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A Report to
The President and
The Congress

National Weather Modification Policies and Programs

November 1979



U.S. DEPARTMENT OF COMMERCE

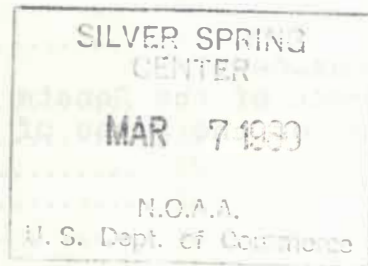
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A Report to
The President and
The Congress

**National
Weather Modification
Policies and Programs.**

Submitted by the Secretary of Commerce
in compliance with Public Law 94-490

November 1979



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U.S. DEPARTMENT OF COMMERCE

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

DEC 17 1979

Sirs:

It is my honor to submit to you a report on National Weather Modification Policies and Programs. This document contains the findings, conclusions, and recommendations of the study required by the National Weather Modification Act of 1976, Public Law 95-490.

Sincerely,

A handwritten signature in dark ink, appearing to read "L. R. Hodges", is written over a faint horizontal line.

ACTING Secretary of Commerce

Enclosure

The President
President of the Senate
Speaker of the House of Representatives

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INTRODUCTION

The National Weather Modification Policy Act of 1976 (P.L. 94-490), reproduced as appendix A to this report (the "Act"), 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. This is the report prepared pursuant to that Congressional directive.

In January 1977 the Secretary of Commerce established a Weather Modification Advisory Board (the "Board") to provide independent advice on the wide range of weather modification issues required to be addressed pursuant to the Act. In April 1977, 17 people with a wide range of backgrounds and distinguished records of service in private and public life were appointed to the Board. The Board was chaired by Mr. Harlan Cleveland, Director of the Program in International Affairs at the Aspen Institute for Humanistic Studies. Members included experts in weather modification, atmospheric science, oceanography, law, economics, international affairs, environmental studies, political science, state government, and public administration.

The Board retained the services of 20 consultants and 6 contractors to prepare study papers on issues and problems associated with weather modification. It met 12 times in 7 states and the District of Columbia between May 1977 and June 1978. Board members heard testimony from over 100 individuals and groups, both from this country and abroad. They spent many hours reading documents, drafting statements, weighing the contributions from consultants, and discussing the issues in public sessions.

The Board's report was issued in July 1978 and contains a comprehensive discussion of the current status of weather modification science, technology, and national and international regulation. The report is commendable not only because of its artistry and thoroughness but also because it was primarily a product of the members themselves rather than the Board's staff. Volume I of the Board's report is included as appendix F to this report. It is the primary source document for much of this report. Volume II, a technical study of the role of statistics in weather resources management, is included as appendix G.

In addition to the Board's report, this report is based on the documents and studies underlying the Board's report and the studies and expertise of the scientists of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and other Government agencies who are engaged in atmospheric and weather modification research and in international atmospheric science activities. Public comment on the Board's report was also requested in connection with its widespread

distribution to interested members of the scientific, environmental, academic, regulatory, and business communities, through an invitation to comment published in the Federal register, and through solicitation of the views of all 50 State Governors.

This report, submitted in accordance with Section 5 of the Act, is organized to respond to each of the specific charges to the Secretary in that Section. As required by Section 5(a)(1) of the Act, chapter I of this report summarizes findings of the Department's study in each of the 11 areas of investigation specified in Section 4 of the Act. As required by Section 5(a)(2)-(6) of the Act, chapters II through VI discuss other pertinent findings and set forth recommendations with respect to a national policy on weather modification and a national weather modification research and development program, levels of Federal funding authorizations desirable to facilitate development of a national program, a management organization to pursue the effort, and the desirable regulatory and international aspects of a national weather modification program.

SUMMARY

Modification of the weather is scientifically possible. If it is done reliably and with predictable results, society would benefit substantially, both economically and by savings of lives. To develop weather modification science and technology to the point where these benefits can be achieved, the Federal Government should undertake a coherent research and development program. A successful program will require in particular a long-term research plan and better coordination of Government efforts underway in a number of Federal agencies and Departments.

Background

Weather modification is human intervention to influence the atmospheric processes and events that comprise the weather. It is now being done deliberately in a variety of ways for mankind's benefit. 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. Experiments in the atmosphere have also yielded promising results in the area of hurricane moderation. Cloud seeding effects on the current scale appear to be localized and are not causing irreversible or large scale weather changes. The weather is also being modified inadvertently, by cities, powerplants, and agricultural activities such as irrigation and deforestation.

Weather can be modified by man, but much more knowledge is needed to intervene in complex atmospheric processes with scientifically predictable results. There are good reasons to believe that a coordinated long-term research and development program can supply many of the missing answers. In recent years, striking advances have taken place in developing the research tools needed to investigate 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 a sound research and development program.

Such a program may prove some technologies that now seem possible to be unworkable or uneconomic. In addition, many members of the public are deeply skeptical about the desirability of "tinkering" with large natural forces that may have unforeseen consequences, even if the scientific community is convinced that weather can be modified predictably and

safely. Thus, a national research program will require widespread public participation and scrutiny at all stages, regulation of activities by the Government when necessary to ensure public safety, and constant reevaluation of experimental progress, problems, and prospects.

Potential Benefits

Effective operational weather modification technologies would have substantial benefits that are likely to outweigh the costs by impressive amounts.

-- 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 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 since 1964 each resulted in losses of more than \$1.4 billion. Preliminary estimates place losses from 1979'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 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.

-- Crop and property damages due to hail, which exceed one billion dollars in the United States alone, would be reduced substantially, particularly in the Great Plains region.

