriers in areas such as climate prediction, mesoscale weather forecasting, disaster warning, and so forth. The oversimplified expectations of early weather modification enthusiasts have been replaced by a realization of the problem's true complexity and of the scope of scientific inquiry which will be required to develop promising concepts into verified technology. The potential benefits to society justify the required effort.

During the last decade the most significant progress in weather modification has been in the advancement of experimental measurement capabilities. Newly developed instrumentation systems, observational platforms, and data processing facilities make certain vital physical observations of cloud systems available for the first time. With these observations, it is now possible to approach the evaluation of weather modification experiments by carefully documenting the hypothesized chain of physical events and to extend this knowledge with the aid of numerical simulation models. Understanding the atmospheric processes involved in weather modification is also essential if the findings of a particular research project are to be reliably transferred to another area. Statistical experimentation should be a later stage of testing than the physical measurements.

It is our view that a major problem in advancing weather modification research is, and has been, the lack of stability of funding. Programs with long-range objectives are too often attempted on very short time scales, and frequently start, stop, or get significantly reduced before any firm conclusions are reached. The report of the Weather Modification Board and the bills now introduced by Senators Bellmon and Stevenson refer to the same problem when they suggest that a focused national program could be helpful in developing a significant and sustained commitment to weather modification research. We agree that a focused national program would be helpful and desirable from this point of view.

Of course, stability of funding is only one aspect of a focused national program. The merit of a focused national program must also be examined from the perspective of scientific progress. The central issue in such an examination is an assessment of the present state of knowledge, because different degrees of focus should be considered, depending on whether one accepted the view that we were on the verge of putting into practice a useful new technology, or if one recognized that important scientific uncertainties still existed. We believe that the existing scientific uncertainties dictate an organization approach which allows different scientists and scientific groups to attack the problems independently, though not in isolation, so that the full benefits of diversity in ideas and in capabilities may be realized.

It is our view that a scientific and technological base does exist, and in fact is being used, to support weather modification research efforts. There is clearly a potential to further address important scientific objectives with the tools and expertise presently available, but increases in a national effort will undoubtedly require commensurate investment in new facilities, such as instrumented aircraft, radars, satellites, automated meteorological networks, and so forth. We also believe that at our present state of understanding large-scale weather modification programs with the simple objective of producing more water on the ground is not now appropriate. Instead, there are a number of testable ideas which need confirmation and there are opportunities to initiate experimentation designed to enhance scientific understanding. We believe that such research is certainly worth pursuing now, as it holds the key to future progress.

We also see another aspect of weather modification research as being important at this time. In parallel with investigations aimed at developing reliable precipitation modification technologies, attention also needs to be focused on surveying the atmospheric water resources of the nation. Knowledge is now inadequate about the forms and types of precipitation, about the types of clouds producing that precipitation, and about the clouds which may be suitable targets for precipitation modification activities in given regions of this country. Exploratory observations and measurements, taken over several years, could pave the way for later decisions on whether or not it might be feasible to augment or redistribute precipitation in an area under given conditions. The same survey effort could also serve as a basis for

assessing the impacts of inadvertent weather modification. Furthermore, the cloud and precipitation surveys could be important in evaluating the downwind effects of weather modification projects, that is to decide whether or not a project for precipitation enhancement in one location alters the precipitation available in regions further downwind. The tools available for these types of surveys are satellites, weather radars, instrumented aircraft and others. The critical step at this time is to develop the appropriate methodologies, and to organize, in a cooperative fashion between federal and state agencies, the data collection and analysis efforts. We believe that such a program would bring worthwhile advantages for the better management of our Nation's atmospheric water resources.

Regarding the reinforcement and better organization of the national effort in weather modification, it is our view that channeling all effort through a single governmental agency or office is not desirable, even though that may be the most direct way for assuring stable funding. Centralization of organization, and of points of view, are disturbing dangers in a field with scientific uncertainties such as weather modification. Careful consideration must be given to such drawbacks when organizational structures are developed, and we believe compromises away from centralization is the appropriate way to go now.

We have reviewed the bills introduced by Senator Bellmon (S. 829) and Senator Stevenson (S. 1644). The policy and findings statements in these bills focus attention on several aspects which are important factors in the development of a national posture. The fact that both bills recognize the importance of a sustained basic and applied research program in order to understand the atmospheric process relative to weather modification is certainly encouraging. In addition, both bills also require the formation of an advisory board and the development of a 5-year comprehensive plan with annual updates, which are positive steps forward. Both bills provide for the consolidation of the responsibility and management of all weather modification activities now in various agencies with the exception of the National Science Foundation and the Department of Defense in the case of S. 1644. As was stated earlier, we believe compromises away from the concept of consolidation or centralization is more appropriate at this time.

We hold the view that much more basic research is needed and should be the heart of the national effort. We also believe that the primary program considerations of any national weather modification program should be to adopt an organizational structure which would: (1) foster the development of the necessary scientific understanding; (2) utilize to as great an extent as possible many different investigators, wherever they are, holding many different views, to investigate the important scientific uncertainties; (3) develop a spirit of close cooperation and coordination among all agencies and organizations be they federal, state, or local, and; (4) advance the education and training in the atmospheric and associated sciences in order to provide the necessary new scientific talent to advance weather modification specifically and atmospheric science in general. Further, it seems to us that agencies who will ultimately apply weather modification technology should be involved in its development.

We believe it appropriate at this time to form a Task Force with representatives from the appropriate federal agencies. This Task Force should be given the responsibility of fostering weather modification research by presenting a National Plan to Congress. We would envisage this plan to be basically a coordination of the research programs proposed by the individual agencies so that Congress can view the various aspects of the national weather modification research effort in their entirety. Such a procedure could eliminate unnecessary duplication and would facilitate support of weather modification research on a rational and stable basis. Because progress in weather modification will come primarily from research, it seems especially important to strengthen research programs related to weather modification within the National Science Foundation.

In conclusion, we recommend that the national effort in weather modification be built on the concept of a multi-faceted and broadly based research program, with a federal Task Force overseeing and presenting that program for Congress's consideration.

STATEMENT OF JEFF HILL, ROBERT I. SAX, RICHARD G. SEMONIN, AND DONALD L. VEAL

The views presented herein are those of the non-federal members of the American Meteorological Society Committee on Weather Modification and should not be construed as an official statement of the American Meteorological Society.

The American Meteorological Society Committee on Weather Modification, as a whole, is currently considering a revised policy statement concerning weather modification which will be submitted to the American Meteorological Society Council, hopefully in time to be considered by them during the annual meeting late in January 1980. The American Meteorological Society represents all involved in Weather Modification whether they be from the private sector, university community, or government agencies and the policy statement will incorporate the views of all concerned.

It is our view that interest at the national level in the development of a national program policy to establish a comprehensive coordinated national program of weather modification research and development is very encouraging.

Man can and does modify the weather both deliberately and unintentionally. There is accumulating evidence that suggests that certain local weather conditions can, in some areas, be significantly altered by means of carefully controlled cloud seeding. Evidence is also mounting which indicates that human activity and land-use changes result in the modification of the weather. Most of the evidence is, however, based on statistical indications which do not yet have the necessary physical support to explain and verify the suggested effects. The science of weather modification, both deliberate and inadvertent, is therefore, largely still in the stage of exploratory research and experimentation.

Modern weather modification is a relatively young applied meteorological science, whose progress is intimately dependent on advances in meteorological understanding in general. The scientific uncertainties that are obstacles to physical understanding in weather modification are also barriers in other meteorological disciplines, such as climate prediction, precipitation forecasting, severe storm warnings, and so forth. The over-simplified expectations of early weather modification enthusiasts have been replaced by a realization of the problem's true complexity and of the scope of scientific inquiry required to develop promising concepts into a verified-responsible technology. Potential benefits to society justify the required effort.

The most significant progress in recent years has been achieved in the advancement of experimental measurement capabilities. New developments in instrumentation systems, observational platforms, and data processing facilities now make certain vital physical observations of cloud systems in their environment available for the first time. It is now possible to reinforce the evaluation of some statistical weather modification experiments by documenting the hypothesized chain of physical events and to extend this knowledge with the aid of numerical simulation models. Understanding the atmospheric processes involved in weather modification is also essential if the findings of one research project are to be reliably transferred to another area. Adequate and sustained support for research in the decades to come should permit major advances in establishing a sound, physical foundation for deliberate and inadvertent weather modification concepts.

It is our view that a major problem in weather modification is and has been the lack of stability of funding. Programs with long-range objectives are too often attempted on very short time scales, and frequently start, stop, or get significantly reduced before any solid conclusions are reached. It appears that the Weather Modification Advisory Board perceived the same problem when they suggested that a focused national program would be helpful in developing a significant and sustained commitment to weather modification research. We agree that a focused national program would be helpful and desirable from this point of view.

Of course, stability of funding is only one aspect of a focused national program. The merit of a focused national program must also be examined from the perspective of scientific programs. The central issue in such an examination is assessing what is our present state of knowledge. If you believe you are on the verge of a useful new technology, different degrees of focus would be prescribed than if you held the view that important scientific uncertainties still existed. We believe that the existing scientific uncertainties dictate an organization approach which allows different scientists and scientific groups to attack the problems independently, though not in isolation, so that the full benefits of diversity in ideas and in capabilities may be realized.

It is our view that the scientific and technological base does exist and in fact is being used to support the present weather modification research efforts. There is clearly a potential to further address important scientific objectives with the tools and expertise presently available, but increases in national effort will undoubtedly require commensurate additional investment in new facilities, such as instrumented aircraft, radars, satellites, automated meteorological networks, etc. We also believe that large-scale weather modification programs with the simple objectives of producing more water on the ground is not now appropriate. Instead, there are a number

of testable ideas needing confirmation. We believe that there are opportunities for experimentation designed to enhance scientific understanding and that these experiments are certainly worth doing now.

In our view, channeling all effort through a single governmental agency or office is not desirable even though that may be the most direct way of assuring stable funding. Centralization of organization, and points of view are disturbing dangers in a field with scientific uncertainties such as weather modification. Careful consideration must be given to such dangers when organizational structures are developed, and we believe compromises away from centralization is the appropriate way to go now.

We believe that the policy and findings statements in the bills introduced by Senator Bellmon (S. 829) and Senator Stevenson (S. 1644) focus attention on several aspects which are necessary in the development of a national posture. It is indeed encouraging that both bills recognize the importance of a sustained basic and applied research program in order to understand the atmospheric processes relative to weather modification. Both bills also require the formation of an advisory board and the development of a 5-year comprehensive plan with annual updates which we also believe is a positive step forward. Both bills provide for the consolidation of the responsibility and management of all weather modification activities now in various federal agencies with the exception of the National Science Foundation and the Department of Defense in the case of S. 1644. As was stated earlier, we do not support the concept of consolidation. It is our view that the program now being conducted by the federal agencies are appropriate attacks on the problems and should be continued. Many of these programs are well-conceived and well-managed weather modification research projects. Further, because weather modification is not now developed as a readily applicable technology, it seems to us that agencies who will ultimately apply the technology must be involved in the technological development. In summary, we believe that since weather modification is in the research phase, the Nation, by a national policy, should foster a diversity of scientific inquiry and do all it can to encourage new scientific talent into the field in order that weather modification can be investigated on as broad a front as resources permit. We also believe that the national benefits to society make the national investment in weather modification worthwhile.

Senator HEFLIN. Dr. Farhar?

Dr. FARHAR. I am testifying as a social scientist with 6 years of research experience on the social aspects of weather modification, as a member of the Colorado Weather Modification Advisory Committee, and as an informed citizen. I am not representing the views of the State of Colorado nor of the Solar Energy Research Institute.

I favor a well thought out national policy on weather modification. Senators Stevenson and Bellmon are to be commended for their efforts in submitting legislation to bring us closer to the goal that so many have urged for so long. The need for this legislation is so well documented that I will not comment on it further here.

I testified in 1976 for the hearings on H.R. 10039 and S. 3383. At that time, I summarized much of the research in which I have been involved, and I will not repeat that testimony, although it might be of general interest as background to the committee's deliberations. In that testimony, I underscored the need for public participation in weather modification decisionmaking. I would like to reemphasize that such participation is essential to the social acceptability of weather modification technologies.

Sometimes the most important results of research are learning the right questions to ask. What we have learned since 1976 is that: First, it is not only what we do with the atmosphere but also how we use technology and the land that affects the weather. This finding comes from the studies of the St. Louis and Chicago area urban weather anomalies, among others. There are complex interactions between atmospheric and human systems. Cities, cooling towers, agricultural lands, powerplants, et cetera, affect the weath-

er nearby and for some distance downstream. Increased rain, lightning, thunder, and hail have been measured. Acid rain, with its negative effects on agriculture and towns, has been observed downstream from industrial cities. Jet contrails are causing the formation of cirrus clouds in otherwise clear skies. Decisions about cloud seeding and land use both affect our weather and probably our climate.

Second, changes in weather are both beneficial and harmful to society. This was learned from the study of impacts in connection with METROMEX and the Chicago area project, and from other studies. For example, evidence suggests that occurrence of traffic accidents increases in linear fashion with increases in rainfall. It has been learned that different crops grown in the same general area need different kinds of weather at the same period of time—heterogeneity of weather needs. Rainfall damages hay during a harvest period while benefiting corn or other crops at the same time. Hail benefits range but harms lettuce or barley. Snow benefits water users downstream but causes costly inconvenience for mountain residents, mining, lumbering, and some recreational activities.

Third, we do not know the net impacts of weather modification activity—including social, environmental, economic, legal, and political costs. A few cost-benefit analyses have shown that weather modification has very high benefit-to-cost ratios, but these analyses have never identified and included the array of societal costs and benefits to be anticipated from cloud seeding activity, nor compared them to other possible ways of solving problems.

Fourth, if weather modification is worth doing, it is worth doing right. This was learned from TASH—the technology assessment of hail suppression. TASH results showed that only very substantial reductions in hail damage accomplished with no reduction in precipitation would be, in the net, economically beneficial to society.

Often it is assumed that severe storm mitigation, increases in precipitation, and decreases in hail are on the face of it beneficial to society. And they might be. And there are many serious problems that remain unresolved, such as liability, climate impacts, long-term environmental impacts, and mitigation of adverse societal impacts which could significantly affect the cost-benefit ratio once they are included in the accounting.

To learn more about the use of cloud seeding in mitigating natural hazards, field experiments with severe storms are required. It is currently standard practice to suspend seeding during severe storms to avoid public relations problems and liability for the adverse impacts caused by severe storms. The Rapid City flood case illustrated the point.

More field research will be required to understand the effects of these types of seeding, but delicate public relations problems will need to be handled for their success. The National Hail Research Experiment provides an example of the kind of public relations work required if the public and other nations are to accept these experiments. Social science evidence suggests that the public will accept activities 1,000 times riskier voluntarily than they will involuntarily.

The features of the two bills that I fully support are a Federal lead agency, a coordinated national weather modification program, adequate and sustained funding levels, and consultation with affected groups. S. 829 calls for evaluation of operational programs, while S. 1644 does not and probably should.

But I do not approve passage of S. 829 in its present form for two major reasons. It calls for NASA as the lead agency, and it proposes vigorous development and use of weather modification without concomitant emphasis on regulation and responsibility for impacts. Selection of NASA as the lead agency was rejected by DOC's Weather Modification Advisory Board. NASA leadership is not desirable for at least two reasons: First, they have very limited prior experience in weather modification, which is not an advantage in the current situation, and second, they have been deeply involved in space technology transfer, an activity which would be premature for weather modification at this time.

I will therefore focus the balance of my comments on S. 1644. While I generally favor this legislation, I have a number of specific recommendations for improving it.

The key regulatory aspects of S. 1644 are a licensing system, development of standard operating practices and strengthening of existing reporting requirements. Regulatory administration of weather modification is a function separable from research administration. Since the public interest is the object of regulation, provision should be made to keep the Federal regulating authority from having the weather modification community as its only constituency. The regulatory function at the Federal level is best kept administratively separate from research and operational concerns if regulation is to be carried out in the public interest.

I would, therefore, propose that the Federal regulatory function be assigned to NOAA and that the administration of the Nation's coordinated research program be assigned to the National Science Foundation (NSF). Each agency has prior experience in the administration of these functions, and each is best equipped to handle these distinct roles. Perhaps two weather modification advisory boards should be appointed. The NSF Board, as described in S. 1644, might be appointed by the National Academy of Sciences. The NOAA Board could have similar representation appointed by the President.

The regulatory provisos of S. 1644 might be further strengthened to provide for Federal permit functions in certain cases. Many States require permits to conduct weather modification activity, but not all states with statutes require this, and many States do not have statutes. Federal permits appear to be needed in the following cases where State laws are inadequate: First, Federal field experiments, which are exempt from State control. Federal review in conjunction with State and local governments and others as provided in S. 1644 provides consideration of local, regional, and national interests in decisionmaking. Federal projects should receive at least the level of review that States would require.

Second, field projects the effects of which cross international boundaries. (There are cases we could discuss, if you are interested, as a panel.) An unregulated technology may be less socially acceptable than a regulated one, since regulation implies safeguards. One

study suggested that the existence of regulation in States has not necessarily slowed weather modification activity.

S. 1644 calls for the "protection of the public and the environment" (section 4). This protection is provided in part by licensing and reporting requirements, and in part by provisions calling for consultation and cooperation with State and local governments and other interested groups that are likely to be affected. This, however, is done in the context of a statute that calls for "the promotion of technology transfer," which makes protection more difficult to achieve.

Expressed public concerns may be given little weight in decisions to permit weather modification activity when statutes call for the encouragement and promotion of technological use. For example, in Colorado, the State weather modification statute "encourages" the use of weather modification technology. Snowpack augmentation was conducted during part of the winter of 1978-79 in the Colorado mountains. Cloud seeding was suspended when it became apparent that we were having a very heavy snow year, and wildlife and ranchers were facing severe problems. It turned out to be a recordbreaking winter for snow.

This fall, two permit applications are pending to conduct snowpack enhancement in these same areas. These are proposed operational programs sponsored by water conservancy districts, ski resort owners, and the Denver Water Board. When we held public hearings in the areas of effect, virtually everyone testifying spoke out against the proposed cloud seeding. Formal resolutions in opposition have been passed by the Colorado Cattlemen's Association and county commissions in San Juan, Pitkin, and Lake Counties, all in areas of effect.

In addition, opposition was expressed by the Colorado Division of Wildlife, the Peabody Coal Co., Routt County Commissioners, a State representative, the Farm Bureau, the Upper Yampa Water Conservancy District and area ranchers. A petition opposing the project was signed by 756 citizens in 3 days.

Some of the problems identified at the public hearing at Dillion on October 3, 1979 were: (1) wildlife had difficulty getting to forage; (2) wildlife ate ranchers' feed; (3) additional water does not benefit the area; (4) additional snow may be caused by area steam generating plants which is inadvertent weather modification and which could be compounded by cloud seeding; (5) late fall pasture would be damaged; (6) strip coal mining roads have to be maintained; (7) the railroad which moves the coal has to plow snow; (8) additional snow loads cause structural strain and collapse roofs and buildings; (9) snow removal costs and danger to highway crews (for example, a snowplow went off Loveland Pass last winter and its driver lost his life); (10) private households are paying as much as \$100 a month for snow shoveling of their roofs and driveways; (11) hazard to children going to school; (12) increase in avalanche danger; (13) burden on the elderly in terms of mobility and snow removal; and (14) danger for coal trucks using steep roads in the area.

What was interesting about this opposition was that it acknowledged implicitly that snow was being increased, and it was just this effectiveness that was causing concern. Several prior controversies

have involved allegations that cloud seeding causes drought (for example, South Dakota, the San Luis Valley, and Pennsylvania).

The point is not that snowpack augmentation causes these problems. The point is that we do not know the distribution of societal costs and benefits of snowpack augmentation—who benefits and by how much and who is harmed and by how much.

I would submit that it is premature to legislate the transfer of a set of technologies whose societal effects are so poorly understood. I would recommend that the phrase "promotion of technology transfer" be deleted from section 4 and that the phrase "and mitigation of identified adverse impacts of weather modification technologies" be added to section 4.

NEPA is not adequate to cover societal impacts of weather modification because these are not even considered unless there is evidence of environmental impact. (When societal impacts are evaluated under NEPA, mitigation strategies are increasingly being implemented.) There is currently no evidence of serious environmental degradation due to cloud seeding activity. It is conceivable that weather modification could have environmental advantages say, through the use of natural storage and improved water quality, in comparison to other techniques of stabilizing the water supply, such as reservoir construction, and to improve water quality, such as desalinization plants.

Weather modification may have more effect on social, political, legal, and economic systems than on environmental ones. The mitigation of undesired impacts is very likely essential if weather modification technology is to find social acceptability without serious conflict. And social acceptance will be necessary for weather modification to provide the benefits of which it is potentially capable.

The management of weather resources does not have to be conducted in an adversarial manner nor its use promoted prior to an understanding of its impacts. All over the country, both opponents and proponents agree that more needs to be known about the effects of weather modification. This is the common ground. The passage of S. 1644, with appropriate revisions, should provide the needed direction for proper weather resource management for the greatest potential benefit of mankind, with appropriate concern for natural systems.

Thank you, sir.

[Attachment follows:]

Following are detailed comments on some of the wording of S. 1644.

- (1) Page 1, line 3: the title might better be the "Weather Resources Management Act."
- (2) Page 2, line 15: "... of both intended and unintended weather modification."
- (3) Page 3, line 10: "... of this capability should henceforth occur under the direction . . ."
- (4) Page 3, line 12: change "capability" to read "application."
- (5) Page 3, line 15: add "and that mitigation of identified undesired effects be part of each weather modification field project."
- (6) Page 4, line 10: delete "technology transfer and . . ."
- (7) Page 5, lines 4-7: what about unintended weather modification?
- (8) Page 6, lines 7-12: especially good.
- (9) Page 13, lines 4-8: add seeding material and rate.
- (10) Page 13, line 9: it might be wise to add a provision for technical review of these reports.

(11) Page 15, line 13: I question whether 50 percent support will be adequate to achieve good evaluation of operational projects, which is needed.

(12) Page 18, lines 3-14: especially good.

Senator HEFLIN. Senator Bellmon was shown this. He has stepped out, but it is our intent to go ahead and let everyone summarize their statements, and then we would go into some questions.

Next, I believe our next witness is Prof. Ray J. Davis of the College of Law, University of Arizona.

Mr. Davis?

Mr. DAVIS. Thank you, Mr. Chairman.

I am here today wearing two hats, as are some of the other people on the panel are. I am present as an expert in the legal aspects of weather modification. A considerable portion of my commitment to legal research and writing during the last decade has been in the field of weather modification law.

Senator HEFLIN. Please let me interrupt you.

Senator Bellmon, I thought we would go through the witnesses and let them summarize their statements. If you feel you want to ask questions, certainly feel free to interrupt and ask questions.

Mr. DAVIS. Also I am here as the president of the Weather Modification Association. The Weather Modification Association is a professional organization which includes virtually all persons involved in actual practice of weather modification. So the legislation that we are speaking of is legislation that involves the group I am representing more directly than any other group. The association also includes other scientists, engineers, technologists, and researchers who have an interest in weather modification. We have long had an interest in Federal proposals for legislation. And accordingly, we are grateful to have this opportunity to appear before this committee and present our views concerning legislative proposals.

In connection therewith, I might say that the Weather Modification Association held its semiannual meeting earlier this month. The major thrust of our meeting was discussion among our members about the provisions of S. 829 and S. 1644, as well as various other proposals for Federal legislation, such as that of the Weather Modification Advisory Board and the North American Interstate Weather Modification Council, which is represented here today by its president, Paul Summers.

These various legislative proposals, I think, can be divided into four topics for the purpose of my presentation today. The first is a statement of a national weather modification policy. Second, provision for Federal weather modification programs. Third, institution of Federal regulation of weather modification activities. And fourth, creation of an organizational structure for effective weather modification participation. I will look at these each in turn.

In the view of our members, it is essential that there be a statement of a Federal position with regard to weather modification. We feel that such a Federal policy statement should include several specific statements.

First, there should be a finding that there has been created a national resource in weather modification research. This has been established in several Federal agencies, including those who ap-

peared here on Wednesday, and in the State university and private sectors. This resource has been created in terms of trained personnel, instrumentation, data management, atmospheric water management, and development of cloud seeding technology.