Program Requirements

To allow weather modification to develop to its full potential, the following changes in the present Federal programs should be undertaken:

-- A national atmospheric R&D program. A well coordinated, long-term national research program into the scientific basis for management of our weather resources will be required. This should focus on obtaining a substantially improved understanding of cloud systems and their behavior, and should include a mixture of theoretical studies, computer modeling, laboratory experiments,

developments in monitoring and cloud seeding technologies, and field experiments in the atmosphere. The research program should also include studies to identify and understand the inadvertent influences of urban and industrial activities on local weather. Much of this research is related to and should also have broad application to other national objectives such as weather forecasting and air quality.

-- Environmental and other studies. For wise application of a weather modification capability, more knowledge is needed about the full range of environmental, social, legal, and other benefits and costs that would result before embarking on large-scale operational weather modification programs.

-- Stable Federal funding. Total funding for deliberate and inadvertent weather modification research in the Federal Government has remained relatively level -- from \$18.6 million in fiscal year (FY) 1972 to \$17.2 million in FY 1980. Seven Federal agencies supported weather modification research in the early 1970's, but only the Department of Commerce's National Oceanic and Atmospheric Administration, the Department of the Interior's Bureau of Reclamation, and the National Science Foundation are now active. Past on-again off-again efforts reflected concern over the state of the art and available assessment tools. The field requires sustained effort over a period of years to achieve reliable results. Preparation of the Federal budget must include an effective review of overall annual funding requirements against a comprehensive research and development plan, to assure that sustained program requirements are met. Modest budget initiatives will be necessary, especially for basic research, to implement such a plan after it is developed; until such time, current authorizations should provide sufficient flexibility to develop specific programs to meet the highest priority research needs.

-- Improved coordination of Federal research efforts. The present Federal strategy of allowing weather modification efforts to proceed independently in any agency with a related mission has resulted in a fragmented weather modification research program. This problem can be alleviated if all Federal weather modification research and development activities are undertaken in the context of a coherent overall long-term research plan. To that end, a Weather Modification Subcommittee should be established under the Committee on Atmosphere and Oceans of the Federal Coordinating Council for Science, Engineering and Technology. This Subcommittee should be charged with developing a 5- to 10-year weather modification research plan for the Federal Government, providing a coordinating mechanism for the conduct of the plan once approved, and assisting the Office of Management and Budget in analyzing annual agency program budget submissions for consistency with the plan.

-- Public involvement. Public acceptance of weather modification research will continue to be an important issue, and a mechanism to ensure public scrutiny of the planning and conduct of a national program is essential. A committee of individuals knowledgeable in the field of weather modification, who represent diverse viewpoints, should be created to act as a special advisory board to the Weather Modification Subcommittee under existing authorities.

-- Federal legislation. Such legislation should include: a clear statement of the national interest in weather resources management; an identification of the goals of a national weather modification program; and a definition of the respective roles of the state and Federal governments.

-- International activities. 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 are now feasible and would be important steps toward establishment of a comprehensive international regime for weather modification. These include: adoption by the United States Congress 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; and promulgation through an appropriate international organization of principles of conduct for the guidance of national weather modification programs.

The Advisory Board Report

This report agrees with many of the conclusions of the Weather Modification Advisory Board's Report set forth in appendix F. The reports differ in some important respects:

-- This report concurs with the Board that as more effective technologies are developed, the Federal Government will have principal responsibility for the health, welfare, and safety of the public with respect to the impacts of weather modification because of its interstate implications, and that Federal regulation of weather modification operators will be necessary. The Board recommends Federal licensing of weather modification operators now. This report concludes that the advantages of licensing at this time are small and are outweighed at present by the associated costs of a regulatory scheme.

-- The Board recommends creation of an autonomous board with direct authority over the operations of the national program. This

report recommends the establishment of a board to advise the Federal agencies preparing and implementing a Federal research plan.

-- The Board concluded that legislation was desirable to allow class actions against the Federal Government under the Federal Tort Claims Act for damages caused by Federal weather modification experiments, and that legislation might also be required to ensure that Federal experiments are not regarded as falling within the exemption from liability in the Federal Tort Claims Act for "discretionary functions." This report defers to the Department of Justice's view that class action legislation is not desirable and concludes that, in view of its concerns about changes in the Federal Government's sovereign immunity status, any legislation with respect to the "discretionary act" exemption should await further experience with its application.

-- The Board concluded "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 1980's, increased rainfall in areas like our High Plains and Midwest by the late 1980's (and) reduced hurricane winds and hail damage by the 1990's." This report agrees with the Board that modification of the weather in useful ways is scientifically possible. However, this report does not attempt to project specific quantitative research results within given time periods, reflecting less certainty about our ability to predict that the remaining scientific questions will be answered in a specific period.

-- The Board concluded that substantially increased levels of funding will be required to support a national research program. This report concludes that only modest funding increases will be required once a new, coordinated Federal research program is developed by the Weather Modification Subcommittee.

-- The Board concluded that all civilian weather modification research and development programs should be centralized in a single Federal agency. This report concludes 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.

These differences about the manner in which a Federal program is conducted, while significant, should not overshadow this report's agreement with the basic conclusions of the Advisory Board that modification of the weather in useful ways is scientifically possible, that prudent steps should be taken now to strengthen activities designed to investigate those possibilities, and that these steps require the Federal Government to develop a coherent, long-term research program and organize seriously for a longer term effort.

I

Summary of Major Findings

This chapter contains a summary of findings on the "state of scientific knowledge concerning weather modification, the present state of development of weather modification technology, and the problems impeding effective implementation of weather modification technology" in each of the 11 areas of investigation specified in Section 4 of the Act.

Major Findings - Item 1

Section 4(1) of the Act requires "A review and analysis of the present and past research efforts to establish practical weather modification technology, particularly as it relates to reducing loss of life and crop and property destruction."*

Introduction

A cloud seeding technology currently exists. It is employed commercially in this country in attempts to clear fog from airports, to augment snowpacks in mountainous regions, to increase rain from summer showers, and to reduce destruction by hail. Seventy-eight operational programs were reported to the Department of Commerce in 1977 under the provisions of Public Law 92-205, the National Weather Modification Reporting Act of 1971. In 1978, fifty programs were reported covering about 5 percent of the country's land area.