A second item that should be included in the statement of national policy is a finding that there is a national need for an ongoing Federal program with a long-term commitment to analytical research and field studies.

And finally, such a Federal policy statement should include the statement to the effect that the Federal Government will itself establish a long-term national weather modification program which will use and coordinate ongoing weather modification activities and insure adequate and stable support of a sustained research effort.

Turning from the matter of policy, which I think is pretty generally supported not only by the witnesses appearing here on Wednesday but also by those appearing today, to the matter of programs, we would like to express our gratitude for Federal programs in the past which have led to the development of weather modification technology. And we urge that the Congress consider an approach in the future which will be well conceived and integrated and will look at all of the complex physical and societal problems associated with utilization of this evolving technology.

Both of the bills before this committee recommend a 20-year Federal research program. The Weather Modification Association agrees that there should be such a continuing program commitment. We advocate that its magnitude should be commensurate with the potential benefits of the developed weather resource.

We are more optimistic about the ability of the weather modification industry to utilize in an effective and sensible fashion Federal funds than apparently were the representatives of several of the Federal agencies who appeared here on Wednesday. We feel that it is possible to utilize these funds in a cost-effective manner. In the past, Federal funds have been made available for assistance of State operation programs, for drought-relief seeding, and for scientific research.

Both bills being considered by this subcommittee thrust in the direction of research. We feel that that is appropriate, but would like to add the note that financial and technical assistance in setting up and evaluating operational programs should not be overlooked by the Congress. That also is a legitimate Federal role.

Turning from programs to the area of regulation, I noted in listening to the testimony the other day that the administration position, as expressed by the Federal agencies, is in opposition to Federal regulation of weather modification.

The Weather Modification Association joins in that position. We oppose instituting a Federal regulatory system at this time. We recognize that there are some States that do not have regulatory statutes. But if you take a careful look, as I have done, at the legislation in the States in which weather modification is in fact being practiced today, you will find that those States have a rather complete system of regulation of weather modification. They have provisions for professional licenses in order to insure that persons who carry out weather modification are competent persons of high integrity. They also have provisions for a permit system which

requires that operations carried out within those States are operations which are planned in a scientifically acceptable fashion and which are carried out with competence and also with integrity.

It is true that in the past there has been considerable variation among the States in their regulatory activities. However, the States that have enacted legislation in the last 4 or 5 years, and the States that have strengthened their administrative regulations with respect to weather modification have generally tended now to follow the pattern of the suggested State statute which has been proposed by the Council of State Governments. You will find that that pattern is the evolving pattern throughout the States.

So it is the position of the Weather Modification Association, that at least for the present, regulation is being carried out effectively by the States in those States in which weather modification is taking place and that there is no need for Federal regulation of weather modification at this time.

I might add that the association is concerned about professional standards and ethics. And we have drawn up a statement of professional standards and ethics. We have a program for certification of our members. We are now in the process of strengthening that certification program. Many State statutes are now utilizing the certification procedures that we have adopted in that they State in their regulations that persons who seek weather modification licenses should be persons who are certified as weather modifiers by a professional organization in the field.

Moving now to the topic of organization, this seems to be the topic which has created the most diversity of opinion in these hearings. I think on the other three topics, there has been a consensus among the witnesses who have appeared. On organization, at least on some points, there has not been consensus, but let's look at the points first on which there has been agreement.

I think that most of the witnesses have agreed with the proposition that now is not the time to centralize Federal weather modification activities into a single agency. The Weather Modification Association agrees with that position. Centralization is not now called for.

A majority of the members of our association would disagree with putting into effect now the so-called lead agency concept. Rather, we would prefer a form of more effective governmental coordination.

We recognize the fact that there are legitimate differences of opinion as to where this coordinating function can be most effectively lodged. These differences stem, I think, from three different factors.

First, the nature of weather modification. Weather modification involves problems relating to water resources development, transportation, agriculture, national defense, energy and commerce. Since these problems are addressed by different departments of the Federal Government, there is no one logical place in which weather modification organizational structure can be housed. If there were a logical place, I am sure that Congress would have found it long since. But there, quite simply, is not one place in which this can be done effectively.

Second, we have to look to the history of weather modification. Since the start of cloud-seeding, weather modifiers have developed relationships and attitudes about different Federal agencies, who have or who have not had weather modification programs. These experiences have reflected themselves in our perceptions about what constitutes acceptable Federal organization for weather modification. I might say that we join in the statements of dismay over the prolonged delays that the National Oceanic Atmospheric Administration has had in submitting the report of the Weather Modification Advisory Board to the Congress. This is one part of the history of weather modification which cannot help but shape attitudes of people in the business.

Finally, one thing that we have to take into consideration is political realities. We, like the members of the Weather Modification Advisory Board, weren't born yesterday. We realize that there are some things we would want that we can't have. It appears to us, given the current attitude of the administration and given the current climate of Government, that coordination is probably the most effective kind of device for insuring wise expenditure of Federal funds that we are going to get. So we favor coordination. It is now the most practical route to take.

A majority of our members favor coordination through some agency other than the National Oceanic and Atmospheric Administration. There are some who do favor coordination through NOAA. But a straw vote taken of our membership at the October WMA meeting shows that the majority do not favor going through NOAA.

At that particular meeting, no one openly stated that they favored coordination or consolidation or activities through NASA. Probably there are some members who would favor that. But no one openly stated that on the floor of the meeting.

Several members of the organization supported the position that I believe will be advocated by Mr. Summers on behalf of the North American Interstate Weather Modification Council. There would be selected a Federal coordinator for weather modification who would be housed in the National Science Foundation; and there would be a committee selected by the National Academy of Science to advise the Federal coordinator. The coordinator would work with the agencies of the Federal Government who are in the business of carrying out weather modification experimentation, would assist them in preparing plans, and would interact with them and with the National Academy of Science advisory board in preparing a weather modification 20-year plan, in preparing 5-year segments of it, and in regularly updating that. The coordinator would work with the agencies to secure adequate appropriations to carry out their missions. As I indicated, probably a majority of our members who were at our meeting would support that kind of approach.

In conclusion, I would like to reiterate that we urge the subcommittee to approve legislation. We have been through hearings before. We have seen bills now for 30 years. It is time now for actual legislation. We are interested in more than just conversation. We would like the weather modification legislation to include a strong statement of Federal policy that would support commitment to a long-term national weather modification program. We

urge that the Congress authorize a 20-year program of research, field testing, and assistance in setting up and evaluating weather modification operations. And finally, we urge that you establish strong Federal coordination of the national program through a Federal coordinator and an advisory board.

Thank you.

[The statements follow:]

STATEMENT OF THE WEATHER MODIFICATION ASSOCIATION ¹

The Weather Modification Association is a professional organization which includes virtually all weather modification practitioners as well as other scientists, engineers, technologists and researchers with an interest in development and management of atmospheric water resources. The Association is a clearinghouse and dissemination agent for weather modification information, and seeks to promote understanding weather modification for beneficial purpose. WMA has adopted an active role in production of policy statements concerning all aspects of weather modification practices. Accordingly, we are grateful for the opportunity to provide the Subcommittee with our assessment of the various approaches to establish a national weather modification policy and a national research and development program.

The federal role with respect to weather modification has long been of interest to the Association and our members. In recent years we have urged a federal inquiry into weather modification policy and programs such as that mandated by Public Law 94-490, and we have twice since its submission to the Department of Commerce expressed our collective support for the final report of the Weather Modification Advisory Board. At our most recent semi-annual meeting, which was held earlier this month at Banff, Alberta, we considered the provisions of S. 829 and S. 1644 as well as proposals of the North American Interstate Weather Modification Council and recommendation of the Weather Modification Advisory Board. This statement is a reflection of the views of our members concerning these suggestions for federal legislation.

Various legislative proposals respecting a national policy and program for weather resource management can be divided into the following topics for purposes of presentation of our views:

1. Statement of a national weather modification policy;
2. Provision for federal weather modification programs;
3. Institution of federal regulation of weather modification activities; and
4. Creation of an organizational structure for effective federal weather modification participation.

Each of these topics will be addressed in turn.

POLICY

The Congress, through hearings, appropriations and adoption of Public Law 92-205 on reporting, and various executive departments of the federal government, through a variety of programs, have in effect make policy statements about weather modification. But there never has been an over-all statement of a national weather modification policy. The Weather Modification Association has long advocated creation of such a policy, and we are gratified by inclusion of the policy statement in S. 829 and S. 1644. Although policy statements in and of themselves do not insure continuous and consistent approaches to legislation and administration, such recitals establish rational foundations for expectations of persons affected. The history of the federal involvement with weather modification has been one of the Congress and federal agencies blowing hot and then blowing cold. This inconsistency has made it difficult for weather modifiers and other affected professionals to know where we stand with respect to the federal government and is agencies and to plan for our future relationship with federal agencies. A legislative statement of national weather modification policy would enhance our ability to plan our futures as well as promote sensible and fiscally responsible federal involvement with weather modification.

A federal weather modification policy statement should incorporate the following elements:

¹ Presented by Ray Jay Davis, Weather Modification Association President, Visiting Professor of Law, Brigham Young University, Provo, Utah.

1. A finding, consistent with that of the final report of the Weather Modification Advisory Board, that a national resource in weather modification research has been established in several federal agencies and the state, university, and private sectors in terms of trained personnel, instrumentation, data management, atmospheric water management, and development of cloud seeding technology;

2. A finding that there is a national need for an on-going federal program with a long-term commitment to analytical research and field studies; and

3. A statement that the federal government will establish a long-term national weather modification program which will use and coordinate on-going weather modification weather modification activities and insure adequate and stable support of a sustained research effort.

PROGRAMS

The Weather Modification Association recognizes the important role of federal programs in past development of weather modification technology. We urge that the Congress provide for the future a well-conceived, integrated approach to consideration of all of the complex physical and societal problems associated with utilization of this evolving technology for addressing national needs. Both S. 829 and S. 1644 adopt the recommendation of the Weather Modification Advisory Board that a twenty-year federal research program be established. The Association agrees that there should be such a continuing program commitment, and we advocate that its magnitude should be commensurate with the potential benefits of the developed weather resource.

Although federal funds have been made available in the past for assistance to state operational programs and for drought relief cloud seeding, the over-all thrust of past federal programs has been to support scientific research, development, and field testing. Both bills being considered by this Subcommittee focus upon research. That is appropriate. However, financial and technical assistance in setting up and evaluating operational programs should not be overlooked. That too is a legitimate federal role.

REGULATION

S. 1644 provides for a federal professional licensing system for weather modifiers; S. 829 does not. WMA prefers the latter approach which relies upon the existing system of state regulation of the profession. We recognize that some states do not have regulatory legislation, but cloud seeding has not often been practiced in such states. Also we are aware that some state administrators lack either power or the inclination to do an effective job of control over the profession. However, in those states in which the bulk of cloud seeding is carried out there are adequate state laws which are enforced by competent administrators. And there has been an accelerating movement toward uniformity of state regulation.

The Weather Modification Association has also been deeply involved in efforts to improve the level of professional competency of persons designing and carrying out weather modification operations. We have long had a procedure for certification of operators, and WMA now is in the process of creating two categories of certified modifiers: one group who are considered competent to design and set up projects, and another who are able to direct daily operation of such projects. Also the Association has adopted a statement of professional standards and ethics for weather modification operators.

ORGANIZATION

Both S. 1644 and S. 829 address the problem of creating a federal administrative structure capable of carrying out Congressional policy and successfully implementing the recommended twenty-year national weather modification program. They would deal differently with the matter, and the North American Interstate Weather Modification Council would handle in another manner. This division of opinion about the how the federal structure should be organized is not something new. In fact it is quite possible that one of the basic reasons for past failure to articulate a consistent federal policy has been attributable to disagreement over the details of what sort of federal administrative structure should be established.

Upon analysis, it is possible to conclude, at least within the weather modification community, our disagreements have stemmed from three major sources.

1. The nature of weather modification. Application of weather modification techniques seeks to help resolve problems relating to water resources development, transportation, agriculture, national defense, energy, and commerce. Since these problems are addressed by different departments of the federal government, there is no one logical place in which the weather modification organizational structure can be housed.

2. The history of weather modification. Since the inception of scientific cloud seeding, weather modifiers have developed relationships with and attitudes about different federal agencies who have had (or not had) weather modification programs. Naturally these experiences have influenced our preceptions of acceptable federal organization for weather modification.

3. Political realities. The Weather Modification Advisory Board called for unification of the federal effort under the guidance of an autonomous board. The degree of autonomy required for real independence does not appear to be supported by the agency proposed by the Weather Modification Advisory Board as the entity within which the board would be housed. Creation of a separate agency to carry out a consolidated effort also seems to be politically unrealistic. Yet it appears that an adequately funded federal program can only be established in the context of an acceptable governmental structure which would give Congress reason to believe that taxpayers' money would be wisely spent.

A majority of the members of the Weather Modification Association favor strengthened federal coordination as the most practical means of organizing the national weather modification program. We oppose consolidation. Two key organizations are necessary to effectuate coordination: a weather modification board, and a federal coordinator with an adequate staff. The Board should be small enough to be workable and large enough to represent private and governmental sponsors, users, scientists and other stakeholders. The suggestion of a nine member board with staggered three-year terms seems appropriate. The coordinator should be a high-level official with the kind of background and talent that would command the respect of the industry and of the federal, state, and local agencies with whom he or she would work.

A coordinated federal weather modification program would not displace any existing federal programs. Instead it would seek to strengthen them. The board would develop a comprehensive five-year weather modification plan which would be updated annually. The coordinator would work with the federal agencies with weather modification missions and with the board in order to incorporate mission agency plans into the national plan. Also the coordinator would assist the agencies in obtaining appropriations for their activities which conform to the national plan.

A majority of WMA members attending the recent Banff semi-annual meeting expressed a preference for housing the coordinator in the National Science Foundation and having as the board a continuing committee of the National Academy of Sciences. That position was advocated at the meeting by Association members who are officers of the North American Interstate Weather Modification Council. Some members expressed preference for coordination with the National Oceanic and Atmospheric Administration, but not consolidation of the federal effort into that agency.

CONCLUSION

The Weather Modification Association urges the Subcommittee to approve legislation which would:

1. Contain a strong statement of federal policy supporting a commitment to a long-term national weather modification program;
2. Authorize a twenty-year program of research, field testing, and assistance in setting up and evaluating weather modification operations; and
3. Establish strong federal coordination of the national program through a federal coordinator and an advisory board.

STATEMENT OF RAY JAY DAVIS, VISITING PROFESSOR OF LAW, BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH, ON THE OUTLINE OF THE LEGAL ASPECTS OF WEATHER MODIFICATION

During the thirty years since the inception of scientific cloud seeding a body of weather modification law has been developing in the United States. For the most part this law has been created by the states. While the federal government has talked a lot about weather modification law, it is the states that have done something about it. For analysis the legal aspects of weather modification can be treated under the following headings:

1. Governmental organizational structure;
2. Water rights;
3. Legal liability;
4. Governmental regulation of weather modification activities; and
5. Multijurisdictional considerations.

ORGANIZATION

Through legislation governmental entities have been designated to perform tasks which relate to weather modification. Thirty-two states have at one time or another passed statutes dealing with cloud seeding, and in most of these cases the state laws have identified, created, or provided for creation of agencies which have been given power to regulate weather modification activities or to conduct them or both.

Regulatory powers have usually been lodged in some existing department, normally one which otherwise deals with natural resources or agriculture. Generally that agency is assisted in carrying out its regulatory function by an advisory board which usually is made up of persons with knowledge about or interest in weather modification. In some jurisdictions where cloud seeders are quite active, a state weather modification director or coordinator is employed along with some staff members. The director's position may or may not be created by statute.

Authorization to carry out weather modification activities is in some states expressly granted to an agency of state government which is usually empowered to work with political subdivisions within such states and with federal agencies. Other laws may give such power to conduct or sponsor cloud seeding to local agencies of government. Some states provide through legislation a means whereby citizens within local areas may set up or abolish special weather modification districts. Those entities can levy taxes and spend the monies received on weather modification.

State and local programs, like those of the federal government, require appropriations legislation when the agencies use general revenue monies to sponsor or carry out weather modification activities. A number of western states have, in times of drought, made special appropriations for efforts to increase precipitation. Utah and North Dakota have made appropriations for their state operational seeding programs. South Dakota did so for a number of years, but for the past few years has not made appropriations for state-funded operations.

WATER RIGHTS

Questions about water rights can arise in two contexts: first, a claim by a riparian or a prior appropriator to rights in supplemental water flowing in a stream due to a seeding-induced augmentation in the supply of water; and second, an assertion by a landowner upon whose property precipitation has not fallen adequately that atmospheric moisture which otherwise would have precipitated was intercepted by cloud seeding. In both contexts there are serious difficulties in proving such claims and assertions. With a single exception, allegations that seeding has "robbed Peter to pay Paul" have not been proven in court actions in which such contentions have been made. And no project sponsor has ever been in court attempting to prove that water in a stream was put there by his seeding effort. Adequate information and generally accepted evaluation of it have not been available. It may be some time before persons asserting legal interests in atmospheric and supplemental stream waters can prove the factual basis upon which their cases must rest.

Assuming contenders for atmospheric waters or for supplemental stream flow can prove the facts, there remain legal water rights questions. In the three cases which have treated the atmospheric water rights issue, judicial statements about ownership have differed. An early 1950's New York case said that landowners had no rights in atmospheric waters above their properties; a late 1950's Texas case said that landowners did have a right to whatever precipitation nature would have provided; and a late 1960's Pennsylvania case recognized a landowner's property interest in atmospheric waters, but said that it would have to give way in the event of government-authorized seeding. From such scattered and contradictory cases it is impossible to draw a firm conclusion as to the state of the law.

Colorado, Utah, and North Dakota have statutory provisions covering waters developed by cloud seeding. Colorado permits them to be appropriated; Utah would allocate them to the holder of the senior water right on the stream whose right had not been as yet filled; and North Dakota says that such artificially-induced precipitation and its runoff shall be treated as naturally-occurring waters. Three different statutory approaches do not represent a trend, but they do show how other legislative bodies might deal with the issue of rights in waters developed through weather modification projects.

LIABILITY

Although lawsuits pending in Los Angeles and South Dakota may change the situation, there is no record of any weather modifier having been defeated in an action for tort damages. Plaintiffs have been unable to prove to the satisfaction of

triers of fact that the losses of which they have complained were caused by the cloud seeding done by defendants. Until better evidence is available, persons seeking damages (like those laying claim to water rights) cannot prove their cases. Cause-in-fact is an essential element of the Anglo-American law of liability.

Plaintiffs in liability actions have asserted a wide variety of legal theories upon which they have sought to base their cases. Common among such theories have been negligence (failure to live up to the standard of professional care required of a weather modifier), strict liability (seeding is an abnormally dangerous activity for which there should be liability irrespective of fault by the modifier), and nuisance (the gravity of harm caused by the activity outweighs the utility of the activity). Statutes in Pennsylvania and West Virginia appear in some cases to mandate a strict liability theory, and laws in a few states seem to indicate that in some cases at least plaintiffs must prove negligence. But all of these common law and statutory approaches to the liability theory issue have been immaterial in view of inability to prove causation.

Defendants have other means of escaping the financial impact of a liability action. In a few states sovereign immunity is a governmental defense, and under the Federal Tort Claims Act planning errors in projects may be asserted to be under the "discretionary function" exception to the statutory waiver of immunity. Indemnity clauses and insurance may shift responsibility also.

REGULATION

About half of the states, the half where weather modification takes place, have some sort of regulatory system over cloud seeding. In recent years new laws and newly enacted revisions of older laws have tended to follow a pattern. They bar unregulated weather modification. Persons in charge of projects are required to have professional licenses. Each project must be conducted under the terms of an operational permit. The license is a document given to those applicants who meet standards of professional competence and integrity. Permits indicate that project design and planning are satisfactory. Of course these laws are only as effective as the enforcement abilities of their administrators permit.

The only federal law which even verges upon regulation is Public Law 92-205, the reporting law. Similar reporting laws in states provide information which administrators can use in deciding whether and when to modify or suspend permits. In addition state regulators often are given specific power to inspect the premises of persons holding weather modification permits or otherwise carrying out intended weather modification activities.

MULTIJURISDICTIONAL

Weather modification, like weather itself, is not confined by man-made geographical boundaries. Interstate and international issues have been raised by cloud seeding efforts in the past. The future obviously will bring further multijurisdictional questions.

Generally states have cooperated with each other in the field of weather modification. States have issued permits for seeding intended to affect target areas in other states. They have shared radar information. They have agreed among themselves to work together in experimental projects. The North American Interstate Weather Modification Council is a more formal illustration of such interstate cooperation.

There have been no interstate lawsuits about cloud seeding. A former Idaho attorney general did threaten both Oregon and Washington with possible litigation over their proposed drought relief seeding upwind of Idaho. Assurances from the governors of those states to the Idaho governor that Oregon and Washington programs would be carried on in such a manner as not to affect Idaho adversely brought the potential controversy to an end. A state complainant, just like a private one, would have trouble proving causation.

Similarly there have been no international legal claims filed because of weather modification. It is clear that a nation has the obligation to inform another country of activities within its jurisdiction or control which may reasonably be expected to have an adverse impact on the other nation. And cloud seeding nations must enter into consultation with countries who request that interaction. But no country has the legal right to exercise a veto power over a weather modification project in another nation. If a claim of harm caused by such seeding can be proved, a country would be legally liable. Proof of causation is, of course, the same problem here that it would be in an interstate legal action or one among private citizens.

The United States has an executive agreement with Canada for exchange of weather modification activities information, and we have entered into a number of

memoranda of understanding over technology transfer of cloud seeding skills to other countries and joint experiments. Also we participated in negotiation of the United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques. We have not ratified the convention. The convention constitutes an undertaking not to engage in "environmental modification techniques having wide-spread, long-lasting or severe effects as a means of destruction, damage or injury" to another country.

For several years now the United Nations Environment Program and the World Meteorological Organization have been working with meteorologists and legal experts on a series of provisions relating to cooperation between countries in weather modification. Those provisions will be presented to the governing councils of the two sponsoring organizations for their consideration and possible further action. The latest draft of them is appended to this statement.

CONCLUSION

While weather modification law, like the science of cloud seeding, is not fully matured, there is a significant body of legal principles and norms which have thus far served relatively well. Organization and regulation are acceptable to meet present needs. Liability and rights questions have not been resolved primarily because information necessary for establishing causation has not been available. Multijurisdictional cooperation, rather than confrontation, has been the norm.

DRAFT DOCUMENT CONCERNING COOPERATION BETWEEN STATES IN WEATHER MODIFICATION¹

(Prepared by WMO/UNEP Meeting of Experts Designated by Governments on the Legal Aspects of Weather Modification held in Geneva, September 17-21, 1979)

Recognizing that the atmosphere is a natural resource of the Earth,

Noting the possible benefits which weather modification may hold for mankind and the environment,

Desiring that weather modification should serve the interests of international understanding and co-operation,

Desiring further that the provisions set out below should be interpreted in such a way as to promote the improvement of weather modification technology and its beneficial use,

Recalling the declaration of the United Nations Conference on the Human Environment approved at Stockholm on 16 June 1972, inter alia, Principles Nos. 1, 2, 20 and 21,

Recalling further the relevant decisions of the Seventh and Eighth World Meteorological Congresses (1975, 1979) and those of the Governing Council of UNEP,

Bearing in mind Resolution 31/72 of the General Assembly of the United Nations—Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (10 December 1976),

Recognizing that the application and further development of the following provisions has to be closely related to the existing state of scientific and technical knowledge in the field of weather modification,

Recommends that States take into account the following:

(1) Weather modification should be dedicated to the benefit of mankind and the environment.

(2) Exchange of information, notification, consultation and other forms of co-operation regarding weather modification should be carried out on the basis of good faith, in the spirit of good neighbourliness and in such a way as to avoid any unreasonable delay either in such forms or in carrying out weather modification activities.

(3) States should gather and record technical and scientific information on weather modification activities. They should ensure that such information is made available to WMO which should continue to prepare and distribute appropriate reports on weather modification activities.

(4) States should, either directly or through WMO, and to the extent possible, give adequate and timely notification to all concerned States of prospective weather modification activities under their jurisdiction or control, which are likely to have an effect on areas within the national jurisdiction of such concerned States.

¹ The term "weather modification", as used herein, means any action performed with the intention of producing artificial changes in the properties of the atmosphere for purposes such as increasing, decreasing or redistributing precipitation or cloud coverage, moderating severe storms and tropical cyclones, decreasing or suppressing hail or lightning or dissipating fog.

(5) States should ensure that an assessment is made of the environment consequences of prospective weather modification activities under their jurisdiction or control which are likely to have an effect on areas outside their national jurisdiction, and, either directly or through WMO, make the results of such an assessment available to all concerned States.

(6) Weather modification activities should be conducted in a manner designed to ensure that they do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

(7) A State under whose jurisdiction or control weather modification activities are planned or are taking place which are likely to have an effect on areas outside its national jurisdiction should, upon the request of a concerned State, either directly or through WMO, enter into timely consultation concerning such activities.

(8) States should encourage and facilitate international co-operation in weather modification activities, including research, and, as may be appropriate, conclusion of bilateral, regional or multi-lateral agreements.

Senator HEFLIN. Senator Bellmon, would you like to introduce your fellow Oklahoman?

Senator BELLMON. It is a pleasure and an honor to be allowed to introduce Dr. Ray Booker, who is not only a member of the Weather Modification Advisory Board, which has done a tremendous service for the Congress and country in preparing the report that they have put together, but who is also a practitioner of the art of weather modification and has been a friend and associate of mine for a long time.

As a matter of fact, it is probably Dr. Booker as much as anyone else who got me interested in weather modification questions. And I have looked to him over the years for guidance and counsel.

Both of us come from Oklahoma, where weather is not particularly reliable as it is in some other States.

So we have had more interest in weather modification going clear back to the days of Indian dances intended to make raindrops fall.

So I am interested that Dr. Booker is here this morning, and I look forward to his testimony.

Dr. BOOKER. I have a statement which I will set aside, because the first thing we checked on Senator Bellmon before we elected him was to make sure that he can read and write, and I assume that all the rest of you can. So I will set that aside and go over the high points.

Senator HEFLIN. That could be a dangerous assumption.

Dr. BOOKER. I think it is a safe one, sir.

I come from private industry, have always been in private industry, and tend to think of things in a way that private industry does. If we are going to try to get something done in the private sector, there are five steps in getting it done:

First, is to decide that we clearly want to do it and to make a clear and firm decision to do it.

The second thing we have to do is to plan it, get some sort of a notion about how we intend to go about it, to get a guide to keep us on track.

The third thing we do is to organize it, to get some sort of an organizational structure that will work.

The fourth thing is to direct it, make sure that somebody is in charge, to be sure that the job is really getting done.

The last thing we do is we control it. We continue to have some means of monitoring what is going on to make sure that what we originally set out to do is in fact what we are accomplishing.

I suggest we are at the point where we have got to decide to do that in the field of weather modification. The time is now to decide on national policy in this field. We are now three decades from the time we started out in this field and we are again considering where we really are, and the testimony is saying that we don't really know enough about weather modification to do it.

Three decades later that sounds like a surprising statement. But there are some reasons for it. We are at a turning point now in science, in the science in this field. Why do I say that?

When we started out 30 years ago, our concepts of how clouds work were very crude and we had some very crude tools for looking at clouds. We didn't understand how they worked and we didn't know how to measure them, even if we knew how they worked. In these last 30 years, we developed some amazingly good tools for measuring what clouds do and we finally understand the intervening processes between seeding clouds, nature seeding or man seeding, and rain on the ground.

We finally have come to the realization that you don't just seed and look in the bucket for what fell out. We have finally realized that we have to look at the intervening processes and that we now have, through satellites, radar, computers, we have the tools for the first time on this earth to adequately monitor clouds. So we are at a turning point right now.

The second reason we have to decide now, is that we have the WMAB report. We have a policy we can adopt, and the country, I think, at large has decided it is a good plan. There are some questions about it, but we will try to address those.

The third reason we should do something about it right now is that, while weather modification is something we can get along without right now, by the end of this century we will need it a lot more. Our chairman Mr. Cleveland mentioned on Wednesday that people moving to the coastline—Mr. Heflin, something you brought up a while ago—people moving to the coast of the United States and other continents around the world are placing the number of people at risk to hurricanes and property at risk very much greater every year.

That is, it is going up exponentially, and by the end of the century we can have great and potentially massive disasters if we do not learn to do something about controlling the winds and hurricanes.

Simultaneously, we have to know more about how you produce rain, how you decrease hail, because the potential of our planet to carry the people on it is diminishing. Now we have to look for sciences that we could ignore some time back. Solar energy, for example. We could ignore that a few years ago and we can't now. We could ignore weather modification a few years ago, but we won't be able to, I think, by the end of this century.

So the time has come to make a decision and I think we have the tools, we have the facts now to make decisions on a national policy in weather modification.

One of the things that was kicked around a lot apparently in the executive branch is, is there a need for legislation. I suggest there is a need for legislation for two primary reasons:

One is that we need a statement of national policy, this plan we talked about, something that we are going to follow to keep us on track. The Congress is the only body we have to make this statement of national policy. I think we should do it.

The second reason we should have legislation and have it now is that Congress is really the leader we have always had to depend on. Congressmen have always been leaders in this field. It was true in the 94th Congress. If the 94th Congress had not acted on S. 3383, Senators Bellmon's and Pearson's bill, there would not now be today a proposed statement on national policy on weather modification. Even in this Congress, it is the leadership of Congress that is making things happen.

A year and a half ago, we had the WMAB report and for 16 months we have been considering that in the executive branch. I suggest if these two bills had not been introduced and if these hearings had not been scheduled we might never get the report from the Secretary of Commerce which was called for by Public Law 94-490.

Then we come to the second step, the organization. Well, if anybody has ever tried to herd a bunch of chickens, you know the value and the benefit of organization. Chickens cannot be driven. They go where they think their best interests are served. And we have heard a lot of testimony about why don't we designate a lead agency.

This has been proposed by committee after board after committee for years. I think designating a lead agency is like designating a lead chicken. The way you get chickens to go where you want them is you put the feed where you want the chickens.

That is to say that if we want to have a national weather modification program, we have to put somebody in charge. Putting somebody in charge means that whoever is in charge handles the budget.

The question then is who is qualified to do that. The biggest reason that centralization is opposed by so many people right now is that there is only one agency that is logical as a place to centralize it, and everybody is unhappy with them, including myself. They have not shown the leadership, the drive and the desire to lead in weather modification. Perhaps the reasons for that can be explained. Perhaps they can be cured.

But I would rather not specify where centralization should take place. I think it could be in any agency. More important than that is the mechanism for directing and controlling the activities.

One of the characteristics, one of the reasons why we have had a lack of leadership, not just in NOAA but other agencies, Agriculture for example, which should be one of the most interested agencies in our Government—and the National Science Foundation in recent years has opted to get out of the field of weather modification. The reason for that is that weather modification tends to be a bit controversial.

Bob White put it very succinctly on Wednesday. He said the reason we didn't get more done while he was Administrator of

NOAA is that it was too hard to endure the pain for the little bit of good you could do. It is a little bit hard to get something done in this field. If you are in middle management in any of these agencies, it is a lot easier to go do something else. Other programs are bigger, in the first place, and they are a little bit more like wearing a white hat.

So if we are to do something in weather modification, we must provide a bit of insulation for this program from the others. Otherwise the leader of this program will have to compete unfairly with other activities for dollars and for access to top administrative officials. The lack of insulation has been at the root of the lack of interest, I think, of all of the agencies who have shown this lack of interest.

How to direct it. I suggest that in an agency—I will not suggest which—in an agency, we designate a director of weather modification that should report directly to the head of that agency, insulating him from the other activities which they have had to compete with in the past. I suggest that he might be called an associate administrator for weather resources management; that he report directly to the administrative head of the agency and be in charge of the weather modification research activities for our Government.

So that takes care of the direction. What about the control? The control is perhaps the most important part of it. I suggest a strong board, as the WMAB suggested a strong board. I still think the WMAB proposal is the best one.

But since nobody endorses that, we have to compromise. Let's change the WMAB proposal slightly. Instead of having the WRMB—having the Weather Resources Management Board appoint a director of the program, let the administrator appoint him—this preserves the line of authority that is so dear to the hearts of administrators.

But we need an oversight. We need a way for this program to be sensitive to the needs of people and to the views of Congress, who has to face the people every 2 or 6 years.

I suggest the Board be charged with looking over the Nation's weather modification project to evaluate it technically, scientifically, to determine whether it is watching for these social, societal problems, the legal ramifications, the environment, and to make an annual report on how the program is going to the Congress. After all, it is the Congress which I think will always retain the greatest interest.

I think the reports of the Board should go directly to the Congress. In addition, I suggest that the Board be charged with responsibility of recommending budget levels for weather modification. Now, this doesn't mean that all weather modification activities in the different agencies should cease. Indeed, they could continue. But this Board should be charged with recommending what the budget levels should be.

The question of centralization, I think, is at the heart of the legislation. It is the biggest unresolved question. I think there is little doubt in anybody's mind that we need to do some good research in this field and we need to move ahead and we need the science and we will be needing it in the next two decades.

Therefore, I think we have to make some hard decisions right now to do some things that are fundamentally right and to look over the rocks in the road that are just a few feet ahead of us. I think that means the hard decision to go ahead and put someone in charge of this and to give them the funding and to admit that we are on a two-decade research program, with increasing implementation all along the way.

That concludes my statement.

[The statement follows:]

STATEMENT OF D. RAY BOOKER, PRESIDENT, AEROMET, INC.

Introduction

It has now been three decades since we began our efforts to modify clouds. We still have not learned how to get reliable results from cloud seeding, and our attempts to do it are still shrouded in controversy and doubt. Funding for weather modification research has declined in recent years in spite of striking technological developments which greatly improve the chances for success. In spite of a widely perceived need for a workable weather modification technology, the interest in some federal agencies in weather modification research has declined.

We do not have a statement of national policy for weather resources management (WRM) technology, even though a great deal of research and operational work persists. Recognizing this need, the Senate took the lead four years ago in seeking the development of a national policy. Bills introduced by Senators Bellmon and Pearson led to Public Law 94-490, which directed the Secretary of Commerce to develop recommendations for national policy on weather modification. The Secretary formed a Weather Modification Advisory Board (WMAB) to conduct a study and recommend a policy. The WMAB conducted an intensive and wide ranging study and submitted its reports 15 months ago. Over 3,000 copies of the WMAB report have been circulated in the United States and the Federal Agencies, and by Congress. The report has generally been regarded as a landmark event in the history of this science because it is the first thorough review of all of the important questions in weather resources management and because the report was in response to Congressional action.

The Senate has again taken the lead with the introduction of S. 829 by Senator Bellmon and S. 1644 by Senator Stevenson. These hearings, with the wide range of opinions sought, is another example of leadership by the Senate on this issue. I want to compliment the Senators and staff members for their persistent dedication to progress in weather resources management.

Now, we have come to the moment of deciding what our National Policy on Weather Resources Management will be. The two bills now being considered by this subcommittee have called for the question to be answered. Even a failure to decide a National Policy now will be a decision because the course of all related events for many years will be influenced by the outcome of these hearings. I suggest that the decision Congress will now make will be our Weather Resources Management Policy for the two decades addressed by the WMAB.

The WMAB report

The WMAB was made up of 17 prominent persons from a variety of backgrounds. They investigated the wide range of issues on which Congress asked for advice in Public Law 94-490. I will review a few of the WMAB findings which I think have the most bearing on our National Weather Resources Management Policy.

Value.—Weather is the most important uncontrolled variable in our lives. Its effects range from mere inconvenience to great famines and massive storms with the great losses of lives and property. While weather modification cannot be expected to make more than very small changes in a limited range of weather situations, the net effect can be very important. In a world where we are living ever closer to the limits of our resources, we must learn to use technologies we could ignore just a few years ago, such as solar power, ocean mining—and weather resources management. Compared to other technologies, the WMAB found an extraordinarily high potential return on our research investment in weather resources management. The reviewers have generally agreed with this WMAB finding.

State of the science.—Certain man made changes in simple clouds have been well documented and can be easily repeated. The more complex cloud systems that produce most of the rain, snow and storms are not well enough understood for us to change them with an always predictable outcome. We were just beginning to learn

how clouds work 30 years ago when we started trying to modify them. Our concepts were much too simple. We have since learned about many complex and rapidly changing processes that occur between seeding and rain on the ground. They can lead to either more or less rain from a given treatment. While we now know enough about the cloud processes to be very optimistic about learning to control them to some extent, we have not demonstrated an ability to do it operationally. I am not aware of any serious challenge on this WMAB finding.

Tools available.—The tools we had for observing clouds 30 years ago, were even cruder than our concepts about how they work. Our primitive radars, questionable airplanes, and "eyeball" observations were simply no match for the complexity and violence of the clouds we tried to modify.

During the last decade, we have made remarkable progress with tools for monitoring and understanding the atmosphere. Satellites can now continuously monitor the great swirling cloud masses around the globe, yet zoom in to study the details of individual clouds. Weather radars can now measure the three dimensional structure over a wide area, yet simultaneously observe internal circulations, ice/water content, hail content, and other details about individual clouds. Optical cloud probes are now able to examine the finest details of millions of cloud particles in a few seconds. We have small, fast, and inexpensive computers that can process the avalanche of data our sensors generate and give us pictures of cloud processes even as they are happening. We have numerical models that can faithfully simulate many of the cloud processes, saving us the time and cost of doing some tests in the atmosphere.

These tools greatly increase our chances for success in future research. This is one of the best reasons why we should now move ahead with a research program.

Research needs.—Our research needs have changed. We now know that we should not seed clouds and look only for the end result—rain at the ground. We now must learn more about basic cloud processes and how they can be altered with reliable results. Within the last few years, we have gained the tools and concepts to do the building block research successfully. When we understand the cloud processes, we can identify the conditions in which we can seed with predictable end results.

This represents a change of research strategy. It means that we now have a much greater chance of success in weather modification research, but we must take a longer view in our plans. We must be willing to study the pertinent atmospheric process until we understand them. It means several years of focused basic research and exploratory research before we try many large, complex weather modification experiments.

The WMAB took note of the fact that progress in the atmospheric process pertinent to weather modification would be a tremendous benefit to forecasting, modeling, cloud physics, and many other sciences. It did not dwell on these fringe benefits because they should not be a major factor in our decision to move ahead.

Operational cloud seeding.—Operational cloud seeding projects arise from the needs of user groups, many of which are willing to bet on an unproven cloud seeding technology because the potential gain from even a marginal success outweighs the costs and risks. Unfortunately, some projects have been poorly designed and not operated with proper care. Almost none of them can be evaluated in an acceptable manner. This inability to evaluate the results is a major cause of controversy. The WMAB recommended several ways of improving the standards for operational projects and of gaining considerable knowledge from them to complement the laboratory research.

The interest of those concerned with operational projects is best served by better research. More effective methods and better definition of the results of seeding can enhance the position of contractors and decrease the controversy that frequently surrounds operational projects. The development and use of sound weather resources management practices will protect the interest of the public and the quality of the environment.

Role of States.—Several states fund operational or research projects as well as regulate them. Their leadership increased during a period when Federal activities were declining. They must play an important role in any National Weather Resources Management Program. The WMAB recommended State-Federal partnership arrangements in some cases where high operational standards allow the achievement of research goals.

Federal organization and leadership.—The most prominent characteristic of the Federal Government's organization for weather resources management is that no one is in charge. The agencies doing research decide their own priorities with no formal mechanism for interagency coordination. Each reports to a difference authorizing committee and a different appropriations subcommittee. There is no Congress-

sional or Executive Branch policy mandate. This situation, quite naturally, leads to overlapping or incomplete research efforts, a lack of enthusiasm, interagency struggles, a decline of federal support, and a loss of valuable personnel and facilities.

The WMAB recognized that the development of a weather resources management technology faces a complex and unique series of problems that require unique solutions. These include:

1. Each Federal agency has certain interests in the development of weather modification techniques, which it is unwilling to surrender to another agency, especially if it believes that agency is not as vigorous or as interested as it is.

2. The controversial aspects of some past weather modification tend to color the whole field and mask the potential for good science with genuine benefits for mankind.

3. Because of the past controversy, it is difficult for weather modification research programs to compete in an ordinary bureaucratic setting with other "white rat" activities for priority in funding requests and access to top administration officials.

4. The research effort has many facets which must be coordinated carefully. This coordination is not consistent with a multi-agency or lead-agency approach, yet the interests of the people served by each agency must be fairly represented.

5. The main reservoir of talent and experience is in the university and private sectors. This, combined with a general need to restrain the growth of the Federal Government, means the National Program must have strong capability for managing "out-of-house" research efforts.

6. The technology to be developed is largely for use by those outside the Federal Government. Therefore, the program should be managed by a unit that has a built-in sensitivity of outside group needs, rather than the insulated insensitivity that is typical of some present arrangements.

For these and other reasons, the WMAB recognized that any of the usual bureaucratic arrangements would give the usual results. The usual results are insufficient in this case.

The WMAB decided, and fervently believed, that the principles of centralization and autonomy were essential to the success of the National Program it recommended. The principle of consolidation was predictably objectionable only to those who would be transferred and their contractors. The principle of autonomy ran contrary to every bureaucratic instinct. We must compromise.

Level of funding.—The WMAB carefully considered the question of an appropriate level of funding. An attempt to project research funding based on potential returned value gave funding levels that were inconsistent with the current philosophy of fiscal restraint. The human and technical resources are available to accommodate the higher level of funding. Many of these resources were lost temporarily to other fields because of insecure weather modification funding. The final WMAL budget recommendations were calculated as an adequate basis for a National Program with perhaps a slower than optimum start-up. I suggest that any further cuts from that level would not be in the national interest, even considering a strong fiscal restraint policy.

Regulation.—The WMAB considered the reasons for, and possible liabilities of, a federal regulation feature of the National Program. On the one hand, here have been clear abuses of the public interest that suggests a form of federal licensing to help curb the abuses. On the other hand, there are other means of upgrading the standards used on seeding projects, including action of professional societies. Further, overzealous or clumsy regulation could hamper the development of the science.

At least two professional societies have taken steps recommended by the WMAB to improve operational standards. Some states have tightened and improved their regulation procedures. I now believe that the progress being made outside of the Federal Government has eased the need that led to the WMAB recommendation for a Federal licensing program. I now suggest waiting a few years before reconsidering the regulation issue.

Comments on the WMAB recommendations

The WMAB report has been reviewed very extensively by all interested parties. After all the reviews, we found that debate, especially within the Executive Branch, boils down to four issues. While we do not yet have the results of the last 16 months of Federal consideration of the WMAB report, I would like to address the issues which I believe have been troubling the Executive Branch.

The need for legislation.—There is a clear and unmistakable need for legislation to be developed by the Congress. Without leadership from the 94th Congress, we would not have any recommendations for national policy. There has been no evidence the Executive would have developed a recommended statement of national policy without Public Law 94-490. The Executive Branch has been unable to decide

its position on the WMAB report. I am convinced that without S. 829, S. 1644, and these hearings, we might never get the report required of the Secretary of Commerce by Public Law 94-490.

The idea that the Executive Branch could organize itself to carry out an effective National Weather Resources Policy and Program without the leadership of Congress is not supported by past performance. I think the Congress should continue to lead by developing legislation. The sooner the better.

Consolidation and autonomy.—Some continued progress can probably be made under the present multi-agency arrangement. However, a serious National Program, such as the WMAB recommended, requires that someone be in charge. Being in charge means having the budget responsibility. The WMAB recommended giving that authority to an independent board that would be assigned to the Administration of NOAA for administrative purposes. While this idea was endorsed by professional and user groups and the community in general, it was not welcomed by the Executive Branch or Congress. I still think it is the best proposal, but I sense that a compromise is necessary.

The S. 1644 proposal to consolidate the National Program under NOAA but without the autonomy the WMAB felt was mandatory, is not welcome to many outside NOAA, including myself. NOAA is generally perceived as an agency that does things in-house and gives a low priority to weather modification. NOAA's delay in forwarding the report of the Secretary of Commerce required by Public Law 94-490 to Congress did little to dispell that image. The S. 1644 plan does not solve the unique problems a National Weather Resources Management Program, as I described them above, would have. The keys to solving those problems is to provide a buffer between the NWRMP and the other agency functions and a strong citizen board to monitor the agency performance, report to Congress and provide an interface with the extra-government stakeholders. The board provided by S. 1644 would only advise. A stronger board is needed.

The organizational aspects of S. 829 are similar to S. 1644 except the NWRMP would be consolidated under NASA. The board would be made up of fewer, better compensated members, but its main function would be to advise. NASA has a better reputation than NOAA for managing complex scientific and engineering endeavors and it already has significant atmospheric research programs. NASA has a reputation for doing work through contractors, which fits the WMAB finding that most of the reservoir of WRM capability is outside of government. The main objection to the S. 829 proposal to consolidate the NWRMP under NASA is that the agency mission is not as closely related to the atmosphere as that of NOAA.

Neither proposal satisfies the unique needs of the National Program. The choice of an agency is not as important as the form of the Program.

I offer a slightly modified version of the WMAB proposal which I believe will preserve the line of authority that any Agency head will want, yet serve the needs the WMAB recognized, and which I summarized above. This plan can be applied to NASA or NOAA, so I will only refer to an Agency and its Administrator. It has the following features.

1. The Administrator would be directed to establish a NWRMP, including the consolidation of all WRM units.

2. The Administrator would be directed to establish a position of Associate Administrator for Weather Resources Management. This person would report directly to him and be responsible for planning, organizing, and conducting the NWRMP.

3. The Congress would establish within the Administration a National Weather Resources Management Board. S. 829 outlines a suitable board because it has only six members but offers the compensation level consistent with attracting the kind of members we want managing this National Resource. It also has six year terms which survives administration changes and allows enough tenure for the members to learn to handle the complex problems the Board would treat.

4. The Agencies, having an active interest in WRM, should have a voice in selecting members for the Board. The Administrator should seek their suggestions before appointing members to the Board. No member of the Board should be a Federal employee.

5. The Board should be charged with observing, advising, and evaluating the progress of the NWRMP. It would have no direct authority over the NWRMP. However, it should be given the responsibility and authority to make an annual report to the Congress and the President on the progress, problems, and prospects of the WRM, including a statement of recommended priorities, a five year recommended plan of action and a recommended budget for the NWRMP. The Agency should submit a separate line item in its budget for the operation of the Board. The Board could independently suggest its own budget level.

6. The Board should be charged with the responsibility of actively seeking out the needs of other Agencies, user groups, international concerns, legal-societal-environmental problems and other matters of policy concern and considering them in its annual reports.

7. This arrangement should cease to exist after 20 years. The Administrator would then treat the NWRMP as any other part of his Agency unless there is new legislation directing otherwise.

I suggest that S. 829 has a good description of the Board envisioned by the WMAB. The description of the responsibility and functions can be easily changed to fit the formula I suggest here. I have suggested a change of wording, which can accomplish what I suggest in the appendix to these remarks.

S. 1644 and S. 829 compared.—Both S. 1644 and S. 829 follow the WMAB recommendations. However, S. 829 has more detail. Its findings and Policy sections are more detailed and more closely follow the suggestions of the WMAB in the following areas.

1. It recognizes the potential benefits to many parts of the economy, especially agriculture.

2. It recognizes that most of the reservoir of competence is in the university and private sectors.

3. It recognizes the proper role of the states in WRM.

4. It recognizes the transnational nature of WRM which requires us to cooperate with other nations.

5. It recognizes the current operational use of WRM techniques and the potential for adding to our reservoir of knowledge.

6. The relation of man's unintended effects on weather to WRM technology is recognized.

7. A specific statement about the use of the university and private sectors in carrying out the NWRMP is included.

8. The important elements of the purpose of the NWRMP are enumerated.

9. Federal-State partnership arrangements, which the WMAB felt were very important are mentioned as a purpose.

10. The environmental concerns that must be part of the NWRMP, including the development of sound weather resources management practices are treated in S. 829.

Conclusions

I believe the time has now come for the Congress to declare our National Policy on Weather Resources Management through legislation. The WMAB report provides the basis and content of this policy and proposes a program to implement it.

I suggest that S. 829 very closely follows the WMAB report and should be used as the final bill to be considered by Senate and House. However, it should be modified slightly to achieve a compromise on the WMAB recommendations regarding Federal Organization and Leadership. I have suggested revised wording for S. 829 in the appendix to this statement.¹

Whatever the outcome, I want to express the deep appreciation of people around the country for the leadership and initiative shown by the Senators and their staff members in developing a meaningful policy and program in Weather Resources Management.