The Federal Government has sponsored weather modification research since cloud seeding became a scientific reality in 1946. Techniques for clearing supercooled fog from airport runways are now proven. Many precipitation enhancement projects conducted over the past three decades present evidence of success. As the Weather Modification Advisory Board concluded, "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." Experiments in hurricane moderation have also been encouraging, but they are too few for definitive results. Much more work needs to be done to determine the efficacy of hail suppression and other weather modification techniques.

*This subject is addressed in chapters 2 and 6 of Volume I and in Volume II of the Weather Modification Advisory Board Report (Appendixes F and G respectively).

Because many of the conclusions drawn from cloud-seeding experiments depend upon statistical analyses, a brief summary of the topic is given in the following paragraphs. The remainder of this section of the report examines the status of present and past research efforts in each of the above subject areas in more detail.

The Role of Statistics

A number of research projects, and a larger number of operational cloud-seeding efforts, have been undertaken since 1946. Research projects, including experimental cloud seeding efforts, are conducted to learn more about clouds and cloud processes, to determine cloud responses to seeding, and eventually to develop, through continued exploration and testing under rigidly controlled conditions, reliable techniques for achieving desirable results at the earth's surface through cloud seeding. Operational cloud seeding is the routine application of such a technique for the purpose of achieving the maximum possible results desired by a group seeking to modify the weather.

Because of the inherent natural variability of the weather, statistics becomes a primary tool for judging what was accomplished compared with what would have happened if nature had not been altered purposefully. The statistical design used in most past experiments has called for some form of randomization scheme for allotting the "seed" or "no-seed" decision to experimental units -- for example, a cloud, a storm, or a day, generally within a designated area. Analyses have consisted mainly of testing the "null hypothesis" on the resulting data. The null hypothesis states that the seeded and unseeded samples are drawn from the same population -- that is, the seeding had no detected effect. If the null hypothesis could be rejected with only a 5 percent chance of being wrong, experimenters have generally accepted that the populations were significantly different and the difference was related to the seeding.

It is no simple matter to develop a statement regarding the statistical significance of an experimental result. There are many potential sources of error in the collected data and some of the errors can be systematic, thus favoring one or the other side of the question. Once the data set is accepted, it can be used to answer many different questions. If the experimenter is allowed to ask an unlimited number of questions, some will appear to be answered positively just by chance. Thus a minimum number of physically meaningful questions is best. Even then, many statistical techniques can be applied to the data to answer the questions selected, and statisticians have legitimate differences of opinion as to which techniques may be most appropriate for a particular experiment. Thus, a range of numbers can be given to express the statistical significance of a given experimental result.

A statement of statistical significance is not the final answer to the question of whether cloud seeding made any difference. Such a statement attempts to indicate the probability that the observed difference could have arisen by chance. If that probability is as low as 5 percent, one is tempted to accept the reality of the effect. But the physical plausibility of the result, the strength of supporting evidence, and other subjective factors are important in making a judgment. Unless most informed individuals find the totality of evidence persuasive, the case cannot be considered proven. In assessing results of experiments in this section, therefore, qualitative terms such as "promising" or "likely" are prevalent.

Federal activities have been limited almost exclusively to research and field experimentation. The results from a number of the more recent seeding test projects have resolved some questions concerning the responses of various types of clouds to several different seeding modes. As the following discussion indicates, however, many other questions remain unanswered.

Supercooled Fog and Stratus Clouds

The simplest of all scientific experiments in cloud seeding is to spread pellets of dry ice or particles of silver iodide into layers of supercooled fog and low stratus clouds. The resulting transformation of the cloud composition from waterdrops into ice crystals is clear, dramatic, and incontrovertible. Initially, the ice crystals are too small to fall from the cloud, but they grow at the expense of remaining waterdrops. As turbulent air motions diffuse them into nearby cloud regions, they can grow large enough to produce a snow shower.

The amount of snowfall produced in this way is trivial because the stratus cloud initially contains so little water. But visibility almost always improves and often a large hole may be opened in the stratus. The U. S. Air Force has practiced this technology for many years at various airbase installations in the United States and abroad, and commercial airlines have used this type of weather modification at selected airports in the northwestern United States. The Soviet Union is said to have experimented with this type of technique over areas much larger than airports. The possibility of using this technique to open holes in winter stratus clouds to increase the amount of solar radiation reaching the ground has been discussed but has received little research attention. Although theoretical calculations have been made to estimate the level of effort needed to open a hole of sufficient size to be meaningful, few field experiments have been conducted for that specific purpose.

Clouds Over Mountainous Regions

The seeding of orographic clouds to stimulate precipitation has been one of the most actively pursued weather modification activities. Most orographic precipitation occurs when winter storm winds encounter mountain barriers. These upslope winds are continuously cooled to form clouds and precipitation. Typically, only about 20 to 50 percent of the water that is condensed to form orographic clouds actually falls as precipitation. The rest is reevaporated on the leeward mountain slopes. Thus orographic clouds are good candidates for seeding to increase the fraction of water falling on the mountain slopes.

A major portion of the precipitation in the mountainous Western United States occurs through the orographic process. Snowpack accumulates during the winter and melts and runs off during the late spring and summer. Much of this runoff is stored in reservoirs for future use as irrigation or domestic water supply. Some of this water helps generate hydroelectric energy. Any increase in the snowpack can therefore be translated directly into additional useful water. Consequently, orographic clouds in the Western States have been long-term targets of both operational and experimental cloud seeding projects.

The 1957 final report of President Eisenhower's Advisory Committee on Weather Control (ACWC) discussed several winter orographic seeding projects. Since no research project results were available, the ACWC studied data from operational seeding projects. They compared target area precipitation during seeded storms with that which occurred in nearby, presumably unaffected, control areas. The target/control precipitation ratios for seeded storms were compared with historical ratios, obtained from data collected before cloud seeding began, to determine the effect of seeding. The precipitation ratios for seeded storms were about 10 to 15 percent higher than the historical averages. These data indicated that precipitation increases had been realized as a result of seeding. Nevertheless, the ACWC judged that more conclusive evidence based on carefully designed randomized field trials should be sought.

A second review of the state of the science of cloud seeding was undertaken by the Committee on Atmospheric Sciences of the National Academy of Sciences (NAS) in 1966. They reported positive results of orographic seeding from randomized seeding projects in Australia and Mexico. The results of four long-term, privately conducted, non-randomized, winter orographic cloud seeding projects in California, Utah, and Oregon were also evaluated. These operational projects were evaluated on the basis of target/control ratios of seasonal streamflow rather than precipitation. Streamflow measures in effect integrate watershed precipitation over the whole season. The target/control streamflow analysis indicated with a good degree of statistical confidence that increases in seasonal streamflow of 6 to 18 percent had

occurred due to seeding. However, this conclusion could be accepted only with reservations because of the necessity of relying on non-randomized data.

In 1973, a further report was prepared by a NAS panel. This panel examined several randomized seeding projects that were either under way or had been completed since the 1966 report. Special attention was given to the combined results of the Climax I (1960-65) and Climax II (1965-70) projects, both conducted in Colorado under the leadership of Colorado State University scientists with support from the National Science Foundation. These benchmark projects were interpreted as giving the first definitive determination of the nature of the response of orographic clouds to seeding. The data indicated that orographic clouds having cloudtop temperatures between -11°C and -20°C were very favorable for precipitation enhancement. Precipitation decreases occurred when cloud top temperatures were colder than -26°C . Precipitation decreases also occurred under very strong wind conditions. The NAS panel concluded: "Hence, in the longest randomized cloud seeding research project in the United States, involving cold orographic winter clouds, it has been demonstrated that precipitation can be increased by substantial amounts on a determinate basis."

Evaluations of the Climax project data subsequent to the NAS report have suggested effects extending beyond the time and spatial limits of seeding for the target area. In some of the experimental years concentrations of ice nuclei in the target area in excess of the normal background persisted for days after seeding had been terminated. In addition, on days when seeding was conducted in the Climax project area, precipitation as far as 160 kilometers (about 100 miles) east of the mountains was found to be higher than on non-seeded days.

Subsequent to the Weather Modification Advisory Board's report, scientists have questioned whether the Climax results may have been biased because the randomly selected seeded days were naturally more snowy than non-seeded days. This point is still being studied.

The progression of evidence suggesting beneficial effects from seeding orographic clouds during the 1950's and 1960's led the Department of Interior's Bureau of Reclamation (BuRec) to propose large-scale application of orographic cloud seeding as a water management tool. As a step toward this goal, BuRec initiated the Colorado River Basin Pilot Project over the mountains of southwest Colorado during the winter of 1970-71. This 5-year experiment was patterned after the Climax project. However, post-experiment analyses revealed serious problems in the operational implementation and transferability to a different area of what were considered well-tested techniques. The randomization scheme required accurate 24-hour forecasts of the suitability of cloud conditions for seeding, a prediction capability beyond the state of the science. Consequently many hours of seeding occurred when conditions

were unsuitable for seeding. This problem was compounded by atmospheric conditions that on certain occasions trapped seeding agents near the generators during seeded days and subsequently allowed contamination of the target area during nonseeded days. The experiment resulted in a finding of no significant difference in precipitation amount on seeded and nonseeded days.

The Colorado River Basin Pilot Project did help to solidify knowledge about conditions under which orographic seeding can be employed beneficially. Reanalysis of the data by meteorological category reaffirmed the Climax finding of the crucial role of cloud-top temperature seedability criteria and the importance of the wind speed across the mountain barrier. It also demonstrated the need for careful design of demonstration projects.

Bureau of Reclamation scientists recently conducted an analysis of the combined data from the Climax project, the Colorado River Basin Pilot Project, and five other randomized winter cloud-seeding research projects conducted in orographic settings in the western Rocky Mountains and on the U.S. Pacific coast. Variables were developed and investigated to establish generalized seedability criteria that would be applicable to a variety of meteorological and topographic conditions. The investigators found strong positive and negative seeding effects associated with selected cloud conditions. These results need further verification with additional data, but meanwhile they can be useful in formulating hypotheses and designing future experiments.

A randomized project carried out in Tasmania was completed subsequent to the 1973 NAS report. Aerial seeding was conducted over a 2600-square kilometer mountainous target area during the entire even-numbered calendar years from 1964 to 1970. No seeding was conducted during the odd-numbered years, to avoid long-term persistence effects that had been suspected in earlier Australian projects. The results indicated a 20 percent precipitation increase during the autumn season with some positive effect in portions of the target area during winter and spring and a possible decrease in summer. Statistical tests indicate a probability of less than 5 percent that the autumn precipitation increase arose by chance. However, some statisticians point out that multiple analyses were carried out within the single experiment (i.e., separate analyses for each of the four seasons), thus placing greater demands on the level of evidence required to reach such a conclusion and making it difficult to attach significance values to the results.

Summer Cumulus Clouds

Cumulus clouds are even more important than orographic clouds as producers of precipitation and generators of severe weather. Cumulus clouds supply as much as three-fourths of the precipitation in middle-latitude crop-growing areas and almost all of the precipitation in the

tropics. Thus development of the ability to increase precipitation from cumulus clouds may have the greatest potential payoff of all possible weather modification techniques. However, the complexity of cumulus clouds and their extreme variability in time and space make modification of such clouds a much more complex problem than modification of orographic clouds.