Senator HEFLIN. Thank you.

The next witness is Mr. Paul C. Summers, Cloud Seeding Program Coordinator, Division of Water Resources, from Salt Lake City, Utah. Mr. Summers.

Mr. SUMMERS. Mr. Chairman, it is indeed a pleasure for me and an honor to appear before this subcommittee.

As was mentioned, I am currently chairman of the North American Interstate Weather Modification Council. This organization has representation from 15 States in the United States and four provinces of Canada. My testimony today is representative of the opinion of the majority of the Council's board of directors.

Weather influences almost all types of human activity. The management of weather for the benefit of society by means of the prudent use of planned weather modification is now technically

¹ The appendix is in the committee files.

possible to some extent. That is, the modification of cold orographic clouds to increase precipitation in the wintertime is believed by many scientists to be technically possible. However, a comprehensive and coordinated program of research and development is required to realize all of the potential benefits of planned weather modification.

The public interest requires the assessment of the economic, environmental, legal, and societal impacts of changes in the atmosphere resulting from both planned and unintentional weather modification. The Federal Government has supervening responsibility for directing the development and management technology in the United States. At the present time the United States lacks a well-defined, properly focused policy and program in weather modification research and development.

A lack of adequate and sustained funding has retarded progress in the development of science and technology in this field. The development and ultimate success of the weather modification technology depends on the development of the necessary scientific basis in a strong and balanced research program in the atmospheric sciences. It depends on the effective utilization of all of the applicable scientific and engineering resources of the Nation, including those in the industrial and academic and other public and private organizations in all regions of the United States.

This technology development requires the advancement of education and training in the atmospheric and associated sciences.

The cooperation of the United States with other nations in international organizations whenever such cooperation is in the national interest is extremely important. This is another area where the North American Interstate Weather Modification Council can be helpful.

As I indicated earlier in my testimony, four provinces in Canada are members of the Council and we have contacts with the Federal Government of Mexico as well.

With that introduction, I would now like to address the bills introduced by Senators Bellmon and Stevenson. The policy and findings statements in these bills are pretty much in harmony with the statements I have made earlier in my testimony.

They do focus attention on many of the real concerns we, interested in weather modification, have for the future of the technology.

Both bills include many good ideas, including the 5-year comprehensive plan and the use of an advisory board, among others.

The problem or concern we have with these bills is the concept of bringing all agencies involved in weather modification into a single agency.

The concept of consolidating agencies, departments, or functions into a single controllable unit is a time-honored and traditional management concept in business as well as government.

In most cases, it works very well, resulting in increased efficiency and productivity. In discussing these bills with university and private scientists, we find there is a great need for a diversity of thought in the exploratory and conformatory research areas.

Consolidating would simply reduce opportunities for funding this innovative research. Realistically, we all know that the Federal budget is subject to many different pressures and constraints.

In the case where there are two, three, or more funding agencies involved, the budget cut does not normally affect all of these in any one year.

If everything was consolidated under one agency, a severe budget cut to that agency could, in effect, severely diminish or wipe out the research effort.

Another problem with consolidation is that it would tend to place the entire future of weather modification in the hands of a few people; that is, an advisory board, one agency, and likely one set of congressional subcommittees.

Anywhere along the line, should one or two people in key positions of power decide they don't like what is happening in the field for whatever reason, political or otherwise, they could in effect disrupt, slow down, or eliminate any immensely beneficial technology.

When the Weather Modification Advisory Board was deliberating the many issues in weather modification, the idea of consolidation under a single agency with an advisory board having a high degree of autonomy seemed like the answer.

In fact, after the Advisory Board's report was released, the Council issued a position statement agreeing with that recommendation of the WMAB.

However, we now better understand that the political realities are such that the degree of autonomy talked about in the WMAB report is not possible; therefore, we cannot support the consolidation concept.

I do not come here only to state what is wrong with the two bills before you, which I'm sure were introduced with the best of intentions, but I bring with me an alternative proposal which we believe could be a step in the right direction.

Presently, the bulk of weather modification research is carried out in the U.S. Bureau of Reclamation and in the National Oceanic and Atmospheric Administration.

There is research to a limited degree being carried out in the National Science Foundation. However, the funding and emphasis on weather modification at the present time in NSF is probably at an all-time low.

We see the orderly development of the weather modification technology involving all three of these agencies.

We believe there is a need for a strong emphasis in basic and fundamental research along with the applied research and development components. NSF seems like the logical agency to be strongly involved in the area of basic and fundamental research.

The Bureau of Reclamation, under its charter, is involved in weather modification in the areas of precipitation enhancement. The Bureau is conducting such research programs as the Sierra Cooperative Pilot Project in the Sierra Mountains in California and Nevada, the High Plains Cooperative Program in Texas, Montana, and Kansas, and a planning and preliminary investigation into the Colorado River Augmentation Project in Colorado and Utah.

NOAA has been involved for several years in an experiment in the Florida area called PACE, preliminary investigations into the precipitation augmentation crops experiment program in the Illinois area (PACE), as well as research into severe storms such as hurricane suppression in Project Stormfury.

Both the NOAA and Bureau programs do involve some basic and fundamental research; however, we believe that the technology would be greatly enhanced if an agency such as NSF had a renewed emphasis in weather modification and were given sufficient dollars to fund creative and innovative research carried out in the university and private sectors.

Therefore, we are proposing a plan which I will submit as a part of my testimony that would involve NSF in a program of basic research and also support the ongoing programs in the Bureau and NOAA.

We believe that coordination among these three agencies is of extreme importance. Therefore, we would recommend that a position of a Weather Modification Research Coordinator be set up and housed in the National Science Foundation.

This coordinator would have responsibilities for working with the three agencies involved to prepare a 5-year plan of research and development and updating this plan annually.

In addition, we are recommending that an advisory board be set up by the National Academy of Science to give advice and recommendations for input to the 5-year plan.

We believe this proposal constitutes a sensibly focused approach to a meaningful national program.

I must stress that successful development of the weather modification technology can only be achieved when the commitment is made by Congress to a sufficient level of funding and to stabilizing that funding level from year to year.

I need to point out that there are concerns within the Council membership for the type of individuals who would be selected to serve on the proposed National Academy of Science Advisory Board.

We have specified in our proposal the types of individuals we wish to see on this advisory board and hope the Academy would request input from the weather modification community before making these selections.

We recognize that under this plan there is no absolute power given to the coordinator or the advisory board to compel agency cooperation.

However, we believe the strength or motivation to cooperate could be embedded in the 5-year plan, particularly if the Office of Management and Budget were to endorse this overall concept.

I would add that realistically, in order for this proposal to be effective, there must be contribution of a very positive nature from the three agencies—Bureau, NOAA, NSF—the coordinator, the advisory board, and stable funding levels for all agencies involved.

I submit as part of my testimony to this subcommittee a document that may be cited as "Weather Modification Research and Development Act of 1979."

Thank you, sir. That is my testimony.

Senator HEFLIN. That will be added in the record.

[The document referred to follows:]

A BILL To declare a national weather modification policy, to establish a comprehensive and coordinated national program of weather modification research and development.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Weather Modification Research and Development Act of 1979".

SECTION 1. FINDINGS.

The Congress finds and declares the following:

- (1) the atmosphere is a public resource belonging to no person, interest, state, or nation;
- (2) weather influences almost all types of human activity;
- (3) many types of human activity such as urbanization, industrialization, power plant operation, irrigation, and general land-use result in unintentional modification of the weather;
- (4) the management of weather for the benefit of society by means of the prudent use of planned weather modification is technically possible to some extent;
- (5) a comprehensive and coordinated program of research and development is required to realize all the potential benefits of planned weather modification and to understand the consequences of human activity in unintentionally modifying the weather;
- (6) the public interest requires an assessment of the economic, environmental, legal, and societal impacts of changes in the atmosphere resulting from both planned and unintentional weather modification;
- (7) the Federal government has a supervening responsibility for directing the development and management of weather modification technology in the United States;
- (8) Federal regulation of weather modification to safeguard the national interest is not required at this time and, in fact, would likely impede progress in developing the emerging technology; and
- (9) the United States lacks a well-defined, properly focused policy and program in weather modification research and development, and a lack of adequate and sustained funding has retarded progress in the development of the technology.

SEC. 2. DECLARATION OF POLICY.

(a) POLICY.—The Congress hereby declares that it is the policy of the United States to formulate, direct, prudently carry out, and maintain a comprehensive and coordinated national research and development program in planned and unintentional weather modification in order to contribute to—

- (1) the protection of life and property from severe storms, hail, tornadoes, hurricanes, and other catastrophic weather events;
- (2) the increase and stabilization of weather resources by means of rain and snowpack enhancement for use in food, fiber, and energy production, drought alleviation, municipal and industrial applications, recreation, and maintenance of the quality of life in general;
- (3) the exploitation and development of solar energy and other atmospheric resources by maximizing the availability of favorable weather conditions, including the dissipation of clouds to admit more sunlight for energy conversion;
- (4) the improvement in land, water, environment, and energy resource planning, development, and use by understanding the effects of such activity in unintentionally modifying the weather; and
- (5) the enhancement of commerce, transportation, agriculture, natural resources, health, and public well-being in the United States.

(b) PROGRAM CONSIDERATION.—In order to achieve the objectives of this Act, the weather modification activities of the United States shall be conducted with full consideration of:

- (1) the development of the necessary scientific basis in a strong and balanced program in the atmospheric sciences;
- (2) the effective utilization of all applicable scientific and engineering resources of the Nation, including those in industrial, academic, and other public and private organizations, in all regions of the United States;
- (3) the close cooperation of all agencies and organizations concerned in order to avoid unnecessary duplication of effort, facilities, and equipment;

(4) the effective development and utilization of scientific and technical knowledge, instrumentation, equipment, and techniques in all scientific and engineering disciplines applicable to weather modification;

(5) the advancement of education and training in the atmospheric and associated sciences;

(6) the highest regard for the interest of and close cooperation with the public, State and local agencies, and user groups that are likely to be affected;

(7) the cooperation of the United States with other nations and international organizations, whenever such cooperation is in the national interests, in order to facilitate the exchange of scientific and technical information and the peaceful and beneficial application of weather modification; and

(8) the development, encouragement, and promotion of socially responsible and scientifically sound weather modification practices.

SEC. 3. PURPOSE.

The purpose of this Act is to establish and provide for a twenty-year comprehensive Federally coordinated national research and development program in weather modification, that includes—

(1) research and experiments to develop reliable, planned weather modification technologies that are of benefit to society;

(2) research and experiments to assess the magnitude and impacts of unintentional weather modification effects; and

(3) promotion of information and technology transfer and technically sound operating standards with States and private contractors.

SEC. 4. DEFINITIONS.

As used in this Act, the term—

(1) "Weather modification" means any planned or unintentional artificially produced change in the composition, behavior, or dynamics of the atmosphere, whenever such change results in the alteration of the weather.

(2) "Weather modification activity" means the use of any device, chemical, or other substance for the purpose of deliberately producing weather modification.

(3) "Board" means selectees by the National Academy of Science.

(4) "State" means any State of the United States, the District of Columbia, or any Commonwealth, territory, or possession of the United States.

(5) "Director" means the Director of the National Science Foundation.

(6) "Coordinator" means Federal Coordinator for Weather Modification in the National Science Foundation.

(7) "Program" means the National Weather Modification Research and Development Program, established in Section 5.

SEC. 5. NATIONAL WEATHER MODIFICATION RESEARCH AND DEVELOPMENT PROGRAM.

(a) **ESTABLISHMENT.**—There is hereby established a National Weather Modification Research and Development Program with the purpose of understanding, developing and improving unintentional and planned weather modification concepts and technologies in accordance with the provisions, policies, and purposes of this Act.

(b) **COORDINATION.**—The Director shall appoint the Coordinator of the National Weather Modification Research and Development program. Compensation for this position shall be at the ES-4 level.

(c) **FUNCTIONS OF FEDERAL AGENCIES.**—In order to carry out the purposes of this Act—

(1) The Director of the National Science Foundation is authorized to—

(A) carry out and support a program of basic and fundamental research and experimentation to understand the atmospheric processes related to unintentional and planned weather modification; and

(B) advance the state of knowledge in weather modification through the initiation and support of research and programs of education and training at universities, colleges and other appropriate institutions, in those sciences which relate to and underlie weather modification technology.

(2) Other Federal agencies charged with the management of national resources or the solution of particular national problems are authorized to conduct and support weather modification research and experimentation programs to develop weather modification technologies that are consistent with their mission requirements and policy goals, and to demonstrate the feasibility of new operational methods.

(3) All Federal agencies with program responsibilities under this Act are authorized to—

(A) carry out and support research on the benefits, costs, values, and impacts of weather modification including the social, legal, economic, and environmental factors of weather modification technologies;

(B) furnish technical assistance and information in the field of weather modification to any other Federal agency, State agency, or user group requesting such assistance or information;

(C) encourage, with the assistance of the Secretary of State, cooperation with other countries to exchange information, participate in international activities, enter into agreements;

(D) utilize the expertise of the Board, as established in Section 7, universities, private contractors, State and local governments, and professional societies as necessary to carry out the provisions, policies, and purposes of this Act;

(E) consult and cooperate with those State and local governments and other interested groups which are likely to be affected or which are likely to affect Program activities;

(F) assist in the preparation of five-year plans for the Program, as provided in Section 6; and

(G) assist in the preparation of annual reports on the Program, as provided in Section 8.

(d) **ADMINISTRATIVE POWERS.**—In order to carry out the provisions of this Act, the head of any Federal agency charged with responsibilities under Section 5(c) of this Act or any employee of such agency designated by its head is authorized to—

(1) adopt, amend, and repeal regulations governing the exercise of his duties under this Act;

(2) acquire by purchase, license, lease, donation, or otherwise such inventions, patents, patent applications, licenses, real property and interests therein as he deems necessary;

(3) accept as a gift, money, material, or services and notwithstanding any other provisions of law, use of any such gift, if the donor so specifies, may be restricted or limited to certain projects or areas;

(4) enter into and perform such contracts, leases, cooperative agreements, or other transactions, including the making of grants, as may be necessary to carry out his duties under Section 5(c) and on such terms as he may deem appropriate; and

(5) use, with their consent, the services, equipment, personnel, and facilities of other Federal agencies with or without reimbursement, and on a similar basis to cooperate with other public and private agencies and instrumentalities in the use of services, equipment, and facilities; and each department and agency of the Federal Government shall cooperate fully in making its services, equipment, personnel, and facilities available to any agency charged with responsibilities under Section 5(c) and, with the approval of the Director of the Office of Management of Budget, each department or agency is authorized, notwithstanding any other provision of law, to loan to such agency, without reimbursement, property, equipment and facilities required for the performance of its duties under this Act.

SEC. 6. FEDERAL PLANNING AND COORDINATION.

The Coordinator in order to achieve the objectives of this Act, shall—

(1) provide the Program coordination to insure an effective and balances effort and to avoid waste and unnecessary duplication; and

(2) in cooperation with the heads of Federal agencies with responsibilities under this Act, prepare a five-year plan for weather modification research and development activities by the Federal government. The five-year plan shall be submitted to the president and Congress not later than one year after the date of enactment of this Act, and shall be revised and extended annually. Each five-year plan shall identify—

(A) goals and priorities for the Program;

(B) program activities and accomplishments needed to ensure that Program goals are met within the time frame established by the plan; and

(C) total Federal funding necessary for the Program to achieve its goals.

(3) meet regularly with heads of Federal agencies or their designee in order to carry out their responsibilities under this Act.

SEC. 7. WEATHER MODIFICATION BOARD.

The National Science Foundation shall call upon the National Academy of Science to establish a nine (9) member advisory board for specified purposes:

(a) **DUTIES.**—The Board shall regularly meet with and advise the Coordinator with respect to—

- (1) planning, development, and implementation of the National Weather Modification Research and Development Program;
- (2) preparing the five-year plan, as required in Section 6;
- (3) preparing the annual report, as required in Section 8; and
- (4) such other matters as the board determines to be of importance and related to the provisions, policies, and purposes of this Act.

(b) **MEMBERSHIP, TERMS, AND POWERS.**—

(1) The Board members shall be drawn from experts in weather modification, socio-economic, legal and environmental and related disciplines. There shall be six (6) members who are experts in weather modification; two each from the university, private and state/user sectors. The remaining members shall be drawn from the other related fields.

(2) No member of the Board shall be an employee of the Federal Government.

(3) Each member of the Board shall serve for a term of three years, except for those members initially appointed to the Board, up to three members shall be appointed for a one-year term, up to three for a term of two years, and up to three for a term of three years. Any individual appointed to fill a vacancy on the Board shall serve for the unexpired term of the member whom he is appointed to succeed.

(4) The Board shall select a member to serve as its Chairman and another member to serve as its Vice-Chairman. The Vice-Chairman shall perform the functions of the Chairman in his absence.

(5) Each member of the Board shall receive compensation at the daily rate for GS-18 of the General Schedule under section 5332 of Title 5, United States Code, while actually engaged in the performance of his duties, and shall be reimbursed for actual and reasonable expenses incurred in the performance of such duties.

SEC. 8. ANNUAL REPORT.

The Coordinator shall prepare and submit to the President and the Congress, not later than January 30 of each year a report on the activities conducted pursuant to this Act during the preceding fiscal year. Each report shall include—

- (1) a summary of the achievements of the Program during the preceding fiscal year;
- (2) an analysis of the progress made toward achieving the goals of the Program;
- (3) a copy of the five-year plan and any changes made in such plan;
- (4) a summary of the budget for the Program, including past expenditures, present requests, and future projections;
- (5) a description of actions which have been taken to improve Federal-State and United States-international cooperation in weather modification; and
- (6) recommendations, including additional legislation, for improving the Federal weather modification effort in order to carry out the provisions, policies, and purposes of this Act.

SEC. 9. CONTRACT AND GRANT AUTHORITY.

(a) **IN GENERAL.**—The head of each Federal agency with responsibilities under this Act may enter into contracts and make grants in order to carry out his responsibilities under this Act. Any such contract or grant may provide up to 100 percentum of the total annual cost of the project or activity involved.

(b) **ELIGIBILITY AND PROCEDURE.**—Any individual, corporation, public or private educational institution, or State or local government may apply to the head of the appropriate Federal agency for a contract or grant under this section. The head of the appropriate Federal agency shall prescribe the form, manner, and content of the application for an actual term of any contract or grant.

(c) **TERMS AND CONDITIONS.**—Any individual or entity who receives Federal funds from a contract entered into or grant made under this section shall keep such records as the head of the appropriate Federal agency shall prescribe by regulation, including—

- (1) records which fully disclose the amount and disposition by such recipients of such funds;
- (2) the total cost of the project or activity for which such funds were so made available;
- (3) any amount of such costs supplied from other sources; and
- (4) such other records as will facilitate an effective audit. Such recipient shall maintain such records for five years after the completion of such a project or

activity. The head of each Federal agency with responsibilities under this Act and the Comptroller General of the United States, or any of their duly authorized representatives, shall have access for the purpose of audit and evaluation to any books, documents, papers, and records of such recipient which, in the opinion of the head of the appropriate Federal agency or Comptroller General, may be related or pertinent to such contract or grant.

SEC. 10. SUNSET PROVISION.

The Program shall cease to exist twenty years after the date of enactment of this Act, unless otherwise provided by law.

SEC. 11. AUTHORIZATION OF APPROPRIATIONS.

(a) NATIONAL SCIENCE FOUNDATION.—In addition to any other funds otherwise authorized to be appropriated to any Federal agency with responsibilities under this Act for weather modification activities, there are authorized to be appropriated to the National Science Foundation, for the purpose of carrying out the provisions of this Act, not to exceed \$5,000,000 for the fiscal year ending September 30, 1981, and not to exceed \$7,000,000 for the fiscal year ending September 30, 1982, to remain available until expended. Funding for subsequent fiscal years shall be authorized on the basis of the five-year plans required in Section 6(a)(2).

(b) COORDINATOR.—In addition there is authorized to be appropriated to the Coordinator a sum of \$500,000 to carry out his responsibilities under this Act for the fiscal year ending September 30, 1981 and \$550,000 for fiscal year ending September 30, 1982. Funding is authorized for subsequent fiscal years.

Senator HEFLIN. I believe most of you were here for Wednesday's hearing when the administration submitted its proposals and the advisory groups gave us their recommendations.

Do any of you have any reactions to Wednesday's testimony as well as each others' remarks? I'll start with you, Dr. Veal.

Dr. VEAL. I would comment on Dr. Booker's five outlined steps, which I agree with.

I think there is one fundamental ingredient that should be clearly understood prior to implementing those steps, and that is to understand with some degree of predictability what you can do before you attempt to do all of those things.

It is in that area that I think we must concentrate.

Senator HEFLIN. Does the remainder of the panel have reactions to the other testimonies, or Wednesday's testimony?

Dr. BOOKER. With regard to Wednesday's testimony, I would react to one thing.

As you know, I guess the decision finally got made on Tuesday morning as to what the administration's position was going to be. And I am not sure that I understand it exactly yet. I haven't seen anything in writing.

But as I understand, there is to be some sort of a coordinating agency or coordinating committee that is very similar to the old ICAS, or Interagency Coordinating Committee on the Atmospheric Sciences. But that didn't work. It never did work.

And if you read the emanations from that committee back when it was operating concerned with weather modification, it sounded very much like sort of a mining camp where all of the miners defend the territory that they have staked out, with not enough imagination about the territory nobody has even covered yet.

There are some things, for example, that should be—that the WMAB pointed out. Research should be going on in this country.

One of them is cutting holes in stratus clouds to make the Sun shine on big cities to decrease so much use of energy for heating, for clearing the streets, and that sort of thing.

It is a very doable thing.

But try as we might, those of us who see that opportunity have not been able to get anyone interested in it. And our Nation is not doing research on it, although that is the first thing that was ever demonstrated in 1946, 1947.

And there are other things.

So I don't think the ICAS idea is any good at all.

Senator HEFLIN. Are there other reactions of other witnesses to other witnesses' testimony on Wednesday?

Dr. DAVIS. Mr. Chairman, as I sat through the testimony on Wednesday and today, I felt a little bit like the weather modification community in some respects has been accused of being an impotent rapist. Let me express what I mean by that. It has been said of us that we are impotent in that this is an emerging science. We are just getting underway. I share the view that there is an awful lot yet to be done, that the future, indeed, will bring these developments. But I think it is important to emphasize that there is weather modification taking place. And in the view of members of the weather modification community, it is taking place now and being done successfully. We are not talking about something that is only going to develop in the future. It is here and now.

Turning to the other half of the accusation against us, that as well as being impotent, we are rapists, that we are creating all kinds of problems. I would like to react to that by saying that, so far as I can ascertain, there has been very little litigation in the field of weather modification. And that litigation, from the point of view of people practicing the art, has been successful. There is one case in which even a temporary injunction was issued against a weather modification operation. The scientific exploration of environmental dangers and of possibilities of harm from weather modification indicates that these dangers are minimal in character.

What is needed in the field of weather modification is not massive regulation. What is needed in the field is not high degree of centralization and control. We need to stop this hot and cold business that has been going on in the Government, where there is adequate funding or at least funding of sorts some years, and then it tails off to nothing and then it comes back and on again, off again.

What we need is some sort of ongoing commitment to assistance in the development of the field in the future and to evaluation of what is taking place. That can be accomplished by this Congress by actual enactment of legislation which will state a policy and which will provide for ongoing continuation of programs of research, field testing, development, and of evaluation.

Dr. FARHAR. I would like to respond to the impotent rapist notion just presented. I think that is oxymoronic. It is simply a totally internally inconsistent term. There is at the moment a lawsuit pending in the State of Colorado that Silverton has filed against a weather modifier there concerning the collapse of their historic jail under the weight of snow this past winter when cloud seeding was going on.

The first time that weather modification loses one of these cases is when it comes of age. That means that it has been recognized that it is really doing something and it does have impacts on people and society.

I don't think it constitutes at all an attack on the technology to be concerned about what its impacts really are. It is simply a more realistic look at what it can do for society, while recognizing that it may be harming some persons.

Senator HEFLIN. Are there other reactions?

Mr. SUMMERS. I would like to make one further comment, if I could.