The science of seeding cumulus clouds for more precipitation has evolved a good deal over the last 30 years. Two seeding concepts -- static seeding and dynamic seeding -- have been employed.

Static Seeding. The "static seeding" concept was based on the assumptions that cumulus clouds are naturally deficient in ice-forming nuclei and that the addition of ice-forming nuclei by cloud seeding should bring the ratio of ice crystals to supercooled water to a more efficient balance and result in more precipitation at ground level. Hundreds of commercial projects based on this concept have operated in the United States and other countries, especially during the dry years of the early 1950's.

President Eisenhower's Advisory Committee on Weather Control investigated several seeding projects over nonmountainous terrain, primarily in the eastern and central parts of the United States. Their 1957 report indicated that they were unable to detect any increase in precipitation from these projects, but they urged more studies of cumulus cloud seeding because of the high value they attached to even a small enhancement of precipitation from clouds over agricultural areas.

As a consequence of the ACWC recommendations, several randomized cloud-seeding projects were initiated. The 1966 NAS report reviewed a number of these projects. Special attention was given to Project Whitetop, conducted in Missouri from 1960 to 1964 by the University of Chicago with support from the National Science Foundation. This project found an increase of 5 to 10 percent in radar echo frequency just downwind of the seeding location, indicating increased precipitation activity within the clouds. This effect gave way to negative effects of about the same amount beyond 65-80 kilometers (about 40-50 miles) downwind. The net result was a decrease of precipitation in the target area as a result of seeding. The net rainfall decreases in Project Whitetop were attributed to overseeding in the face of high natural ice particle concentrations.

Another randomized summer cumulus research project was conducted in southern Arizona from 1957 to 1964 by the University of Arizona also with NSF funding. The results of this project were inconclusive, but less precipitation occurred in the target area for seeded cases than for non-seeded cases.

In the absence of other results from randomized research projects, many of which were still under way, the NAS staff reviewed 14 short-term, nonrandomized operational projects conducted in the eastern United States. They found evidence of precipitation increases in the range 0 to 33 percent, several of them at moderate to low levels of statistical significance. They concluded that these results could not be regarded as conclusive evidence of precipitation increases from cloud seeding, but that they were suggestive of positive effects and warranted some optimism.

The 1973 NAS report discussed two additional randomized summer cumulus projects that had been completed since the 1966 report. One was a project carried out over the Sierra Nevada range by Fresno State College scientists, where observational evidence suggested that precipitation was stimulated by seeding. However, the project design made no provision for quantitative evaluation of precipitation increases. The second project was a long-term randomized effort carried out on the Necaxa River Basin in central Mexico by the Mexican Light and Power Company. Evaluation of the seeding experiments showed evidence of a strong positive effect, at least in certain categories of precipitation from special meteorological situations.

The 1973 NAS report also devoted attention to new analyses of the Project Whitetop data. Several post-hoc statistical analyses by outside investigators reported, overall, decreases in precipitation in the target area and extending in all directions from the target. A final analysis of Project Whitetop by the original investigators reported that negative effects were associated with southerly low-level winds, while days with westerly winds showed positive effects. They also found, using radar echo-top data, that increases in precipitation had occurred when radar tops were between 6,090 and 12,180 meters (about 20,000-40,000 feet). When echo tops were higher, there were decreases in precipitation. Thus, certain conditions for favorable and unfavorable effects due to seeding seem to have been identified. However, other tests are needed to confirm this finding.

Dynamic Seeding. The concept of "dynamic seeding," first suggested in 1948, was developed and used experimentally during the late 1960's. This technique employs massive seeding to convert supercooled liquid water to ice rapidly during the active growth phase of a cloud. Scientists hypothesize that the resulting release of latent heat increases cloud buoyancy, invigorates the cloud and prolongs its lifetime, increases its efficiency, and ultimately enhances rainfall. Several factors were important in making dynamic seeding practical. These included the development of numerical cumulus cloud models that could simulate cloud processes, at least in a crude way, the development of minicomputers, and the development of pyrotechnic seeding devices.

Tests of the dynamic seeding concept were conducted in Pennsylvania, Arizona, the Caribbean, and southern Florida during the late 1960's. These tests confirmed the increased growth of the clouds predicted by the numerical cloud models. Subsequently, the effect of dynamic seeding on rainfall in Florida cumulus clouds was investigated by NOAA in two projects in 1968 and 1970. A comparison of radar-measured precipitation from individual seeded and non-seeded clouds showed a 100 to 200 percent increase in precipitation for seeded clouds. The increase was significant at the 5 percent level -- that is, the hypothesis that there is no difference between the seeded and non-seeded clouds could be rejected with the probability of being wrong at most 5 times out of 100 (and the probability of being right at least 95 times out of 100).

The Florida Area Cumulus Experiment (FACE) was organized by NOAA in 1970 to determine whether dynamic seeding can be used to augment precipitation from cumulus clouds over an extensive area in south Florida. Exploratory field experiments were conducted during five summers from 1970 through 1976. Results from the FACE experiments suggest that under some conditions dynamic seeding increases rainfall. Because of the multiplicity of ideas examined and the subjective influences of those conducting the experiment (a problem discussed further in section 2 of this chapter) -- conditions typical of all exploratory experiments -- these conclusions cannot be assigned useful statistical significance levels. For that reason, a confirmatory Florida experiment was initiated in the summer of 1978.

In an area-type summer cumulus cloud experiment conducted in South Dakota from 1969 through 1972 by the South Dakota School of Mines and Technology, statistically significant precipitation increases were reported for days characterized by cumulus showers. On days with large thunderstorms, essentially no seeding effect occurred. The investigators ascribed the results to dynamic seeding although the seeding rates used were much smaller than those in either the FACE or Caribbean experiments. This points up the fact that there is no hard and fast line between static and dynamic seeding.