I come from a State where we have a large operational program which some of the testimony here indicated is premature. This has been going on for some years now and we feel that we are getting positive results.

I have been asked by many people as to why would I support the kind of suggestion that I have here that only really seems to support further funding of research.

Well, although we do believe that the technology is workable, as I said, to some extent, and that is to the extent that we are using it, certainly research is extremely important, and that would filter to benefit the operation of projects down through the increased technology. And I think that that is somewhat obvious.

Senator HEFLIN. Dr. Veal, you stated that the most significant progress in weather modification has been in advancing our capabilities in experimental measurements.

As one who has an interest in hurricanes and tornadoes, could you tell us the current state of knowledge in severe storm moderation and what advances have been made in the measurement of these kinds of severe storms?

Dr. VEAL. I have no expertise in hurricanes. I have never worked with hurricanes and I know very little about them.

I defer the question concerning hurricanes to our colleagues who are working within the national hurricane experimental laboratory in Miami.

With regard to High Plain severe storms, I have had some considerable experience investigating the increase of precipitation, as well as mitigation of hail.

Our research to date does not tell us how to reduce hail at this time. We have learned a great deal about the mechanisms of thunderstorms and feel that we now understand more about them.

But I would not tell you that we can reliably and predictably reduce hail at this time.

In terms of instrumentation, we have developed within the last decade a tremendous amount of equipment which allows us to look at the cloud elements, as well as the total motion fields, and the cloud environment of the storms, using instrumented aircraft, satellites, radar, and meteorological networks.

I think we now have a much better chance to understand how clouds develop naturally and that we may be able to modify them to our benefit sometime in the future.

Senator HEFLIN. Would anyone else like to comment on hurricanes and tornadoes? I am particularly interested in the current state of knowledge and the prospects of development and research in these areas.

Dr. Booker?

Dr. BOOKER. I am not an expert on hurricanes, either. We did look into it to a considerable extent during the year of the study of

the WMAB. The seeding experiments that have been done have the results that we hoped they would.

The only problem is that there is only just a smattering of evidence that we really can probably decrease the wind and hurricanes. The theory is a very plausible one. That is, that the links in the chain individually look good. What is wrong, in my opinion, and I think in the opinion of the WMAB in the report we have, is that not enough is going on.

We have had the standing capability for some years, which I understand cost us several million dollars a year. But we just haven't been doing any research in that area. We haven't been doing experimental seeding.

There are difficulties, I recognize. But I believe the difficulties are not as great as have been made to sound.

I think that we should be moving ahead much faster in that area than we are. It just takes more leadership.

Senator HEFLIN. In the plans for the future, let us assume that Congress establishes a policy and we proceed with the Stevenson-Bellmon proposals, or modifications and combinations which will come forward.

Where should the responsibility for dealing with matters like hurricanes and tornadoes be vested?

Is this a type that is going to have to be vested in a unit of the Federal Government, or is it a mixture of State and Federal Governments? Is it a mixture of private industry and government?

What is your analysis, looking to the future of where the responsibilities should be placed pertaining to such matters as tornadoes, which cross State lines, and hurricanes, which have international consequences?

Dr. BOOKER. The WMAB looked at that very question, sir. Most weather modification—that is seeding for rain increase and all that—is generally on a scale that is not inconsistent with regulation by States.

The WMAB recommended that States continue as they have to take a lead role in regulating and sort of taking care of that aspect of it.

However, when we get to the matter of hurricanes and to other storms, we are not doing really anything about tornadic storms. But let's focus on hurricanes.

The storm is so big that it is really outside of the range that a State can handle. And therefore, in that instance, the WMAB felt fairly positively that that fell in the category of Federal control. That was Federal jurisdiction and should stay there.

Senator HEFLIN. In your statement, you talked about the tools available as such things as satellites, the use of satellites to monitor the great swirling cloud mass, weather radars, optical cloud probes, and the use of computers to process the avalanche of data that is gathered.

In dealing with these types of weather problems like hurricanes and tornadoes, do you have any recommendation as to where you ought to vest the research, or how it ought to be organized in regards to that type of weather problems that we have?

Dr. BOOKER. Yes, sir. I started doing research in weather modification in 1962 or 1963. And as a pilot who was a meteorologist, I

flew about 3,000 penetrations. I think during the early days, both Dr. Veal and I were doing it with the crudest kinds of things. I remember an observer with his hand out the window with a black glove and a one-inch square painted on the palm of that glove. He looked at the ice crystals hitting that square and talked about them in a tape recorder.

Today, by comparison, we have the ability to point to Doppler radars at storms and measure the motions within them and even determine if an incipient tornado is there a half hour before it forms.

We can tell the phase of the particles that are forming in the cloud. And instead of a hand out the window, we have the optical probes that I mentioned in the paper and computers to process that data.

The point is that we are up probably two orders of magnitude, maybe 100 times our ability to monitor things than we were 10 years ago. However, that has a cost as well. The cost is that it is now very complex. No longer can you just do a simple experiment with a few tools. Now it becomes something that a laboratory, a group of very competent scientists and engineers working in a very coordinated fashion have to do.

So while our ability to learn is many times greater, the responsibility to organize ourselves into workable teams is much greater.

So where should the responsibility lie, looking down the road one or two decades? A centralized organization with muscle and good direction just makes more sense in trying to capitalize on the various complex, but very useful tools we now have available.

Senator HEFLIN. I suppose in these large weather problems that the military and other agencies are doing something, or at least are cognizant of the problems. And, of course, there are international problems on this.

Let me ask Professor Davis. On Wednesday, the administration noted the U.S. involvement in international activities and you also mentioned international aspects in your statement.

Is the United States doing anything in getting other nations to cooperate in experiments for hurricane moderation? And also we might say with regard to weather moderation, is there an international aspect to this?

Mr. DAVIS. NOAA has taken over Project Stormfury. Stormfury is the hurricane experiment of the United States, and in connection with that, as indicated in testimony on Wednesday, there has been an effort which thus far has not succeeded to enter into arrangements with Mexico so that experimentation can take place in the Pacific Ocean area off the coast of Mexico. Also we are involved in negotiations with the Government of Australia for Stormfury/Australia. So far as I know, Stormfury/Australia has really been hung up on the issue of the memorandum of understanding provision regarding liability. The Government of Australia and our Government have not yet come to an agreement about the liability provision in that memorandum of understanding. I trust that they will arrive at an agreement in the near future so that can go forward.

We have had Stormfury going on for many years now, but it has been over a decade since they have done any seeding. The Storm-

fury activity, of course, does involve international cooperation, and part of the problem has been the problem of working with other countries.

I might say, while you are mentioning international ramifications, that the United States has been involved with other countries in an effort to lay the beginnings of a foundation for international law in this field. The National Oceanic and Atmospheric Administration has worked hard on that. Experts on the technology and on law have assembled with persons from other countries to draft some "principles" relating to international law in the field of weather modification.

In September of this year, there was a meeting of experts designated by governments sponsored by the United Nations Environment Program and the World Meteorological Organization. At that time there was further refinement of those statements of principles which are now designated "provisions" rather than "principles." They will be presented to the governing councils of those two international organizations by them. It is my understanding that the United Nations Environment Program would like to see coming out of this some sort of draft convention and that the World Meteorological Organization is not ready for a draft convention. So what will come out of it is problematical.

Incidentally I have appended to one of my statements on law a copy of the Draft Provisions Relating to International Cooperation in Weather Modification and a copy of the preamble to those draft provisions. I think they represent the state of current thinking concerning international arrangements of this sort.

Senator HEFLIN. First let me preface my remark. We are now very conscious of the expenditure of monies—at least some of us are—and we relate matters to cost efficiency. Prefaced with that, have there been any studies made to study the Federal programs of disaster, centralizing and limiting to weather disasters like hurricanes, tornadoes, as to the amount of Federal money that is being spent for those disaster programs and making some type of hopeful—I suppose it would almost have to be a crystal ball—approach toward what the cost of weather modification could be and what savings could result if you were to obtain an effective and efficient method of weather modification? Have there been any studies on just compiling the figures on weather disasters?

Dr. BOOKER. That has been done. The WMAB did compile some figures on that. I can't recall them, but to give you—well, I should say that one of the things that the WMAB recognized in compiling these figures to caution the reader on is that even though hurricanes, for example, may cause so many billions of dollars of damage, weather modification is not going to eliminate that. There is no way. It is simply that we do not have that sort of power. In fact, all we can do is create a few ice crystals in clouds which didn't exist before and hope that that sets a chain of events in process that will decrease, in a measurable way, what might have occurred.

The theory of hurricanes is that if we were to decrease the wind in the core, in the eyeball, since we know that the damage due to a hurricane is proportional to the square of its wind speed, if you reduce the wind from 100 knots to 90 knots, you reduce the damage

more than 10 percent. It is not just a 10-percent reduction, but more than a 10-percent reduction.

Now the problem is that in today's state of knowledge, about what we have done is to identify the links in the chain. And what I meant awhile ago when I said we were at the turning point, we now know what these links are and know a few things about them. We know how to go about understanding them, but I am afraid we cannot tell you today what the degree of effectiveness is likely to be, except that it will be a small part. It can only be a small part of the total damage, whether it be hurricanes, hail storms, or tornadoes or whatever. The effects are ultimately going to be small.

Senator HEFLIN. Dr. Farhar, do you have a comment?

Dr. FARHAR. The research you are asking about has been done at the Institute of Behavioral Science at the University of Colorado under the direction of Dr. Gilbert White where each of the natural hazards has been assessed—what we know about it, what research has been done on it. There are monographs on drought, hail, flood, and so on. That would be the best source of information, I think, about hazards and their effect on society.

Senator HEFLIN. Dr. Veal?

Dr. VEAL. I would like to make one comment with regard to centralization. I think it is important that all of us remember that weather modification covers in its generic flavor a very broad set of problems: fog elimination, precipitation enhancement be it rain or snow augmentation, hail mitigation, severe storm mitigation, hurricanes, tornadoes, and societal and environmental impacts. It covers that very broad range.

It is for that reason that I believe that centralization of organization many times brings on centralization of point of view. And with that very broad range of interests, it seems to me that at our current understanding what we need to foster is diversity in the points of view in order that we don't miss some of the opportunities for understanding.

Senator HEFLIN. Senator Bellmon, I think you have places to be. If you would like to go ahead and ask some questions, please do so.

Senator BELLMON. Thank you. I will be very brief. I do have another meeting to go to in about 10 minutes.

Mr. Chairman, I appreciate your allowing me to participate. I have before me the committee print on "Weather Modification Programs: Problems, Policy, Potential", published by this committee in May of 1978.

On page 245 there is a table which I have updated for the 1979 figures in the President's budget, but it shows in 1972 the Department of Commerce, which is basically NOAA, spent \$3.94 million on weather modification, and the President's budget has \$2.7 million, so if you take into account inflation, that means that NOAA between that period from 1972 and 1979 has cut its weather modification investment roughly in two. The next column is Interior. In 1972, they were spending \$6.66 million. Their 1979 figure in the President's budget is \$4.5 million, so they have cut to probably half, in two, not quite. National Science Foundation was spending \$5.5 million in 1972; in the President's 1979 budget, they are down to \$1.1 million. They have come down from 5½ to 1.1; they have cut to probably less than 10 percent of what they were doing in

1972. The Department of Defense had \$1.82 million in 1972; they are down to \$0.7. Again, taking inflation into account, they are spending about 20 percent of what they did then. The Department of Agriculture has never had a significant item. They were \$360,000 in 1972; they are zero in 1979.

Looking more at the National Science Foundation, their total budget has gone up from \$622 million in 1966 to \$996 million in 1979, so based upon the percent of their total budget—they have come down almost to nothing.

I don't know what this says to the rest of you, but it tells me that none of these agencies that presently have a role in weather modification care 2 cents about it. Everyone of them are regularly deemphasizing their weather modification activities. And what it says to me is that rather than taking a chance on any of this crowd, we ought to look around for somebody that might be concerned about this problem and might put forth some effort and might make an investment.

I have heard some of you say you don't want a lead agency. I can suggest to you that unless somebody takes an interest and gets in and pushes, these kinds of programs fall through the cracks. I don't know who is the right agency to lead, but somebody has got to get in here and take some interest on weather modification, or it will continue to get the same kind of treatment that it has had over the last 6 or 7 years.

Dr. BOOKER. That is the very point that WMAB is trying to make in its proposal. They recognized the lack of interest and lack of leadership in all of the agencies. I think one agency in the testimony on Wednesday indicated their budget is up to \$10 million in 1980, the Bureau of Reclamation. That seems to be on the upbeat.

Dr. VEAL. For your purposes now, Senator Bellmon, the actual expenditure in 1979 was \$8.6 million in DOI.

Senator BELLMON. Which?

Dr. VEAL. Department of the Interior. The actual expenditure was \$8.6 million in 1979. They have had a considerable increase.

Dr. BOOKER. The basic thing is that the WMAB—

Senator HEFLIN. The Department of the Interior shows an increase, but hasn't it been more in the field of technology, rather than research?

Dr. VEAL. In the field of research, as I understand research.

Senator BELLMON. Well, I am only going to be around here 1 more year, and I would like to see something put in place. I was interested in Senator Heflin's questioning about hurricanes. Frankly, we don't have very many hurricanes in Oklahoma, so this isn't an area—

Senator HEFLIN. But you have some tornadoes.

Senator BELLMON. We are concerned about drought and tornados and hail. It is plain to me that there is reason for practically everyone to be concerned about weather modification because it affects our food supply and our energy consumption and whether or not we can fly when we want to and whether or not we can go to the beach when we want. So we all have reason to be involved. I don't know what the potential for this new science or technology really is, but I am concerned, all through the years we have spent roughly—probably it averages out \$16 or \$17 million a year in the

last 10 years, and we just aren't getting the maximum use for our bucks. Nobody is carefully monitoring what happens when an agency does its thing; another agency does its thing; and a great deal of information that could be acquired from this investment is simply being lost.

I am concerned, Mr. Chairman, that unless Congress passes legislation, unless we do succeed in setting up first of all somebody that is in charge, some agency that is in charge, and second, some objectives that we are going to try to reach, that we are simply going to go on another 20 years scattering our shots over the landscape and not knowing what the real potential of this science of weather modification is.

I don't have any further questions. I would just like to thank you for the interest you have and encourage you to move ahead with the best piece of legislation you can develop.

Senator HEFLIN. Thank you, Senator Bellmon.

In your faculty's testimony, Dr. Veal, you recommend that a national weather modification program utilizing the expertise of researchers holding diverse views should happen. Why would consolidation and centralization hinder this?

Dr. VEAL. Many times it has been our history in science in this country whereby we have centralized the organization, and we have also centralized its formulation, and in that centralization of formulation, what isn't thought of in that group is not included in the program. The views of others then are not incorporated in the research efforts. In our state of understanding now, we must incorporate a diversity of views.

I think cloud physicists don't agree on many areas.

Senator HEFLIN. I imagine the same thing was true about the Manhattan project at the time that they were discussing atomic energy.

Dr. VEAL. That's possibly correct.

Senator HEFLIN. Mr. Summers, you recommend that the National Science Foundation handle the basic research in weather modification, yet you note that both NOAA and the Bureau of Reclamation have performed some basic research. What kind of research would NOAA and the Bureau of Reclamation be limited to?

Mr. SUMMERS. I don't know if they would be limited necessarily if it were coordinated so it would fit into what was needed in all aspects of the science. Part of the thinking there of the Coordinator is that the Coordinator and the Advisory Board and the 5-year plan developed could indicate where that is going on. It is not that it is bad to be done in the Bureau, it is that it is not being coordinated—what is being done with other agencies. It is simply a matter of coordination. Maybe not simply, but it is a matter of coordination.

That is why we have emphasized the strong coordination concept in our proposal.

Senator HEFLIN. Professor Davis, Dr. Booker, and Mr. Summers have all recommended a Federal licensing system not be established. Do you see any type of Federal licensing in the future or do you think State laws will be sufficient? Are there ways that the Federal Government can provide uniformity among State regulations without a Federal licensing provision, rather than by requiring Feder-

al licenses for those who participate in weather modification experiments?

Dr. BOOKER. I was one of those who developed the WMAB recommendation for Federal licensing. Now my testimony is the reverse of that. You may read in the WMAB report that one of the things we recommended is that professional societies take an active role. We were concerned that the standards used in cloud seeding projects were not up to par. But if the professional societies wanted to do something about it, they could. The States could also do some things. In the intervening 16 months which we have been granted to think about this, some things have happened.

The WMA, for example, has instituted a rather admirable program of certification whereby applicants who would do seeding in the field are tested for their knowledge and for their experience. That is the sort of thing that the WMAB was hoping for and felt would be very effective. Since some other things that have happened are good, in the meantime I have come up with the opposite viewpoint that now I think we should not institute a regulation or a licensing at the Federal level at this point.

I think we should give it a few years. The problem is not severe enough now that we just have to do something. I think we should let the States and the professional societies carry on what they are trying to do right now. I think they are moving ahead.

Mr. SUMMERS. I would only add to that that one of the primary reasons for the North American Interstate Council to be organized was to help States to implement uniform statutes. Professor Davis has been helpful in that area. He has helped several States in preparing legislation. I think at this point in time I would agree very much with Dr. Booker that the—and also Professor Davis' testimony—that legislation in States that are being affected by weather modification is adequate at the present time, and some time in the future should the technology develop very usable technology that is used by many States, perhaps then Federal regulation would be necessary.

Certainly at this time—for instance, the State of Utah has a statute that requires licensing permits and controls, I think, quite well, adequately, all weather modification activities that are ongoing in the State.

Senator HEFLIN. As we proceed in this matter, there may be a number of questions that we would like to have your thoughts on. If so, we will submit some written questions to you, and we would appreciate it very much if you would try to answer them in writing and send them back so they would be made a part of the record.

I think with that in mind we will bring the hearing to a close at this time, unless some of you have something else that you want to add, or comment on.

Mr. DAVIS. Senator, I would just like to conclude with a comment that we are appreciative of this opportunity to express the views of the people involved in the field. It isn't always that the legislative process takes into account the interests of the affected persons. We are delighted that this is one of the exceptions when it does take that into consideration.

Senator HEFLIN. Thank you.

[Whereupon, at 11:29 a.m., the hearing was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

TERRITORY OF GUAM,
OFFICE OF THE GOVERNOR,
Agana, Guam, U.S.A., July 2, 1979.

CHAIRMAN,
Senate Committee on Commerce, Science, and Transportation,
The Capitol, Washington, D.C.

DEAR SENATOR: The Government of Guam has reviewed Senate Bill No. 829, the Weather Resources Management Act of 1979, in respect to its applicability to Guam's unique setting. The potential for controlling the weather on Guam has implications on disaster preparedness, agricultural development, flood control and the island's overall water supply.

Control of typhoons and tropical storms could reduce the everpresent threat to life and property on Guam. Rain control could vastly stimulate field farming as lack of irrigation and the high expense of water distribution are the major constraints to farming much of Guam's prime agricultural lands. In respect to controlling typhoons, this would also eliminate a major constraint to agricultural production on Guam.

Guam has extensive flood hazard areas which would potentially be controlled through weather management. Recharge of our sole source aquifer is dependent on rainfall percolation and thus could also be managed through weather control.

I recognize that much of the state-of-the-art of weather resources management is experimental and innovative technology. As an island, Guam might be subject to undesirable secondary or indirect impacts resulting from extensive weather modification projects on, or adjacent to, the larger continental land masses. However, I am greatly interested in its long-range potential benefits to Guam. I support passage of this bill and would like to be kept informed of the progress of this legislation. Guam would like to participate in this program if established through law.

Further questions concerning Guam's interest in this subject should be directed to the Director, Bureau of Planning, P.O. Box 2950, Agana, Guam 96910. Thank you for your consideration.

Sincerely yours,

PAUL M. CALVO,
Governor of Guam.

TERRITORY OF GUAM,
OFFICE OF THE GOVERNOR,
Agana, Guam, U.S.A., September 21, 1979.

Senator HOWARD W. CANNON,
Chairman, Senate Committee on Commerce, Science, and Transportation, Washing-
ton, D.C.

DEAR SENATOR CANNON: The Government of Guam has reviewed Senate Bill No. 1644, the Weather Modification Management Act of 1979 and finds that it has a similar intent, as found in Senate Bill No. 829, the Weather Resources Management Act. As you know, I supported Senate Bill No. 829 in my letter to your office dated July 2, 1979. Our concerns with Senate Bill No. 1644 are relatively the same as previously discussed. Weather modification and management on Guam could have important primary effects on disaster preparedness, flood control management, agricultural development and the island's supply of fresh water. The potential benefits, though contingent upon highly innovative technology, merit establishment of a well-planned research and management effort.

An additional concern which I would like to address relative to both bills, is Guam's unique setting within the Western Pacific Region. Whereas, weather modification and management on the mainland would necessitate a high degree of interstate coordination, the same degree of regional cooperation in the Western Pacific would be required. Guam is located such that specific weather modification on or around Guam would potentially create spillover effects on other Micronesian island

groups, some of which attain a political status separate from the United States. Thus, weather resources management in this region could involve much foreign agreement and proposals for weather resources zones of management boundaries would not be inconceivable.

Another concern related to Guam's unique setting, is that island ecosystems are extremely fragile and complex. Guam could not afford to absorb many adverse impacts if errors in weather modification projects were to occur. I feel that any projects or management efforts should only follow a thoroughly prepared and approved environmental impact assessment.

After careful review, I support the intent of both bills but feel that Senate Bill No. 1644 is the most definitive approach. However, the specific reference to "environmental assessments" in Senate Bill No. 829—Section 7(a)(1) paragraph 2, and other aspects of operating practices is favorable over the comparable Sections 6(b)(6) and 7(b)(1)(B) in Bill No. 1644. I would prefer that further specificity in respects to operating practices be incorporated into the latter bill.

I appreciate your keeping me informed of the status of this legislation. Thank you for the opportunity to provide comments.

Sincerely yours,

PAUL M. CALVO,
Governor of Guam.

DESERT RESEARCH INSTITUTE,
Reno, Nev., August 2, 1979.

Senator PAUL LAXALT,
Russell Office Building, Washington, D.C.

DEAR SENATOR LAXALT: In 1977 the Secretary of Commerce established a National Weather Modification Advisory Board (NWMAB) to study the status of weather modification in the United States with a view to developing a national program. The report of this Advisory Board is currently with the Secretary of Commerce who, we understand, also produced a report relating to this general subject area. In particular, this second report relates to the possible establishment of a national program within the national Oceanic and Atmospheric Administration.

I am sure you are aware that there are many concerns within the scientific community and the weather modification community generally about the centralization of the national program within NOAA. These concerns are based principally on NOAA's questionable previous history in this field and the fact that sponsored research by NOAA outside their own laboratories has been somewhat minimal. On the other hand, the Bureau of Reclamation within the Department of the Interior has developed, over the past 15 years, a strong cooperative program in weather modification in which many University programs were spawned and continuing large scale cooperative experiments have been developed in which universities and the private sector have been strongly supported.

One common factor which has emerged from the recent deliberations on weather modification by the NWMAB, the private sector and university groups, is that the National Science Foundation's basic research effort should be much more strongly supported.

The National Science Foundation program in weather modification was, in 1972, a moderately well supported activity with a budget approximating \$5 million. The program was moved from Atmospheric Sciences Section of NSF into Research Applied to National Needs, in about 1972. When the program was transferred back to back to Atmospheric Sciences in 1977, the financial support for the program was much reduced and we understand is currently supported by an appropriation from the office of the Director of NSF, at a level of \$1.2 million per year.

This letter is to acquaint you with the fact that the Desert Research Institute strongly supports the recommendations of the NWMAB to rebuild and augment the support for basic research on weather modification within the National Science Foundation. A copy of the Board's report and recommendations was delivered to Mr. Sam Ballinger of your office by Dr. Warburton of the DRI during his recent visit to Washington.

We do hope that you might consider these issues in your deliberations for appropriations for such programs. The Desert Research Institute is currently a recipient of support from the Weather Modification section of NSF.

Thank you for your consideration.
Sincerely yours,

LLOYD P. SMITH, *President.*

UNIVERSITY OF WASHINGTON,
Seattle, Wash., September 24, 1979.

Senator ADLAI STEVENSON,
Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: I believe that S. 1644, which states national policy in weather modification and establishes a national R & D program, is in the national interest; and I hope it can be passed by the Congress. The provisions are sound and well drawn, in general; and the bill is specific on appropriate topics while leaving necessary flexibility for carrying on research.