The South Dakota School of Mines and Technology also conducted a cumulus cloud seeding project for rain enhancement and hail suppression in North Dakota during the summers of 1969 through 1972. The project was randomized by day with silver iodide released into cloud updrafts at the base of the clouds. A recent statistical analysis of this project by the Weather Modification Advisory Board's statistical task force indicates that overall differences in rain for seeded and unseeded days were negligible and not significant. However, they found that when seeded days are separated into days judged suitable and unsuitable for dynamic seeding the mean difference in average rainfall between (suitable) seeded days and unseeded days approaches statistical significance.

Winter Cumulus Clouds

Randomized tests of seeding winter cumulus clouds for increasing rainfall were carried out in Israel between 1961 and 1967 (Phase I) and between 1969 and 1975 (Phase II). In both experiments, cumulus clouds moving inland from the Mediterranean Sea were seeded from airplanes at relatively high dosage rates. The results of Phase I indicated an increase in precipitation of about 15 percent (with statistical significance) when cloud tops were between about -10°C ($+14^{\circ}\text{F}$) and -25°C (-13°F). Phase II, considered to be a confirmatory experiment testing the conclusions of Phase I, indicated a 13 to 15 percent increase in rainfall at significance levels of 4 percent and 9 percent (in two significance tests) -- that is, the null hypothesis could be rejected with the probability of being wrong at most 4 and 9 times out of 100, respectively. When the results of Phase II became known, the Israeli Government stopped experimenting and launched a program of operational seeding at every cloud opportunity. A post-hoc analysis of effects downwind of the target indicated a positive response to seeding as far as 160 kilometers (about 100 miles) downwind.

The Weather Modification Advisory Board's Statistical Task Force reviewed the only report thus far published about Phase II of the Israeli project. They concluded that "If closer critical analysis of the study and its data fails to detect flaws, the results of this study would be judged to constitute confirmatory evidence that rainfall amounts have been increased by cloud seeding." The Statistical Task Force's report to the Weather Modification Advisory Board is included as appendix G to this report.

The closest analogs of the Israel-type cloud systems in this country appear to be the winter cyclonic storms along the California coast and in the Pacific Northwest. These storms are known to contain numerous convective rain bands within which the highest intensity precipitation is located.

A randomized seeding project involving this type of winter cloud was carried out by Aerometric Research, Inc. near Santa Barbara, California, during the period between 1967 and 1974. During the first 4 years (Phase 1), seeding was accomplished by a high-output pyrotechnic device at a single site on a 1000-meter (about 3,280-foot) ridge line. The emphasis was on seeding individual convection bands embedded within winter cyclonic storms. Seeding was randomized band by band. Analyses of Phase 1 indicated precipitation increases of 50 percent or greater from seeded bands at high levels of statistical significance. There was also indication of up to 50 percent precipitation increases extending 160 kilometers (about 100 miles) downwind of the generator site.

Phase 2 shifted the scene of action 100 kilometers (about 62 miles) to the west and further explored the downwind effects. Seeding was carried out from aircraft flying within convective bands upwind of the target area. Seeding was randomized in 48-hour periods, but the test was abandoned before an adequate sample was collected. Rainfall in the target area and in a region extending 250 kilometers (about 155 miles) downwind was reported to have been increased 50 percent or more by seeding. Although Phase 2 was terminated before any statistical significance could reasonably be anticipated, the results of Phase 2 suggest that the dynamic effect was realized in the seeded precipitation bands.

Hail Suppression

Hail, another form of precipitation from cumulus clouds, is a major cause of agricultural crop losses and property damage in the United States, especially in the Great Plains region. Most of the damage is caused by the larger hailstones. Consequently, suppressing the growth of large hailstones has been a long-time goal of weather modification activities. Efforts to suppress hail began in the United States in the 1950's. Privately supported projects over small areas first took place in high crop loss areas in Nebraska and West Virginia well before experimentation had established a scientific approach to hail suppression.

Hail research efforts appeared in Canada in the 1950's culminating in a major hail-suppression project in 1974. The project, a cooperative effort between segments of the Canadian Government and McGill University, was conducted in the Province of Alberta and began as a mixture of operations and experimentation using cloud-base and cloud-top seeding techniques. In 1976 the project became fully operational as a result of pressure from farming interests. The randomized experiment, lasting only two years, was too short to provide firm scientific conclusions about seeding to suppress hail.

The first major U. S. hail suppression research experiment occurred in northeastern Colorado in 1959, but results were inconclusive. Operational programs of hail suppression, without any proof of great success or any foundation of sound scientific experimentation, continued into the 1960's and 1970's in Colorado, Kansas, Texas, North Dakota, and South Dakota. Between 1958 and 1977, 71 hail suppression field operations and experiments were conducted, mostly in the Great Plains.

Hail suppression has been practiced on all continents except Antarctica. United States companies have played an important role, through exportation of hail-suppression techniques, in its spread to Kenya, Italy, South Africa, and other nations. Most of these projects have been ended by a lack of continued financial support because the evidence of hail suppression was not strong enough. The Soviet Union has

developed an ambitious hail-suppression effort and claims a 60 to 80 percent effectiveness in reducing hail. Similar programs have been fostered in several eastern European countries, and Soviet hail-seeding equipment and supplies are marketed for sale around the world.

A 7-year experiment in Switzerland between 1957 and 1963 suggested a 66 percent greater frequency of hail days in the seeded sample than in the unseeded sample, rather than the intended decrease. This difference was found to be statistically significant. France, Italy, and Switzerland are currently conducting a joint hail suppression experiment in Switzerland that is a carefully designed effort to test the effectiveness of the Soviet system and hypothesis.