I have noted two minor points of ambiguity which may cause confusion:

1. Sec. 11a specifies that grants or contracts to a State are limited to 50 percent of costs, while grants or contracts to other entities may cover 100 percent of costs. This might be construed as restricting research grants to state universities to 50 percent while not restricting grants to non-state universities.

2. Sec. 12a(1)A states that NSF "shall retain control over the supervision and direction of basic Federal research related to weather modification". This might be construed as placing all basic research on weather modification within NSF or as giving NSF authority over the National Program. I suggest replacing the phrase quoted above with "shall retain the authority to support basic research related to weather modification".

Sincerely yours,

ROBERT G. FLEAGLE, *Professor.*

TEXAS DEPARTMENT OF WATER RESOURCES,
Austin, Tex., October 15, 1979.

HON. ADLAI STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Russell Senate Office Building, U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: The purpose of this letter is to provide you with a position statement of the Texas Department of Water Resources (TDWR) concerning S. 829, the Weather Resources Management Act of 1979 and S. 1644, the Weather Modification Management Act of 1979. It is respectfully requested that the TDWR position on this matter be made a part of the record of hearings which are scheduled to be held by your Subcommittee in Washington, D.C. beginning on October 24, 1979.

The people of Texas are fully aware of the influence of weather on their everyday life. This influence is especially evident in the High Plains of Texas where droughts and violent hailstorms are commonplace occurrences. With approximately 10 million acres of land cultivated annually for production of food and fiber, rainfall and hailfall anomalies at times determine the strength of the High Plains economy. Studies by this Department in support of the High Plains Cooperative Program (HIPLEX) for a 14-county, 8.1 million-acre region of the High Plains including the Big Spring-Snyder, Texas economy indicate that the net effect of 10 percent additional rainfall on the dryland and irrigated agricultural sectors would be an overall expansion in business output for the 14-county region of approximately \$3.86 million annually or \$1.75 per acre of cropland, and an annual increase in regional income of about \$2.30 million or about \$17.71 per capita.

For the past decade the State of Texas has been keenly interested in weather modification. In 1967, the State Legislature enacted a Weather Modification Act to be administered by the Texas Water Development Board, one of three predecessor water agencies of the current Texas Department of Water Resources. The Act is aimed at encouraging weather modification activities in the State of Texas which are both beneficial to the user and acceptable to the scientific community.

The weather modification interests of the State of Texas are principally twofold. First, the TDWR is responsible for administering the Act with respect to all operational weather modification projects in the State. Secondly, Texas has a committed interest in research and development of weather modification activities within the State. The Texas Water Code assigns the TDWR authority to develop weather

modification as one proven technology that may be integrated into the State's water resources management system.

Because the population and economic growth of Texas are expected to continue, orderly development of Texas' water resources to meet present and increasing future water needs is imperative. The growing need for additional water, coupled with a perennial decline of available water from current water resources, brought about the development in 1966-1968 of the Texas Water Plan. The Plan was designed to both conserve and protect the quality of existing water resources and, quite importantly, to develop new sources of freshwater within the State. The role of precipitation management through weather modification is considered in the Plan as one potential avenue for the development of an additional source of freshwater.

Under the authority of the Act and the direction of the Texas Water Plan, the TDWR has participated in a comprehensive research program, known as the High Plains Cooperative Program (HIPLEX), since it was initiated by the Bureau of Reclamation in 1974. The HIPLEX Program is a federally sponsored research effort in the field of weather modification in the U.S. High Plains east of the continental divide. It is part of the U.S. Department of the Interior's "Project Skywater," which is designed to develop an effective technology for precipitation management to help serve the Nation's freshwater supply needs. Research is being conducted from three experimental sites, representative of the northern, central, and southern sections of the Great Plains. The southern site is located in the Big Spring-Snyder area of Texas.

Research at the Texas HIPLEX site, after four years, has made significant contributions toward our understanding of the shower-producing clouds and their environment in West Texas. Only after we understand the physical makeup of these clouds can we proceed toward the ultimate goal of realizing, through weather modification, additional freshwater on the ground for agricultural, municipal, industrial and recreational needs.

The philosophy of the HIPLEX program is based upon the cooperation and participation of user groups at both the State and local levels. This arrangement fosters feedback of information between user groups and scientists and assures us that the end product of our years of hard work will be acceptable to the technical and scientific communities and, most importantly, responsive to the needs of the people. It is our belief that this philosophy is the basis for the current overall success of the Texas HIPLEX program and is in no small way a result of competent leadership and foresight on the part of the Bureau of Reclamation staff.

This Department supports the concept of the 1978 recommendation of the (Federal) Weather Modification Advisory Board to ultimately consolidate all existing weather modification activities at the Federal level into a single National Weather Resources Management Program (and Board). However, because of the real need to close the gap between researchers and users, we believe it is imperative to maintain the momentum of the existing Bureau of Reclamation "Project Skywater" program during this transitional period.

We are concerned that some of the proposed legislation at the Federal level may adversely affect the autonomy of the existing Bureau of Reclamation's "Project Skywater" and that its current momentum may suffer as well as its continuity, direction and purpose. This is likely to set back all "Project Skywater" programs both in time and in credibility; thus, increasing both costs and effort to regain the momentum it currently enjoys. We therefore, respectfully request that consideration be given to maintaining the Bureau's "Project Skywater," including HIPLEX, in its present posture and under its present leadership until its purposes are achieved.

We appreciate your consideration of our statement as your Subcommittee continues its challenging task.

Sincerely,

HARVEY DAVIS,
Executive Director.

TEXAS DEPARTMENT OF WATER RESOURCES,
Austin, Tex., November 7, 1979.

HON. ADLAI STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Russell Senate Office Building, U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: Please refer to my letter of October 15, 1979 subject as above. The purpose of the present letter is to provide you with an amended statement of the Texas Department of Water Resources (TDWR) concerning S. 829, the

Weather Resources Management Act of 1979 and S. 1644, the Weather Modification Management Act of 1979. It is respectfully requested that the amended TDWR position on this matter be made a part of the record of hearings on these two bills which were held by your Subcommittee in Washington, D.C. on October 24 and 25.

At the time of my October 15, 1979 position statement the draft of a substitute bill prepared by the North American Interstate Weather Modification Council (NAIWMC) had not been introduced into the record. We, therefore, limited the applicability of our comments to S. 829 and S. 1644. I understand that Paul Summers, Chairman of the NAIWMC, introduced the draft bill into the record of the hearings on November 26, 1979.

Although the applicability of our October 15, 1979 comments were limited to S. 829 and S. 1644, we did not come out in favor of either of the two bills; we only supported the 1978 recommendation of the Weather Modification Advisory Board. The principal thrust of our October 15 statement was to urge that "Project Skywater" be left under the Bureau of Reclamation's direction until its objectives had been achieved.

The Department, after thorough study of the draft bill proposed by the NAIWMC (copy enclosed) wishes to specifically support that draft bill and express the hope that it be properly introduced for consideration by appropriate members of the Congress.

Sincerely,

HARVEY DAVIS,
Executive Director.

NATIONAL WILDLIFE FEDERATION,
Washington, D.C., November 2, 1979.

Hon. ADLAI E. STEVENSON,

Chairman, Subcommittee on Science, Technology, and Space, Senate Committee on Commerce, Science, and Transportation, Washington, D.C.

DEAR MR. CHAIRMAN: Reference is made to the recently-concluded public hearings held by your subcommittee on two weather modification bills, S. 829, the Weather Resources Management Act, and S. 1644, the Weather Modification Management Act. It is requested that the contents of this letter be made a part of the official record of that hearing in lieu of personal testimony.

The National Wildlife Federation has its headquarters at 1412 Sixteenth Street, N.W. in Washington, D.C. It is a nonprofit, nongovernmental organization which has independent affiliates in all 50 states, Guam, Puerto Rico, and the Virgin Islands. These affiliates, in turn, are made up of local groups and individuals who, when combined with associate members and other supporters of the Federation, number an estimated 4.1 million persons.

As you know, I had the privilege of serving as a member of the Weather Modification Advisory Board. I accepted the invitation to serve, principally, to ensure that in its deliberations the Board fully considered the potential environmental effects stemming from either intentional or unintentional weather modification. In my judgment, the WMAB's final report contained a set of recommendations which, if folded into any proposed federal legislation, would adequately safeguard the environment. Unfortunately, neither S. 1644 nor S. 829 contain provisions fully satisfactory in that regard. References in both bills to environmental effects are too brief and lack sufficient specificity. The Federation directs your attention to the contents of Chapter 8 of the WMAB Final Report (pp. 139-145) and urges that both bills be revised, particularly to adequately reflect the "two steps beyond NEPA" approach described in that chapter on page 141.

We are pleased that Section 6 of S. 829 specifically provides for research on unintentional weather modification. A national strategy to cope effectively with such phenomena as acid rain fallout is badly needed. S. 1644 needs strengthening in this regard. Also, it is vitally important that any proposed legislation provide adequately for international cooperation and coordination. While both bills contain a few references to this subject they could stand more detail, especially S. 1644. Again, the WMAB Final Report (Chapter 10) provides some excellent proposals.

On the matter of best management practices, NWF is pleased at the attention paid to this subject in Section 7 of S. 829. We recommend that S. 1644 be revised to include similar coverage.

As far as organization is concerned, it seems to us that the federal effort in weather modification R & D likely would be improved if overall management authority was vested in one agency instead of continuing the current interagency coordination approach. But what is needed even more are formulation of a national

policy in weather modification and then a firm commitment from federal program planners and legislators to provide, over the long haul (20 years), consistent research funding. Such funding must be in amounts sufficient to satisfactorily resolve the many still-remaining substantive questions concerning the efficacy of weather modification.

We are enclosing, for your additional information, a copy of a pertinent resolution adopted by NWF in 1975.

Sincerely,

THOMAS L. KIMBALL,
Executive Vice President.

Enclosure.

RESOLUTION No. 7—WEATHER MODIFICATION

Whereas the state of the art in weather modification has progressed to the point where man, in his efforts to enhance agricultural production, aid commerce and avert natural disasters, now is frequently able to modify weather to increase precipitation, suppress hail, and dissipate certain kinds of fog under favorable atmospheric conditions; and

Whereas there is a growing body of evidence that intentional weather modification can inadvertently affect the environment by causing long-term changes in vegetative cover, by adding potentially toxic chemicals to the environment, and by otherwise upsetting complex ecological systems; and

Whereas the long-term social implications and legal aspects of advertent weather modification present serious unresolved problems: Now, therefore, be it

Resolved, That the National Wildlife Federation, in annual convention assembled March 14-16, 1975, in Pittsburgh, Pennsylvania, hereby urges all governmental agencies and private contractors to conduct advertent weather modification activities with extreme caution and only when and where there is substantial evidence that such activities will not have significant adverse effects upon the environment.

STATE OF MONTANA,
OFFICE OF THE GOVERNOR,
Helena, Mont. November 2, 1979.

Senator HOWARD W. CANNON,
*Chairman, Senate Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.*

DEAR SENATOR CANNON: Since 1974, the State of Montana has been a host to the largest, ongoing weather modification research program in the United States. Termed the High Plains Experiment (HIPLEX) and sponsored by the U.S. Bureau of Reclamation, this research endeavor is aimed at resolving in the critical uncertainties of increasing growing season precipitation. It has been, and continues to be, a cooperative effort which involves the Federal Government, state agencies and local citizens. As a direct participant in HIPLEX, our state has found the research to be timely, well-directed and pertinent to needs in a large portion of this country. Likewise, our role in HIPLEX has led to a fuller understanding of the national need for a pervasive and long-term commitment to weather modification research. Therefore, representing a state with experience in weather modification, I wish to address the related legislation which was introduced in the U.S. Senate—the Weather Resources Management Act (S829) and the Weather Modification Management Act (S1644).

At the outset, I wish to express my pleasure with the much deserved attention being given to the field of weather modification by Congress. I am hopeful that as a result of deliberating these pieces of legislation, we will see a greater impetus to the development of this important technology. I do not wish to offer specific comment on the provisions of either bill. Rather, I would ask that the following be among the provisions of any final legislation to be considered:

(1) a strong and clear statement of national policy that encourages the proper development and use of weather modification technologies;

(2) a commitment to the long-term support and funding of weather modification research and development; the "feast and famine" circumstances that characterize the past will never allow us to accomplish the complex tasks associated with properly developing this technology;

(3) a requirement that state-level involvement is reflected in the planning and coordination of a national weather modification development program;

(4) an allowance for state issuance of licenses and permits for weather modification activities; this should particularly be the case for states like Montana which have the necessary regulatory framework in place; and

(5) an implementation scheme for a national weather modification program which provides for the necessary coordination and yet has multi-agency involvement. The constituency of weather modification is sufficiently diverse that no single agency will likely be able to develop the technology in a manner which is responsive to the needs of the various user groups. I would therefore favor an approach which allows individual agencies to develop the technology in a manner which aligns with their particular mission, and suits the special needs and desires of their clientele. For example, the U.S. Bureau of Reclamation has long-standing involvement with western water resource issues. Among its activities has been the research and development of weather modification techniques for increasing our supplies of water. In consideration of this background, perspective and function, the Bureau should therefore be the agency charged with developing the technology of weather modification for application to problems involving agriculture and energy development. A similar case might be argued for other agencies who have the special insights needed to adequately define a weather related problem and develop the technology in a manner which leads to a proper resolution. In the absence of this approach, there is a serious question whether the technology can be put to its fullest and most appropriate use.

I appreciate the opportunity to offer comment on these important pieces of weather modification legislation. I am most hopeful that, through Congressional action on these bills, we will see a significant and much-deserved increase in the development rate of this promising technology.

Sincerely,

TED SCHWINDEN,
Acting Governor.

STATE OF COLORADO,
DEPARTMENT OF NATURAL RESOURCES,
Denver, Colo., November 9, 1979.

SENATOR ADLAI E. STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Senate Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: This letter is submitted as testimony for the record of the national weather modification legislation hearings held by the Senate Subcommittee on Science, Technology, and Space of the Senate Committee on Commerce, Science, and Transportation on October 24 and 26, 1979.

Colorado endorses the alternate proposal for weather modification legislation submitted by Paul Summers in testimony before the Committee. The draft, "Weather Modification Research and Development Act of 1979", was adopted unanimously as the position of the North American Interstate Weather Modification Council at its Sixth Annual Meeting in Salt Lake City on 7 November 1979.

Colorado has a large stake in weather modification research and development, particularly winter orographic seeding. Winter orographic programs have been conducted in Colorado for the past several years under combined federal, state, and local funding as well as with local funding only. As the Weather Modification Advisory Board report indicates, this technology may offer a high potential for broad scale operational use. It may prove to be the best means to augment the flow of the Colorado River throughout the River Basin. If so, it will heavily impact the mountain states.

A strong federal policy with sustained funding appears vital for the orderly development of weather modification technology and for assessment of the economic, legal, environmental, and social impacts of both planned and unintentional weather modification. Barbara Welles of my staff attended the Committee hearings on October 24 and 26. After review of testimony presented at those hearings, the recommendations of the Weather Modification Advisory Board and the current interests of the mission agencies engaged in weather modification research and development, we support legislation for a program to involve NSF in basic research and support the continuing programs of the Bureau and NOAA.

We feel this can be accomplished best by a program of coordination as opposed to a lead agency concept. We strongly endorse the proposal of the North American Interstate Modification Council for a coordinated national program of weather modification research and development with sustained funding, a coordinator

housed in the National Science Foundation and a Board established by the National Academy of Science.

We support your efforts for a national weather modification policy and wish to be cooperative wherever possible. If it would be useful, we would be happy to discuss our ideas with you further.

Sincerely,

HARRIS D. SHERMAN,
Executive Director.

SALT RIVER PROJECT,
Phoenix, Ariz., November 9, 1979.

Senator ADLAI E. STEVENSON,
Chairman, Committee on Commerce, Science, and Transportation, Subcommittee on Science and Technology, Immigration Building, U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: The Salt River Project, the nation's oldest multi-purpose reclamation project, is comprised of the Salt River Valley Water User's Association and the Salt River Project Agriculture Improvement and Power District.

The District is a political subdivision of the State of Arizona and operates the Project's electrical facilities and provides electricity to approximately 301,000 residential, commercial, industrial and agricultural power users in Maricopa and in portions of Gila and Pinal counties.

The Association is a non-profit Arizona corporation, responsible for the administration of the water rights of its shareholders. As agent for the District, the Association operates and maintains the irrigation, transmission and distribution system, which provides water for agricultural, industrial and municipal uses in the Project's 250,000 acre area. This includes 70% of the water used by eight communities having a combined population in excess of one million people.

The Project appreciates this opportunity to express our concerns and suggestions regarding the two weather modification bills before your subcommittee (S. 829 and S. 1644), as well as a proposed bill submitted as part of testimony to the U.S. Congress 26 October, 1979 entitled "Weather Modification Research and Development Act of 1979".

The Salt River Project has been, and continues to be, interested in weather modification activities that may enhance the natural precipitation process. These bills have been analyzed by the professional staff at Salt River Project, and we have concluded that the basic premise of all three bills is to develop a unified national policy for a strong and balanced program in weather modification. This concept has our full support, and we would like to go on record as generally supporting and endorsing the proposed bill and testimony which Paul Summers submitted on behalf of the North American Interstate Weather Modification Council. The NAIWMC bill contains three provisions of particular interest to the Salt River Project that we hope will be included in any national weather modification bill:

1. Federal licensing/regulation should not be required due to adequate licensing and reporting capabilities which currently exist at the State level.
2. The designation of a coordinator to be housed in the National Science Foundation to oversee and direct weather modification activities of NOAA, Bureau of Reclamation and the National Science Foundation. This coordination process allows these leaders in weather modification to continue and maintain their diverse and innovative research programs.
3. That funding be adequate and stable enough to assure the development of weather modification technology.

Thank you again for this chance to express our views of this important piece of legislation.

Sincerely,

REID W. TEEPLES,
Associate General Manager—Water.

ILLINOIS INSTITUTE OF NATURAL RESOURCES,
STATE WATER SURVEY DIVISION,
Urbana, Ill., December 21, 1979.

Senator ADLAI STEVENSON, III,
Russell Senate Office Building, Washington, D.C.

DEAR SENATOR STEVENSON: This letter is being written with a tone of considerable urgency with respect to the status of legislation for weather modification. I understand that the Administration is moving rapidly to develop a CAO Subcommittee on Weather Modification. This concept was first proposed by Administrator Richard Frank in his testimony on 24 October concerning S. 1644 and S. 829. I see an effort to get a degree of federal coordination without ever getting a truly national policy for weather modification that will protect and develop it properly in the years ahead.

I encourage you to get legislation out of Committee calling for a national program in weather modification. I know that you and your staff have heard from a variety of concerned sources. There is considerable anxiety about getting something done in this next session of Congress. Many people look to you to provide the leadership to finally get a national policy adopted.

My assessment of the October testimony, plus extensive discussions with people in all areas of weather modification, lead me to conclude that there is general agreement about four key areas.

The first includes total support for getting a statement of a national policy for weather modification; that is, it fits within the national interest.

Secondly, there is near consensus on the concept of having a more sizeable, long-term commitment to basic research efforts in weather modification with this being conducted at the National Science Foundation.

Third, there is a general backing for the concept of not having federal licensing of weather modification at this time. Fourth, the consensus, in my judgement, about leadership and coordination of the federal effort does not favor a lead agency or single agency control (no one will give it the autonomy needed). Hence, most agree that the wisest strategy is to 1) leave the major players (NOAA and Interior) as they are with their mission approaches, and 2) to secure general programmatic coordination at NSF with NAS Advisory and Planning Boards.

Study of much of the October testimony, including that of most scientists present and the industry (as represented by the Weather Modification Association and the North American Interstate Weather Modification Council) show uniformity around these four points. I also believe that the major agency involved in weather modification (Interior) is supportive of this approach, and I have reason to believe there are interests in the House around legislation that would essentially embrace these four topics. The only group that would be against this approach presumably might be NOAA.

Regardless of whether you perceive the reshaping of legislation around these four concepts or not, I do hope you will get your bill out very soon. I would be very willing to come and discuss this issue with you, should that be your desire. Moving ahead is extremely important and we look to you for the action needed.

Sincerely,

STANLEY A. CHANGNON, JR.,
Head, Atmospheric Sciences Section.

Enclosure.

COMMENTS ON THE NATIONAL WEATHER MODIFICATION PROGRAM

Now, more than 15 months after the issuance of the Weather Modification Advisory Board's (WMAB) report to the Secretary of Commerce, several issues are clear. The WMAB recommended a consolidated national program under the aegis of DOC with strong autonomy to protect the program from normal bureaucratic lethargia. I have closely followed federal activities relating to weather modification since the issuance of the Board's report, although NOAA has, as of October 22, 1979, not formally transmitted the WMAB report (or their revised version) to the President or Congress. I have made an assessment of what has and has not, occurred since July 1978. Review and interpretation of these events indicate to me a likely course of the future federal program.

Several signals are clear.

The Administration is not interested in new expensive scientific programs and specifically is not interested in developing a large weather modification program. The federal budget is tight and the scientific community is not sufficiently supportive of weather modification to make OSTP or OMB willing to support it on a large

scale. Let us consider the leadership potential and the interests of the major agencies involved in weather modification.

NOAA is typically bureaucratically timid and is not strongly pushing for a major weather modification program because DOC, OSTP, and OMB resist them. NOAA's scientific leadership is apparently not deeply interested in weather modification, particularly when those layered above them in DOC and the rest of the Administration are not supportive. For a variety of reasons, a consolidated enlarged national program under NOAA leadership has little likelihood of coming to pass in the foreseeable future.

Now let us consider the Bureau of Reclamation (BR) program which is the only large and strong program of planned weather modification. The BR is essentially pleased with its status. It is not interested in a consolidated effort, and furthermore, is not interested in becoming the "home" of a consolidated national program. The scientific quality of their program has improved greatly in the last few years. It is heavily project-oriented and tends toward project-applied research. Some in the scientific community are not convinced yet that the BR program is scientifically superb, but a viable constituency exists.

One might conclude that the only possible place to consolidate the national effort is in NASA. NSF is clearly not the place for it. NASA appears to be a logical place, but NASA is a very hesitant host. I am not convinced that NASA would be a better place than NOAA. The proposed bills calling for consolidation in NOAA and NASA do not provide the autonomy the WMAB and I sought. Hence, consolidation seems, at best, very risky, unlikely, and undesirable if buried without strength in a single mission agency.

Another important factor that has emerged since the WMAB report is that some of the leadership in the atmospheric sciences community is not totally supportive of a large new national program in weather modification. This is due to several factors, not the least of which is the perception that a new major program in weather modification will remove support from other interest areas. Many of these leaders have also expressed concern about the lack of progress and lack of the scientific readiness of weather modification. A basic concept that one hears everywhere is that much more basic research in cloud physics and dynamics is needed, and that basic research should be the heart of a re-directed national effort.

Given these observations and uncertainties, what can one conclude and where does one turn? One point seems clear—consolidation of the national effort as called for in S. 1644 and S. 829 is now unrealistic. The Bureau of Reclamation has the only sizeable program in weather modification and they do not seek to be the home of a consolidated national effort. Is the status quo all we need? Mission agencies need to be involved in weather modification if they choose (like BR), but the status quo, the mission agency approach, fails to meet the needs for 1) basic research sustained at a substantial level over a long period, and 2) for coordination and planning of the national effort.

After consideration of this situation, a program has evolved. It involves something like this. First, let the mission agency programs proceed and be strengthened. The Bureau of Reclamation, with its largely applied research program having an experimental focus, allows for the conduct of two good experiments. Their Sierra and HIPLEX Projects are well along and appear to be well-conducted scientific experimental-demonstration type efforts. In a sense, maintain their program, enlarge it if possible, and sustain their viable constituency which includes much of the weather modification industry. NOAA's program is less well defined and smaller and needs more support.

Second, the nation needs a complementary effort in basic research. How do we get the support for a rather extensive basic research program that is needed to move the field ahead in some systematic way? Here, the only real hope lies outside of the "mission agencies." The solution and opportunity seem clear: the National Science Foundation is the basic research arm of the nation. Furthermore, my readings suggest that OSTP, OMB, and the leaders of the scientific community believe that the focus of the future should be in the basic research area (see also the WMAB report); hence, I believe the scientific community would support a sizeable basic research program in planned and inadvertent weather modification. Such an effort at NSF would attract many scientists back into the field. Here, I am suggesting we need a long-term commitment (20 years) to basic research at NSF with an annual program of \$5 to \$6 million. WMAB discussions with the Director of NSF in 1977 found interest at NSF in developing a strong basic research program.