In 1971, the Federal Government established a National Hail Research Experiment in northeastern Colorado. This experiment, a major effort in applied research on hail suppression, included a randomized seeding test stimulated by the Russian experience. An analysis of the data collected after 3 years of experimentation revealed that there was no statistically significant difference between the seeded and nonseeded incidence of hail. The planned 5-year statistical experiment was terminated after 3 years because the analyses indicated that statistically significant results could not be expected after 5 years, and the emphasis subsequently shifted to more fundamental studies of convective storms.

Hurricane Moderation

Very little experimentation has been done on modification of severe storms. The single exception is the hurricane -- one hurricane modification concept has undergone some experimentation by NOAA and Department of Defense scientists. The concept involves strategic silver iodide seeding of the eyewall and inner rainband clouds of a mature hurricane in an attempt to displace outward the ring of ascending air in the eyewall and thereby reduce the maximum wind speed. The idea is to slow down the hurricane's rotation in the same manner as a spinning ice skater who extends his arms. Three mature Atlantic hurricanes have been seeded by project STORMFURY scientists, but only one experiment -- on hurricane Debbie in 1969 -- tested the displacement moderation concept. Hurricane Debbie was seeded five times at 2-hourly intervals on August 18 and again on August 20. On the first seeded day, the maximum wind dropped 30 percent 4 to 6 hours after the last seeding. It reintensified on August 19, but again dropped by 15 percent 4 to 6 hours after the last seeding on August 20.

These results are in the direction predicted by preliminary numerical models. However more research and experiments are necessary before any firm conclusions can be drawn.

Other Applications

In addition to cloud seeding for rainfall and snowfall enhancement, hail suppression, hurricane moderation, and opening holes in supercooled stratus, several other objectives in weather modification have been sought. These include seeding with silver iodide to reduce lightning strikes, seeding warm fogs with moisture absorbing particles to improve landing conditions at airports, seeding with dry ice in high-humidity regions of the clear air to create cloud layers, dusting snow covered surfaces with carbon black to increase the rates of melting, and coating lakes and reservoirs with long-chain alcohols to reduce evaporation (and similar treatment of cloud drops to make clouds last longer). Theoretical research and field experimentation have been conducted in each of these areas, but they all are ideas lying fallow pending further research or new physical insights.

Summary

As the preceding discussion indicates, 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 in 1946. The behavior of clouds and cloud systems has proved to be so variable that physical cause and effect are difficult to follow and predict. The technologies for intervening in a predictable manner in these complex cloud processes are still at an early stage of development.

Most experimental efforts have focused on precipitation enhancement. There has been evidence of success, although it falls short of final scientific proof. Of all the orographic cloud seeding projects reviewed, only one failed to show some positive results, and indicated precipitation increases ranged as high as 20 percent. Results of the many cumulus cloud precipitation enhancement projects varied more widely. Some of those using the static seeding concept resulted in apparent decreases in precipitation; others indicated precipitation increases as high as 33 percent. Most, however, were inconclusive. One project, in Israel, has established statistically convincing results -- precipitation increases of about 15 percent -- and has gone operational. Those projects using the dynamic seeding concept have demonstrated fairly conclusively that the growth of a single cumulus cloud can be stimulated using this technique, but the question of predictable increases in areal precipitation as a result of growth and merger of clouds and cloud systems is still open. The Florida cumulus project has provided evidence of success, and further data will be available from a second phase of that program, which is now in progress. Results of seeding projects in convective bands in California and cumulus clouds in North Dakota were encouraging, although inconclusive.

There are many reasons for this state of affairs. Research has been discontinuous and definitive tests are lacking. Operational projects have not made adequate design provisions for establishing proof of success. Without proof of effectiveness, applications have been on-again-off-again and uneven in coverage. Results of the practical application of the technology are therefore difficult to document. Despite promising experimental results, there has not yet been any widespread impact in terms of reducing crop losses or loss of life from storms.

Past seeding activities have suffered from several common deficiencies. Principal among them has been the general inadequacy of our knowledge of cloud structure and behavior. This deficiency remains the foremost deterrent to progress in present efforts. Other important problem areas include project designs that do not provide adequately for essential statistical evaluations, inadequate measurement techniques and instrumentation, and unsatisfactory seeding strategies. These matters are discussed further in the next section of this chapter.

Major Findings - Item 2

Section 4(2) of the Act requires "A review and analysis of research needs in weather modification to establish areas in which more research could be expected to yield the greatest return in terms of practical weather modification technology."*

Introduction

As the Weather Modification Advisory Board concluded, "The prime requirement of a national weather modification policy is to learn 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 their behavior is essential for development of the entire range of weather modification techniques.

The research program to achieve such an understanding will require a range of efforts, including laboratory studies of basic cloud processes, improved computer models and monitoring techniques, and cloud seeding experiments in the atmosphere. Fundamental cloud processes and their interactions are poorly understood, and greater research into these basic scientific problems will be 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. However, two cloud seeding techniques for enhancing snowfall and rainfall are already well enough developed to warrant proof-of-concept field experiments, and others (for summer rain enhancement, precipitation augmentation from winter cumulus clouds, and hurricane amelioration) are at the stage where exploratory field experiments should be conducted in connection with other studies.

Scientific uncertainties are typical of the first stages of development of new technologies. This report agrees with the conclusion of the Weather Modification Advisory Board that, despite such uncertainties, modification of the weather in useful ways is

*This subject is addressed in chapters 1 through 5 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

scientifically possible. As section 3 of this chapter indicates, the potential benefits of an operational weather modification technology are so substantial that they should be pursued through a well-organized Federal research and development program to resolve the outstanding scientific issues.

Basic Scientific Problems

Most modification efforts employ the same basic technology -- nuclei are introduced into the supercooled region of a cloud or cloud system to convert liquid water drops to ice. Lack of understanding of important intracloud and cloud-environment conditions and interactions makes neat separation of the various modification techniques and responses difficult. Rain, hail, lightning, and wind are all interrelated, and attempts to modify one may well affect others. The aim of a national weather modification research program 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. Such a program will require a mix of quantitative theory, laboratory studies, numerical modeling, and field experimentation.