I propose, therefore, development of future legislation which sets forth a national policy for weather modification, much as S. 1644 states. The major features of this proposed legislation would include 1) coordination of the federal research effort, 2) a

commitment to a long-term basic research program at NSF, and 3) encouragement of R and D programs by the interested mission agencies. This is not what the WMAB or I sought, but it appears to be the most likely solution within the constraints and interests of the real world.

A federal coordinating program with the leadership housed in the NSF seems a logical way to coordinate this type of federal effort. This must be more than the earlier ICAS effort. I would recommend an advisory board, say located at NAS, serving the Coordinator at NSF and charged with developing the national planning.

My recommended approach also moves NSF back into a basic research role in weather modification similar to that pursued in the 1960's.

The above enumerated problems blocking a big national program, coupled with the needs everyone agrees with (basic research), plus consideration of the constituency in the scientific community and that behind Congress could and should lead to support of a new federal program with a more specific purpose, responsible coordination and a larger scale basic research program within the National Science Foundation. This approach provides for sensible growth of the field.

PROJECT SKYWATER—THE BUREAU OF RECLAMATION'S WEATHER MODIFICATION RESEARCH PROGRAM

BACKGROUND INFORMATION

I. History and accomplishments

This weather modification research program was initiated in the Bureau of Reclamation by Congress in 1962 for "research on increasing rainfall by cloud seeding." All funds have been appropriated through the Public Works Bills (Energy and Water Development Appropriations). The program has often received directions and recommendations and funds above budget from Congress. These are listed in the attached "Summary of Appropriation Language."

Several of the key congressional directives are:

"Emphasis is to be placed on actual water production, and the exploration and research are to include application of existing weather modification methods." (1965)

"Determine the best and most economical methods of augmenting water supplies for Reclamation projects by weather modification." (1966)

"Expand the budget program for atmospheric water resources research and to initiate the planned nationwide program." (1968)

"Initiate pilot weather modification projects." (1969)

"Prepare plans for the Colorado River Augmentation Demonstration Program." (1978)

"Initiate a high-altitude downwind seeding effects research effort." (1979)

"Conduct rain augmentation research in the Southwest in areas where drought patterns are developing." (1979)

These directives have been implemented by the Bureau. All funds have been used toward the development of technology to increase water supplies by weather modification. Through the 1962-79 period, \$78.6 million has been spent by the Bureau on precipitation augmentation research and resolving the socioeconomic, environmental, and legal issues associated with it (table 1). The program has conducted 15 major cloud seeding field experiments and has cooperated in six programs sponsored by others (table 2). There are three projects underway in the program:

A. HIPLEX (the High Plains Cooperative Program) with field activities at: Miles City, Montana; Big Spring, Texas; and Goodland, Kansas (stand down status).

Table 1. - Bureau of Reclamation
Weather Modification Research Contractor Expenditures
1962 through 1979

Universities

University of Arizona	\$ 69,600
University of California	36,812
Colorado State University	2,833,183
Colorado University	360,708
University of Denver	435,998
Fresno State College	2,461,447
Harvard University	20,965
University of Michigan	32,625
Montana State University	1,030,796
University of Nevada	4,504,913
New Mexico State University	900,835
New York University	325,467
North Dakota State University	91,500
University of North Dakota	2,522,051
Oklahoma University	40,286
Pennsylvania State University	39,929
San Diego State University	24,631
South Dakota State University	128,800
South Dakota School of Mines and Technology	5,875,180
Taft College	11,000
Texas A&M University	60,000
Utah State University	2,335,954
University of Southern California, Los Angeles	11,870
University of Washington	575,076
University of Wisconsin	84,461
University of Wyoming	6,622,809
Equipment, Facilities, Miscellaneous	93,104
Total - Universities	\$31,530,000

Private Firms

Atmospherics, Inc.	\$ 221,447
Aerometric Research, Inc.	792,190
Aeromet, Inc.	19,775
Aerosystems, Inc.	110,903
Amos Eddy, Inc.	67,441
T. G. Owe Berg, Inc.	103,012
E. Bollay Associates	1,263,378
Colorado International Corporation	745,463
Convergence Systems, Inc.	698,486
EG&G, Inc.	2,851,731

Table 1. - Continued

Private Firms - continued

Enterprise Electronics, Inc.	\$ 588,126
Electronic Techniques, Inc.	722,491
ERT, Inc.	1,321,630
HERS, Inc.	7,655
MBAssociates	183,458
MEE Industries, Inc.	23,300
Meteorology Research, Inc.	3,586,860
Motorola, Inc.	11,000
North American Weather Consultants	847,451
Precipitation Control	26,250
Stanford Research Institute	10,000
Travelers Research Institute	67,482
Weather Science, Inc.	271,790
Western Magnum, Inc.	17,030
Western Scientific Services, Inc.	2,175,875
Western Weather Consultants, Inc.	128,817
Other small firms	38,900
Total - Private Firms	\$16,901,941

State

Colorado Department of Natural Resources	\$ 99,815
Kansas Water Resources Board	160,000
Illinois State Water Survey	952,905
Montana Department of Natural Resources and Conservation	1,249,098
South Dakota Weather Control Commission	138,696
Texas Water Development Board	3,041,320
Utah Department of Water Resources	408,714
Washington Department of Ecology	2,418,524
Total - State	\$ 8,469,072

Other Federal

Army - Pueblo Depot	\$ 45,200
Air Force	82,000
Atomic Energy Commission	6,240
Forest Service	696,922
Geological Survey	361,975
General Services Administration and others	263,079
National Oceanic and Atmospheric Administration and NSSL	1,855,422
National Science Foundation and NCAR	308,053
Navy	261,800

Table 1. - Continued

Other Federal - continued

Soil Conservation Service	438,991
Regional Offices - Reclamation	<u>365,046</u>
Total - Other Federal	\$4,684,728
Bureau of Reclamation	\$17,039,640
Total Program	<u>\$78,625,381</u>

Table 2. - Research Project Costs

<u>Project</u>	<u>Cost</u>
<u>I. Past Experiments</u>	
+ Flagstaff Cooperative Experiment, Arizona	\$ 2,017,706
* Park Range Atmospheric Water Resources Program, Colorado	1,263,378
* Colorado River Basin Pilot Project, Colorado	7,258,344
* Central Sierra Research Experiment, California	2,461,447
+ Precipitation Enhancement Program and Other Research, Illinois	952,905
* Bridger Range Project, Montana	1,010,796
* Jemez Mountains Project, New Mexico	900,835
* Pyramid Lake Pilot Project and Other Research, Nevada	4,257,886
+ North Dakota Pilot Project, North Dakota	880,000
+ Altus Project, Oklahoma	<u>1/</u> 271,790
+ Cloud Catcher Project and Other Research, South Dakota	3,722,000
+ San Angelo Project, Texas	820,066
* Wasatch Program, Utah	2,335,954
* Cascade Project, Washington	2,418,524
* Elk Mountain Project, Wyoming	3,966,000
<u>II. Current Projects to September 1979</u>	
+ High Plains Cooperative Program, Montana-Kansas-Texas	\$ 19,098,000 (48% complete)
* Sierra Cooperative Pilot Project, California	\$ 4,032,000 (24% complete)
* Colorado River Augmentation Demonstration Program, Colorado	922,000 (planning stage)
* Orographic research.	
+ Cumulus research.	
<u>1/</u> Terminated due to funding.	

B. The Sierra Cooperative Pilot Project with field activities
at: Auburn, California (Sierra Cooperative Pilot Project)

C. Colorado River Augmentation Demonstration Program (planning stage)

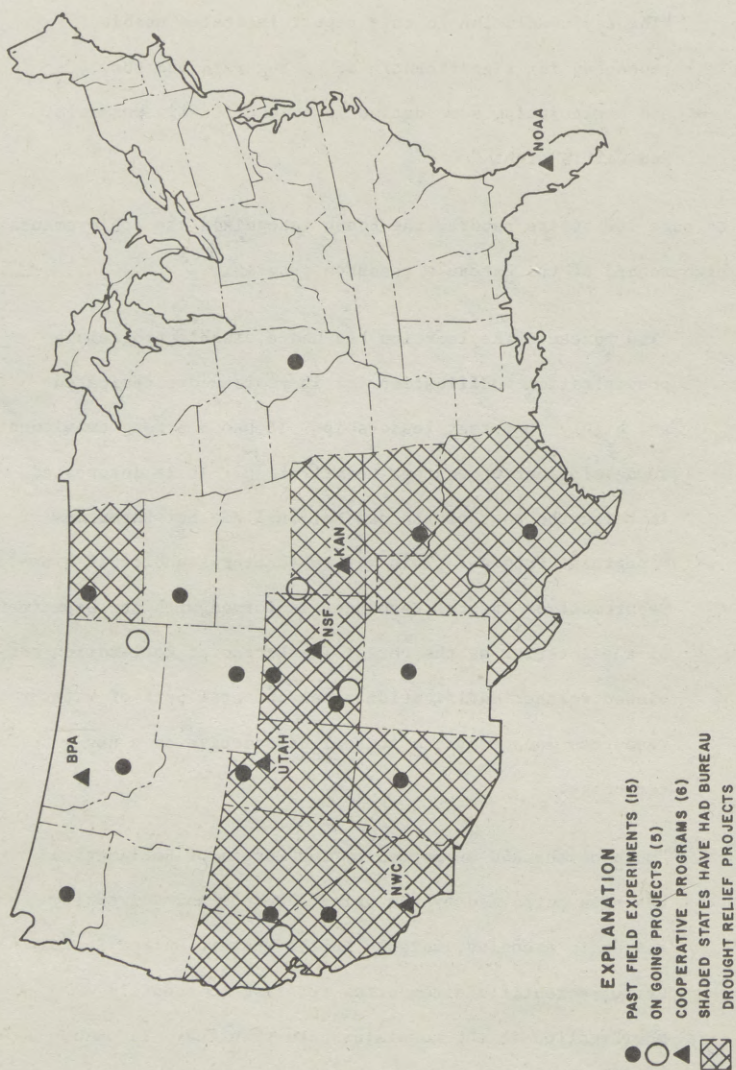
In addition to research, the Bureau has conducted emergency drought-relief cloud seeding programs during 1972 in Oklahoma, Arizona, and Texas, using Office of Emergency Preparedness funds. Through the Emergency Drought Act of 1977, the Bureau granted \$2,121,533 in nonreimbursable funds to six states for cloud seeding projects:

North Dakota	\$ 184,313	rain increase
Colorado	600,000	snow increase
Utah	553,500	rain and snow increase
Nevada	183,720	rain and snow increase
Kansas	300,000	rain increase
California	<u>300,000</u>	snow increase
	\$2,121,533	

The following map illustrates the extent of Project Skywater activities

The scientific accomplishments of this program have been major contributions to the main finding of the Weather Modification Advisory Board in their report, "The Management of Weather Resources," to the Secretary of Commerce which states:

Bureau of Reclamation Major Field Research Projects 1962-1979 PROJECT SKYWATER



"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."

On page 200 of its report, the Board recognized the achievements and high regard of the Bureau's research program:

"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."

The technical findings from Bureau research are given in contractor reports and scientific papers by contractors in professional journals. Bureau scientists also prepare summary analyses and professional papers.

The program has:

1. Provided the background data and local management experience for establishing current operational projects. Findings of local research projects have been used in founding operational programs in North and South Dakota, Colorado, Texas, and Utah.
2. Provided weather modification education and experience for many of the scientists now in this field. Graduate students and young scientists do much of the work on experiments.
3. Developed permanent facilities and sophisticated equipment for conducting present and future research and established skilled research support teams. For example, to meet Skywater requirements, the University of Wyoming developed a sophisticated, state-of-the-art cloud physics aircraft. This King Air is used extensively in both

summer and winter research projects to obtain a wealth of information about the atmosphere. In addition, Bureau scientists created the Environmental Data Network to support field research activities. The network not only supplies immediate access to data for forecasting, but also provides near-real-time data to a growing number of non-Reclamation users. Bureau scientists and technicians developed mesonets - networks of remotely operated weather stations which beam data to users via satellite for timely input to decisionmaking in field research and subsequent evaluation.

4. Assisted operational programs through loan of equipment and supplies, access to computer cloud models and environmental data, and provision of scientific advice and planning assistance.
5. Provided training for weather modification pilots who ultimately make the final seeding decisions in cloud seeding operations.
6. Provided comprehensive studies of the environmental, social, agricultural, economic, and legal aspects of weather modification.

About 10 percent of research funds are devoted to studying these associated problems.

7. Established important precedents for Federal-state-local cooperation, cost-sharing, and joint operating principles for research, operational, and emergency cloud seeding projects.

8. Provided national leadership through periodic conferences involving representatives of the academic community, private firms, citizens groups, and other Government agencies. Skywater Conference IX, on Precipitation Management and the Environment, drew prominent scientists from across the nation to study the possible environmental effects of cloud seeding research. The 1977 conference was one of the first, most prominent forums for such discussion. The Bureau also conducted a workshop of great importance in 1978 - The Workshop on the Geographical Variability of Physical Parameters Thought to be Relevant to the Modification Potential of Summertime Convective Clouds. Leading scientists from the United States and Canada met to exchange information on measurement techniques and observations and to launch a study on geographical variability.

9. Integrated weather modification into comprehensive water planning through such efforts as the proposed Colorado River augmentation and the Ogallala aquifer study.

II. Funding Source and Amounts

All funds for the Bureau of Reclamation's Atmospheric Resources Management program, "Project Skywater," are appropriated through the

Public Works Bill (Energy and Water Development Appropriation). The House and Senate Subcommittees on Energy and Water Development have this program under their purview.

All Project Skywater funds are administered through the Office of Atmospheric Resources Management (Dr. Bernard A. Silverman, Acting Chief), a part of the Bureau of Reclamation's Engineering and Research Center, Denver, Colorado. This office has a staff of 35 people, including scientists, engineers, and other specialists and secretaries. Four scientists are located at Miles City, Montana, and two at Auburn, California. The organizational chart and staff credentials are shown in Tables 3 and 4.

Table 3. - Organizational Chart

Division of Research

Office of Atmospheric Resources Management

Research and Development Branch

Adaptation Branch

Program Support Branch

Table 4. - Professional Staff Credentials

No.	Title	<u>Degree status 2/</u>		
		Ph.D.	MS	BS
3	Supervisory Research Physical Scientist	2	1	-
6	Research Physical Scientist	1	4	1
16	Research Meteorologist	5	7	4
1	Electronics Engineer	-	-	1
3	Computer Specialist	-	1	1
3	Writer Editor	-	-	2
2	Electronics Technician	-	-	-
1	Contract Specialist	-	-	-
3	Meteorological Aid	-	-	1
1	Meteorological Technician	-	-	1
1	Student Trainee	-	-	-
<u>5</u>	Secretarial/Clerical	-	-	<u>1</u>
<u>1/</u> 45		8	13	12

1/ 35 full-time positions, 7 part-time positions, and 3 regional office assignments.

2/ These degrees are in such relevant fields as atmospheric sciences, economics, meteorology, electronics engineering, agricultural engineering, civil engineering, physical science, physics, chemistry, public administration, journalism, political science, law and business administration. Five bachelor degrees are in progress.

Full-time Positions by Grade

<u>No.</u>			
GS-16	1	Staff locations - Denver, Colorado Miles City, Montana Auburn, California	35
GS-15	3		5
GS-14	4		<u>5</u>
GS-13	10		45
GS-12	10		
GS-11	1		
GS-9	1		
GS-7	2		
GS-6	2		
GS-5	<u>1</u>		
Total	35	Average GS grade - 11.9	

The approved estimated total cost of the total program is \$158 million. Through fiscal year 1979, \$78.6 million - or about 50 percent - has been expended.

The following chart shows the growth of budgets and funding for the Atmospheric Resources Management Program.

The Atmospheric Resources Management Program is divided into nine budget or project line items.

	<u>Estimated total</u>	<u>Cost through September 1979</u>
Development of Cloud Seeding Technology	\$ 43,250,000	\$38,361,000
Planning, Special Studies, and Other Support	8,700,000	5,775,000
Environmental Effects Projects	3,500,000	2,125,000
Sierra Cooperative Pilot Project	17,000,000	4,032,000
High Plains Cooperative Program (HIPLEX)	41,000,000	19,098,000
Comprehensive Evaluation	1,000,000	227,000
Southwest Drought Area Research*	1,000,000	63,000
Colorado River Augmentation Demonstration	30,600,000	922,000
Program Management and Technical Assistance	<u>12,000,000</u>	<u>8,022,000</u>
	\$158,050,000	\$78,625,000

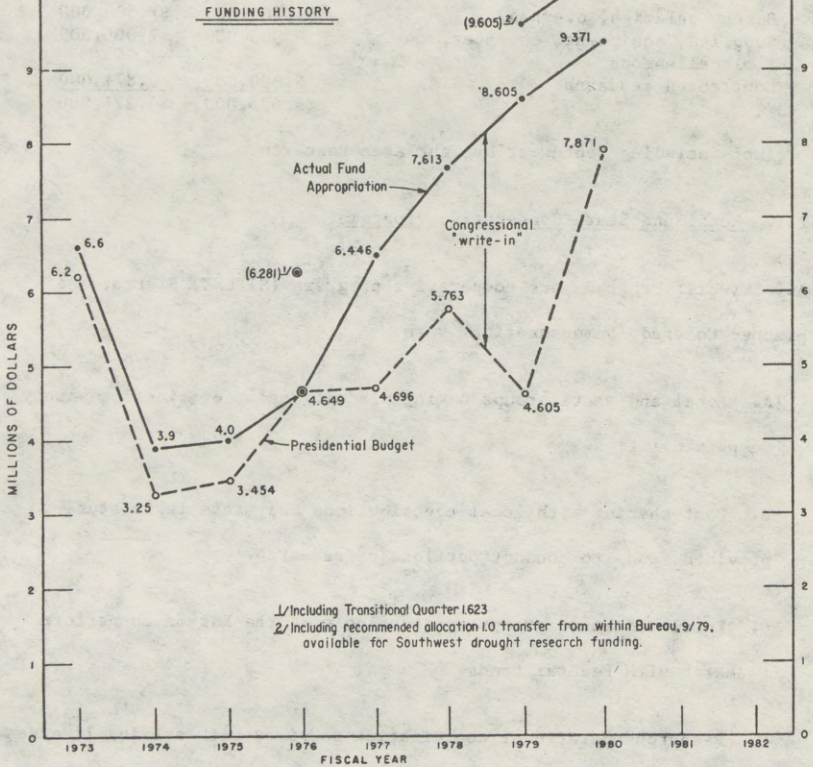
*Added in 1979 - note Senate recommendation.

Most of the research in Project Skywater is performed through contracts with universities, private firms, and state and other Federal agencies.

Total 1962-1979 Expenditures

Universities	\$31,530,000	40 percent
Private firms	16,902,000	21 percent
State agencies	8,469,000	11 percent
Other Federal agencies	4,685,000	6 percent
Bureau, equipment, miscellaneous	<u>17,039,000</u>	<u>22 percent</u>
	\$78,625,000	100 percent

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
ATMOSPHERIC WATER RESOURCES MANAGEMENT
"PROJECT SKYWATER"



In 1979 and 1980 an estimated 75 percent of the program will be for contracted research.

	<u>1979</u>	<u>1980</u>
Bureau salaries, overhead	\$1,400,000	\$1,500,000
Supplies, equipment, computer, miscellaneous	905,000	1,000,000
Contracted research	<u>6,300,000</u>	<u>6,871,000</u>
	\$8,605,000	\$9,371,000

(not including Southwest Drought Area Research)

III. Local and State Cooperative Programs

All Skywater Programs are cooperative programs (HIPLEX, Sierra, and planned Colorado Demonstration) with:

- A. Local and state groups having planning and operational advisory responsibilities.
- B. Cost-sharing with local contributions and state legislature-provided funds to conduct portions of research.
- C. Local and state groups contracting with the Bureau to perform research with Federal funds.
- D. Research-operational coordination services with seeding licenses and permits provided through the State agencies.
- E. Sharing of data and analysis, especially through special Skywater workshops and conferences.

f. Loan of equipment and computer programs and data to states to assist in their programs.

Table 5 lists cooperative agreements with State Governments and other Federal agencies. The HIPLEX program has about \$250,000 to \$300,000 funding provided annually by the three host states plus use of personnel. The Colorado River Augmentation Demonstration Program is being planned with at least 20 percent local and state cost sharing.

Because of the importance of the Colorado River Augmentation Demonstration Program and its direct relation to the Secretary's responsibilities to augment the river according to Public Law 90-537 and maintain water quality, a high degree of interagency coordination is anticipated (USGS, Soil Conservation, WAPA, Streamflow Commissions, Forest Service, etc.)

In general, the Bureau's approach has been to make local and state groups "full partners" in the field research projects. They actively participate in all meetings and have prime responsibility in the public information, economic and social impact study, operational suspensions, and interproject coordination areas. This has been very satisfactory although the Bureau has had to encourage and fund development of local and state expertise to handle these tasks in some areas.

Table 5. - Cooperative Research With Other State and Federal Agencies (Current and Past Agreements) 1962 - 1979

<u>State</u>	
State of Washington, Olympia, Washington	Atmospheric research to develop cloud seeding techniques.
State of Montana, Department of Natural Resources Helena, Montana	Study impact of weather modifi- cation on the High Plains of eastern Montana.
State of Kansas, Water Resources Board, Topeka, Kansas	Cooperative effort in HIPLEX.
States of Colorado-Kansas-Nebraska	Cooperative effort in HIPLEX.
State of Colorado, Department of Natural Resources, Denver, Colorado	Cooperative agreement for precipitation managment research in Colorado. Background studies for Colorado River Augmentation Demonstration Program.
State of South Dakota, Weather Control Commission, Pierre, South Dakota	Scientific research and assistance.
State of North Dakota, Weather Modification Board, Bismarck, North Dakota	Cooperative agreement for study of weather modification activities.
State of Wyoming	Cooperative agreement for study of weather modification.
State of California, Department of Water Resources, Sacramento, California	Preliminary assessment of environmental effects of cloud seeding in California.
State of Texas, Department of Water Resources, Austin, Texas	Comprehensive atmospheric research and development.
State of Nevada	Cooperative effort for research on precipitation management in the State. Administered by the University of Nevada Systems.

Table 5 - Continued

State of Utah, Division of Water Resources, Salt Lake City, Utah	Review and develop evaluation procedures for Utah cloud seeding programs.
<u>Federal</u>	
Department of Agriculture, Soil Conservation Service:	Snow measurement operations.
Naval Ordnance Test Station	Research on practicability of increasing water supply through cloud seeding.
Department of the Interior, Geological Survey, Colorado	Perform survey of possible sites for stream-gaging stations.
Navy Weather Research Facility, Norfolk, Virginia	Research on ice-phase seeding.
Naval Weapons Center, China Lake, California	Research to improve cloud seeding materials and equipment.
Atomic Energy Commission, Washington, D.C.	Test radio isotope profiling snow gage.
National Aeronautics and Space Administration, Greenbelt, Maryland	Evaluate ERTS data collection system.
Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado	Develop methods for interpreting trends in behavior of forested drainage basins.
Department of Agriculture, Pacific Southwest Forest and Range Experiment Station Berkeley, California	Study effect of cloud seeding on central Sierra snowpack.
National Science Foundation/ National Center for Atmospheric Research, Boulder, Colorado, 20040	Assistance to HIPLEX sites through atmospheric nucleation studies.

Table 5 - Continued

National Oceanic and Atmospheric
Administration, Boulder, Colorado

Develop wind field information
for climatological data in the
American River Basin, California.
Develop cloud models in support of the
Bureau's winter orographic weather
modification program. Perform
research studies using the
Geosynchronous Satellite Imagery to
estimate and forecast convective rain
in the High Plains States.

IV. Foreign Cooperative Activities

The Bureau has also been asked to cooperate on international development and application of weather modification, especially to share research findings and experiences with others. These have been through interagency agreements involving the Department of State. The Bureau presently has an agreement with the Canadian Atmospheric Environment Service and National Research Council of Canada for them to be an active partner and provide research aircraft to cooperate in the Bureau's HIPLEX at Miles City, Montana. We also have an agreement with Spanish Director General of Hydraulic Works to direct the technical initiation of a cloud seeding project in the Canary Islands. The Bureau of Reclamation has also provided scientific assistance on weather modification to eight other foreign nations. Bureau contractors are encouraged to share their expertise internationally and foreign consultants are involved in Bureau programs. Project Skywater scientists have also been involved in cooperative efforts with various foreign nations (table 6).

V. Reclamation - NCAR Scientific Cooperation

The Bureau of Reclamation and the Convective Storms Division of NCAR (National Center for Atmospheric Research) plan to collaborate in a joint field program at the HIPLEX site near Miles City, Montana, during the period May, June, and July 1981. A coordinated measurement

Table 6. - Foreign Cooperative Activities by
Bureau of Reclamation in Weather Modification

- 1967 - Dr. Kahan traveled to India as a member of a team of experts sponsored by the Department of State and Department of Defense for drought relief in the Ganges Basin.
- 1969 - Dr. Kahan traveled to Russia as a member of a panel of experts assembled by NOAA under a Department of State program for international science exchange.
- 1969 - Dr. Kahan traveled to Lebanon at the request of that Government under the Department of State reimbursable agreement.
- 1971 - Dr. Kahan traveled to Tasmania at the request of the Government of Australia to consult on the randomized cloud seeding program being undertaken there for the hydroelectric company. Cleared with the State Department.
- 1971 - Dr. Kahan traveled to Venezuela, Argentina, and Brazil to consult on weather modification under the Participating Agency Services Agreement with Department of State/AID.
- 1975 - Dr. Howell traveled to Jamaica to consult on cloud seeding at the request of the Jamaican Government under a reimbursement agreement.
- 1976 - Dr. Kahan traveled to the Canary Islands to consult on weather modification at the request of the Spanish Government under an interagency agreement among the Department of State, the National Science Foundation, and the Bureau of Reclamation.
- 1978 - Dr. Howell traveled to the United Arab Emirates to consult on weather modification under a Reimbursable Program of the Department of State and Interior.
- 1978 - Dr. Silverman traveled to Switzerland as a scientific consultant on the international PEP (Precipitation Enhancement Project) to be initiated in Spain. The topic of this meeting was the preliminary environmental impact study for PEP.
- 1978 - Dr. Howell traveled to the Canary Islands to consult on weather modification at the request of the Spanish Government under an interagency agreement between the Bureau of Reclamation and the Department of State.

Table 6 - Continued

- 1979 - Dr. Silverman traveled to Spain to participate on a panel of experts discussing dispersion of seeding materials in PEP.
- 1979 - Dr. Silverman consulted on the statistical design and evaluation of PEP while in Canada.
- 1979 - Initiation of a weather modification project in accordance with an Interagency Agreement between DOS and DOI and under cooperative program between Director General of Hydraulic Works and Bureau of Reclamation entitled "Techniques for Planning, Developing, and Managing Water Resources."
- 1979 - Cooperative Agreement (Memorandum of Understanding) with Canadian Atmospheric Environment Service and Natural Research Council of Canada for participation in HIPLEX experiment at Miles City, Montana, with instrumented research aircraft crew scientists.

program on convective clouds and storms will be carried out to elucidate how microphysical processes and the air motion interact in the formation and development of precipitation. A general theme of these investigations will be to obtain answers to the question, "What determines the efficiency of precipitation?" The goal is to resolve some of the fundamental problems that stand in the way of evaluating the potential of weather modification techniques and of predicting precipitation and severe weather. The National Science Foundation and the scientific community recognize this effort as one of three major national programs that focus on mesoscale meteorological research and development. Research groups in various universities, NASA, and NOAA have indicated their interest in participating in the program.

VI. Economic and Environmental Considerations

The Bureau has followed a general guideline in conducting field research to devote about 10 percent of project costs to monitoring and assessing the ecological, economic, and social impacts of the additional precipitation by cloud seeding. Some of these studies have been among the most comprehensive in the field.

All studies to date indicate that the environmental effects are minor and include beneficial as well as possible adverse impacts. These still need to be studied over a long-term period.

The principle driving interest behind cloud seeding is that it can produce additional water for very low relative costs. In the Colorado River Basin, for example, augmentation costs per acre-foot of water are estimated at \$1.50 to \$5.00 where other alternatives are approximately \$100 or more per acre-foot. For rainfall, costs of 2 to 10 cents per acre for up to 1 inch of water, plus hail suppression, are generally being quoted. These apparent low costs, plus the easy initiation and termination aspects, give benefit/cost ratios of 10:1 or better. These benefit/cost comparisons also need further research.

A Final Environmental Statement for Project Skywater (INT FES 77-39, October 25, 1977) has been prepared and filed. This is a programmatic statement covering the entire Reclamation research program in cloud seeding for enhanced precipitation and projections of long-term impacts.

VII. Active Research Contracts

There are 32 research contracts and cooperative agreements for performing research outside the Bureau, as shown in table 7.

Table 7. - Current Research Contracts and Agreements

HIPLEX - High Plains Cooperative Program

SCPP - Sierra Cooperative Pilot Project

Contractor	Purpose	Total contract amount	Scheduled completion
Aerosystems, Inc. 7-07-83-V0022	Calibration tracing research aircraft for the SCPP	\$ 84,574	1979
Atmospherics, Inc. 9-07-85-V0020	Data collection and analysis for the SCPP	2,194,341	1984
Colorado International Corporation 7-07-83-V0004	Cloud seeding and survey research aircraft for HIPLEX	970,110	1980
Colorado State University 9-07-85-V0025	Digital satellite data collection and analysis for Project Skywater	1,140,472	1984
State of Colorado 9-07-85-V0027	Cooperative preparation of comprehensive weather modification research and development plans for Colorado River region	62,500	1981
Amos Eddy 9-07-83-V0024	Objective analysis for HIPLEX to determine convective storm characteristics	17,930	1980
Electronic Techniques, Inc. 8-07-83-V0019	Automatic environmental surface observation platforms	24,285	1979

Table 7 - Continued

Contractor	Purpose	Total contract amount	Scheduled completion
Electronic Techniques, Inc. 9-07-85-V0021	Forecasting support for the SCPP	\$2,116,452	1984
Environmental Research and Technology, Inc. 14-06-D-7673	Meteorological research in Kansas for HIPLEX	1,627,399	1980
Forest Service-Pacific Southwest Forest and Range Experiment Station 6-07-DR-20010	Effects of precipitation augmentation upon central Sierra snowpacks under various cover conditions	242,806	Yearly extension
Geological Survey	Stream gage operations Middle Fork Piedra	15,475	Yearly extension
State of Kansas 14-06-D-7642	Cooperative state weather modification program in connection with HIPLEX in Kansas	160,000	Yearly extension
Meteorology Research, Inc. 14-06-D-7699	Instrumented cloud base aircraft and analysis research in connection with HIPLEX	1,407,471	1980
Montana Department of Natural Resources 14-06-D-7577	Cooperative state weather modification program in connection with HIPLEX in Montana	1,591,335	1981
North American Weather Consultants 7-07-83-V0008	Continuing design review, and evaluation of the SCPP	1,177,822	1984

Table 7 - Continued

Contractor	Purpose	Total contract amount	Scheduled completion
University of North Dakota 14-06-D-7581	Downwind studies and associated research	\$1,454,855	1979
University of North Dakota 9-07-83-V0023	Research radar and meteorological monitoring; computer processing and analysis of radar data	3,301,436	1984
University of North Dakota 9-07-85-V0026	High altitude downwind effects and pilot training	1,035,228	1983
National Oceanic and Atmospheric Administration 8-07-83-V0015	Doppler radar and acoustic sounder research	221,874	1979
National Oceanic and Atmospheric Administration 8-07-83-V0016	Convective rain estimation in the High Plains using Geosynchronous satellite imagery	110,500	1979
National Oceanic and Atmospheric Administration 8-07-83-V0017	Cloud model development in support of Skywater programs	114,310	1979
National Science Foundation-NCAR 6-07-DR-20040	HIPLEX atmospheric nucleation studies	106,700	1979
National Science Foundation	Cost sharing of support of the Colorado State University Cloud Simulation Laboratory	120,370	1979

Table 7 - Continued

Contractor	Purpose	Total contract amount	Scheduled completion
National Science Foundation	Support of Colorado State University field research and analysis	\$ 75,983	1979
National Science Foundation	Data collection and analysis in support of the SCPP by University of Nevada	67,027	1979
South Dakota School of Mines and Technology	Evolving design and evaluation of the HIPLEX experiment	1,543,742	1982
Soil Conservation Service	Use of snow telemetry system	735	Yearly extension
Texas Department of Water Resources 14-06-D-7587	Cooperative state weather modification program in connection with HIPEX in Texas	2,612,253	1981
Utah Division of Water Resources 6-07-DR-20060	Ecological impact studies of the Uinta Mountains of Utah	160,000	1979
Utah Division of Water Resources 8-07-83-V0012	Develop design criteria and evaluation procedures for Colorado River Augmentation Demonstration Program	228,714	1979

Table 7 - Continued

Contractor	Purpose	Total contract amount	Scheduled completion
Western Weather Consultants 8-07-83-V0010	Forecasting support and analysis for the HIPLEX at Miles City, Montana	309,338	1982
University of Wyoming 7-07-83-V0001	Cloud physics airborne research for winter and summer programs of Project Skywater	4,285,257	1982
Electronic Techniques, Inc. 9-01-81-80059	Supply mesonet remote stations for data collection	262,900	1979

Revised October 27, 1978

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program
1962 - 1979

Date	FY Bill	Body	Document	Provision
9-30-61	1962	Senate, 87th Congress 1st Session	Report No. 1097 pages 28-29	Increased rainfall by cloud seeding, \$100,000.--The committee recommends allowances of \$100,000 to be used for research on increasing rainfall by cloud seeding. This amount would be utilized in cooperation with the National Science Foundation and the Weather Bureau, which are expected to contribute funds and participate in this research.
10-4-62	1963	House, 87th Congress 2nd Session	Report No. 2531 page 20 Conference Report	The amount provided includes . . . ; and up to \$100,000 for weather modification research.
12-5-63	1964	Senate, 88th Congress 1st Session	Report No. 746 page 32	Weather modification, \$50,000.--The committee recommends an increase of \$50,000 for a study of scientific findings and recommendations on coordination of future research by the South Dakota School of Mines at Rapid City, South Dakota.
8-5-64	1965	Senate, 88th Congress 2nd Session	Report No. 1326 page 30	Weather modification research, \$2 million.--The committee recommends an increase of \$2 million in the amount (\$100,000) programmed for weather modification research. The increase is to be divided between research on orographic and convective weather systems. Emphasis is to be placed on actual water production and the exploration and research is to include application of existing weather modification methods.
8-13-64	1965	House, 88th Congress 2nd Session	Report No. 1794 page 39 Conference Report	The increase above the House figure includes \$50,000 for Alaskan investigations and \$1,000,000 for weather modification research.
6-17-65	1966	House, 89th Congress 1st Session	Report No. page 43 Committee Print	Atmospheric water research program.--The amount recommended by the Committee includes \$2,30,000 for the atmospheric research program, an increase of \$1,000,000 in the budget estimate. This program was initiated in the current fiscal year and it is believed the increase allowed is necessary to continue effectively this important research program to determine the best and most economical methods of augmenting water supplies for reclamation projects by weather modification.

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program

1962 - 1979

Date	FY Bill	Body	Document	Provision
8-19-65	1966	Senate, 89th Congress 1st Session	Report No. 632 page 33	Atmospheric water resources.--The committee recommends an increase of \$2,500,000 over the budget estimate of \$1,230,000 for the atmospheric water resources research program. This is \$1,500,000 more than the amount allowed by the House of Representatives. The amount allowed by the House is necessary in order to maintain the program at its present level; but, in order for facilities and personnel developed during the past year to be utilized to the best advantage the amount recommended by the committee is required to permit an expansion of the current program. Of the increase recommended by the Senate, \$500,000 is to be used for the application of existing weather modification methods for the actual production of water.
10-13-65	1966	House, 89th Congress 1st Session	Report No. 1163 page 36 Conference Report	The increase provided over the House bill includes . . . ; and atmospheric water resources research program \$750,000. None of the latter increase is to be used for application of existing weather modification methods for the actual production of water.
9-15-66	1967	House, 89th Congress 2nd Session	Report No. 2044 page 59	Atmospheric water resources, \$3,000,000
10-3-66	1967	Senate, 89th Congress 2nd Session	Report No. 1672 page 32	The committee recommends the following additional increases over the budget estimates: . . . Atmospheric water resources engineering research--\$1,000,000, which will provide a total program during fiscal year 1967 of \$4,000,000. It is the committee's belief that the importance of this work warrants this proposed \$1,000,000 expansion of the program.
10-10-66	1967	House, 89th Congress 2nd Session	Report No. 2216 page 37	The increase provided over the House bill includes: . . . ; and for atmospheric water resource engineering and research \$750,000.
7-20-67	1968	House, 90th Congress 1st Session	Report No. 505 page 60	The committee has approved . . . (2) a reduction of \$250,000 in the estimate proposed to continue the atmospheric water resources program. Although the Committee strongly endorses the objectives of this program, the \$4,750,000 allowed, an increase of \$398,000, should provide for a very effective program in fiscal year 1968 considering the major increases provided in recent years;

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program

1962 - 1979

Date	FY Bill	Body	Document	Provision
9-28-67	1968	Senate, 90th Congress 1st Session	Report No. 574 page 30	The committee concurs with the following increases over the budget estimates allowed by the House of Representatives: . . . Atmospheric water resources research.-- \$5,000,000 to provide a total of \$10,000,000 to expand the budget program for atmospheric water resources research and to initiate the planned nationwide program. This will provide an increase of \$5,250,000 over the House allowance.
10-24-67	1968	House, 90th Congress 1st Session	Report No. 820 page 34	The increase provided over the House bill includes: for atmospheric water resources research, \$368,000.
6-14-68	1969	House, 90th Congress 2nd Session	Report No. 1519 page 56	The Committee reduction . . . includes the the following: (1) a disallowance of the increase of \$900,000 proposed for the Atmospheric water resources research program. The Committee has allowed \$4,615,000 to continue this research, the same as the current year level. Although the Committee endorses the program objectives, involving the development of a practical cloud-seeding technology to increase available water supplies, it believes it is imperative that the studies be closely coordinated with the weather research being conducted by other Federal agencies and expects that all steps necessary will be taken to assure that overlap and duplication of effort is avoided. The Committee requests that a special report be submitted to the Committee in this regard in connection with the appropriation request for fiscal year 1970.
7-15-68	1969	Senate, 90th Congress 2nd Session	Report No. 1405 page 26	The Committee also has included an additional \$150,000 for atmospheric water resources research in order to initiate pilot weather modification projects.
7-24-69	1969	House, 90th Congress 2nd Session	Report No. 1788 Conference Report page 30	Amendment No. . . : and \$150,000 to initiate pilot weather modification projects in connection with the atmospheric water resources research program.
10-2-69	1970	House, 91st Congress 1st Session	Report No. 91-548 pages 63 and 68	(Note: No specific language -- budget allowance of \$4,765,000 recommended without change within General Investigations recommendation.)

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program

1962 - 1979

Date	FY Bill	Body	Document	Provision
11-10-69	1970	Senate, 91st Congress 1st Session	Report No. 91-528 page 39	(Note: No specific language -- budget allowance of \$1,765,000 recommended without change within General Investigations recommendation.)
12- 2-69	1970	House, 91st Congress 1st Session	Report No. 9-697 Conference Report page 16	(Note: No specific language -- budget allowance of \$1,765,000 recommended without change within General Investigations recommendation.)
6-18-70	1971	House, 91st Congress 2nd Session	Report No. 91-1219 page 67	The Committee's net reduction consists of . . . and a decrease of \$300,000 made in the Atmospheric Water Resources Research Program. The allowance of \$6,500,000, an increase of \$1,467,000 over the 1970 program level, should provide for adequate expansion of the program in fiscal year 1971.
8-12-70	1971	Senate, 91st Congress 2nd Session	Report No. 91-1118 page 43	The Senate committee concurs in the House adjustments in the budget estimate for "General Investigations." (Note: \$6,500,000 appropriated.)
7-26-71	1972	House, 92nd Congress 1st Session	Report No. 92-381 page 59-60	The Committee has allowed \$6,234,000, a reduction of \$500,000 in the estimate, for continuation of the research program. Although the Committee fully supports this effort on which about \$28 million has been expended to date by the Bureau, it believes that an adequate program can be carried out within the amount provided. In total, Federal agencies had available about \$15.6 million in FY 1971 for weather modification programs including \$7.6 million for precipitation modifications.
7-30-71	1972	Senate, 92nd Congress 1st Session	Report No. 92-329 page 34	The Committee recommends an increase of \$675,000 for General Investigations. Of this amount, \$575,000 is for atmospheric research, of which \$75,000 is for cooperation with the City of Watford, North Dakota.
9-14-71	1972	House, 92nd Congress 1st Session	Report No. 92-479 Conference Report page 31	The increase provided over the House bill amount includes \$325,000 for the atmospheric water resources management program, including \$75,000 for the North Dakota Pilot Project.

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program
1962 - 1979

Date	FY Bill	Body	Document	Provision
6-19-72	1973	House, 92nd Congress 2nd Session	Report No. 92-1151 page 52	The Committee's allowance includes reductions in the following budgeted items: Atmospheric Water Resources Management Program (Project 81water). The Committee has allowed \$6,000,000, a reduction of \$200,000 in the estimate, for continuation of the research program. Although the Committee continues to support this effort on which about \$35 million has been expended to date by the Bureau, it believes an adequate program can be carried out within the amount provided, considering that Federal agencies have budgeted a total of about \$21 million for continuing weather modification programs in fiscal year 1973. The Committee believes that the Bureau's program, which has been conducted for several years under its general research authority, is now at the stage of development where specific legislative authority should be proposed by the Administration and considered by the Congress to determine the future nature and scope of the effort. Within the amount allowed, the Committee has made provision for \$375,000 for continuation of the contract research work at Utah State University.
6-27-72	1973	Senate, 92nd Congress 2nd Session	Report No. 92-923 page 34	Atmospheric Water Resources Management Program \$1,000,000 Includes: Extended Southern Plains \$ 300,000 Sierra Cooperative Pilot Project 50,000 North Dakota Pilot Project 75,000 Winter seeding techniques 75,000 North Platte Pilot Project 100,000 Environmental Study 200,000 Within the funds provided for Atmospheric Water Research Management, the Committee directs that contract research work at the University of Nevada, South Dakota School of Mines, University of Wyoming and Utah State University be continued at the fiscal 1972 levels.

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program
1962 - 1979

Date	FY Bill	Body	Document	Provision
8-7-72	1973	House, 92nd Congress 2nd Session	Report No. 92-1310 Conference Report page 28-29	Atmospheric Water Resources Management Program \$800,000 The increase for the Atmospheric Water Resources Program is allocated as follows: Extended Southern Plains Project, \$250,000; Sierra Cooperative Pilot Project, \$50,000; North Dakota Pilot Project, \$75,000; Winter seeding techniques, \$50,000; North Platte Pilot Project, \$75,000; and Environmental study, \$100,000. The managers also direct that, within the funds provided, contract research work at the following universities to be continued at the 1972 funding levels: University of Nevada, South Dakota School of Mines and Technology, University of Wyoming, and Utah State University.
6-25-73	1974	House, 93rd Congress 1st Session	Report No. 93-327 page 47	(Note: No specific language - budget increase of \$400,000 to \$3,650,000 included)
7-20-73	1974	Senate, 93rd Congress 1st Session	Report No. 93-338 page 35	Atmospheric Water Resources Management Program +\$500,000 The Committee has provided additional funds for Atmospheric Water Research Management to be allocated for the planned High Plains Cooperative Experiment. The Committee reaffirms its strong belief in the importance of Project Skywater, and urges the Bureau to give every consideration to and to utilize the research capabilities at the several colleges and universities located in the States covered by the High Plains program.
7-26-73	1974	House, 93rd Congress 1st Session	Report No. 93-409 Conference Report page 28	The increase provided over the House bill amount includes the following: Atmospheric Water Resources Management Program--\$250,000

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program

1962 - 1979

Date	FY Bill	Body	Document	Provision
6-3-74	1975	House, 93rd Congress 2nd Session	Report No. 93-1077 page 49	"Increase in budget" (as footnote to \$4,000,000 allowance which represents an increase from budget of \$3,454,000)
7-26-74	1975	Senate, 93rd Congress 2nd Session	Report 93-1032 page 47	Note: No change to house report
8-8-74	1975	House, 93rd Congress 2nd Session	Report 93-1274 Conference Report page 26	No language (No change in house amount)
6-20-76	1976	House, 94th Congress 1st Session	Report 94-319 page 59	No language
12-4-75	1976	Senate, 94th Congress 1st Session	Report 94-505 page 81	No change of language
12-10-75	1976	House, 94th Congress 1st Session	Report 94-711 Conference Report page 57	Both House and Senate provided \$4,649,000 for FY 1976 and \$1,632,000 for the Atmospheric Water Resources Management Program (Project Skywater). Further, the Committee of Conference agrees that the Bureau of Reclamation should allocate from within the amount made available, sufficient funds (estimated at approximately \$35,000) to complete the cloud seeding and cloud physics research program under a contract with the University of Wyoming.
6-8-76	1977	House, 94th Congress 2nd Session	Report 94-1223 page 64	No specific language; Increase shown in table, \$4,650,000 to \$6,400,000.
6-17-76	1977	Senate, 94th Congress 2nd Session	Report 94-960 page 73	No specific language -- no change in house increase.
6-24-76	1977	House, 94th Congress 2nd Session (Conference Report)	Report 94-1297 page 30	No specific language -- no changes.

SUMMARY OF APPROPRIATION LANGUAGE
Atmospheric Water Resources Program
1962-1979

Date	FY Bill	Body	Document	Provision
5-29-77	1978	House, 95th Congress 1st Session	Report No. 95- page 81	No specific language - Table showing \$1,850,000 increase, \$5,700,000 to \$7,550,000, specifically showing 0 to \$600,000 for Colorado River Augmentation Demonstration Program and \$3,050,000 to \$4,000,000 for High Plains Cooperative Program.
6-25-77	1978	Senate, 95th Congress 1st Session	Report No. 95-301 pages 65 and 70	"Funds in the amount of \$7,550,000 have been provided by the Committee for the Atmospheric Water Resources Management Program to advance verification and assessment of the benefits of cloud seeding technology. Major field research is currently underway on the Sierra Cooperative Pilot Project and the High Plains Cooperative Program (HIPLEX). The additional funds will enable the Bureau of Reclamation to undertake further downward research and to expand cloud physics and rainfall studies under the HIPLEX program; advance cloud seeding work related to the Sierra Cooperative Pilot Project; and prepare plans for the Colorado River Augmentation Demonstration Program."
6-1-78	1979	House 95th Congress 2nd Session	Report 95-1247 page 106	The funding table in the House report was also repeated. No specific language - Table showing \$3,000,000 additional (4,554,000 to 7,554,000) including \$500,000 for Colorado River Augmentation Demonstration Program.
8-7-78	4974	Senate 95th Congress 2nd Session	Report 95-1069 Page 90 and 97	The Committee recommends an increase of \$1,000,000 over the \$7,554,000 provided by the House for the Atmospheric Water Resources Management Program. The additional funds will be used to initiate a high-altitude downward seeding effects research effort in conjunction with the northern plains experiment of the HIPLEX program as well as comprehensive development of cloud-top seeding technology. This includes ground radar guidance support, weather modification pilot training, and research into the operational cost effectiveness of these new seeding methods. Further, the Committee recognizes the importance of the development of weather modification as a means of mitigating drought in semi-arid regions of the United States. The Committee recommends that the Bureau of Reclamation allocate \$1,000,000 from within the total resources available to the Bureau to conduct rain augmentation research in the Southwest in areas where drought patterns are developing.

Date	FY Bill	Body	Document	Provision
8-14-78	1979	House 95th Congress 2nd Session	Report 95-1490 page 57 (conference report)	The Table on page 97 shows an additional \$1,000,000 to House Report for total of \$8,554,000. Table showing \$8,554,000 allowance.