Two basic scientific problems are of particular importance and deserve special attention. The first is the need to expand our understanding of the interactions between cloud microphysics and cloud dynamics (i.e., between precipitation development and air motions). The second is the need to unravel the issue of the origin and initial growth of ice in natural clouds and to develop more realistic measures of the ice-forming potential in these clouds.

The most fruitful approach to the first problem will be through combined high quality observational studies and numerical modeling efforts, backed up with specialized laboratory investigations. To cope with the second problem, good observational data on cloud glaciation must be obtained in experiments in which the evolution of the cloud is documented so that account can be taken of all relevant factors, such as ice nucleus concentrations, droplet spectra, and cloud duration.

Because clouds are variable in space and time, rapid-scanning remote sensing devices will be a necessary component of these observational programs. In addition, because cloud behavior varies with geography, comparative studies will be needed in several parts of the country. For example, clouds in tropical areas such as Hawaii present special problems because they often rain by a process that does not involve ice; this "warm rain" process may be amenable to modification by seeding with moisture absorbing materials, but such seeding techniques are not well developed or understood. Finally, the intensive cloud studies described above should be accompanied by computer model development leading to an ability to simulate realistically both natural and seeded cloud

behavior. The models in turn should enable improved prediction of precipitation and improved design and evaluation of weather modification experiments.

Field Experiments

Because of the atmosphere's complexity, atmospheric research cannot be undertaken solely in the laboratory or with a computer. At some stage the research must move into the field. Well-designed field experiments are an essential component of a weather modification research program, and those experiments must be carried out over many years to obtain definitive results.

A wide range of opinions exists within the scientific community about when field experimentation should occur. Some scientists feel that complete understanding of the cloud processes involved is necessary before initiating seeding experiments. Others believe that success will come only through experimentation in the atmosphere itself and that those experiments should begin at once. The best approach lies between these extremes. Experience of the last two decades demonstrates that a substantially improved understanding of cloud systems and their behavior cannot be achieved by field experiments alone and that major significant increases in basic understanding come from research carried out in conjunction with experimental field projects. Experiments in the atmosphere are needed to test the validity of seeding concepts developed on the computer or in the laboratory and to search for evidence that will refine, broaden, or shift those concepts. However, experiments must be designed carefully to take full advantage of existing knowledge and to incorporate contributory research.

Two principal types of field experiments must be undertaken -- exploratory and confirmatory. Exploratory experiments may have several intermediate goals. Some will be aimed at improving knowledge of natural cloud conditions; others will seek understanding of the effects of seeding on cloud processes and will test hypotheses about the physical mechanisms involved. However, the ultimate goal of a good exploratory seeding experiment will be a physically plausible model of the weather system under investigation and a clear hypothesis of how and when seeding will influence the system. These experiments must include a broad range of observational and modeling techniques. In addition, the experimental conception, design, conduct, and evaluation should include the expertise of specialists in statistics, cloud and mesoscale physics, atmospheric modeling, hydrology, and related disciplines.

The objective of confirmatory seeding experiments is the establishment of some particular hypothesized seeding effect as a fact, within some small and well-defined margin of error. Confirmatory experiments must be precisely designed, tightly controlled, and free of unconscious or accidental bias. Subjective judgments or decisions during

the conduct of the experiment or subjectivity in collecting and handling data could influence the observed results and, as a consequence, totally invalidate the experiment. Even small biases could be serious, since the effects of seeding are small and difficult to differentiate from natural events. The accepted approach in conducting confirmatory experiments is to withhold from all those who make decisions or judgements influencing the numbers to be analyzed any knowledge of whether the period in question is seeded or unseeded until all data are in final form. This approach is analogous to the practice in medical experiments where anyone making subjective judgements concerning the management of the patient does not know whether the patient is receiving the medication being tested or a placebo.

Special facilities are needed to provide essential support for many weather modification studies and most field experiments. Examples of such facilities include calibration equipment for seeding generators, specialized radar and other remote sensing systems, instrumented or seeding aircraft, and mini-computers for on-site data processing. These facilities are expensive and their need is common to many field projects. A coordinated joint-use program is needed to manage the utilization of these common facilities to ensure that they are available to projects that need them and that they do not sit idle for extended periods of time.

Specific Weather Modification Techniques

Two cloud seeding techniques -- enhancement of orographic snowfall in the Rocky Mountains and augmentation of subtropical rainfall by dynamic seeding -- are already well enough developed to warrant proof-of-concept experiments. The substantial potential benefits of such techniques are discussed in section 3 of this chapter of the report. Satisfactory exploratory experiments have been concluded in these areas and are discussed in section 1 of this chapter. Confirmatory tests of these techniques should therefore receive first priority among the field experiments to be conducted by a national weather modification research program.

Three other cloud seeding techniques -- summer rain enhancement in mid-latitudes, precipitation augmentation from winter cumulus clouds, and hurricane amelioration -- are at the stage where exploratory experiments should be conducted as an adjunct to the intensive observational studies and other research discussed earlier. As discussed in section 3 of this chapter, the ability to increase rain from summer cumulus clouds appears to have great potential economic benefits for agriculture. Despite the weaknesses in our understanding of fundamental cloud processes, techniques for the modification of showery, warm-season cumulus clouds over the High Plains and the midwestern United States -- areas which are distinctly different meteorologically -- deserve major exploratory tests as part of a national weather modification research program.

Promising research has been conducted on augmenting precipitation from winter cumulus clouds and cloud bands, especially in California and over the Great Lakes. Further tests of seeding techniques applicable to these cloud systems is warranted.

The ability to ameliorate the destructive forces of hurricanes also promises substantial economic benefits. Research in this area must be conducted with five closely interacting aims: measurements by direct and remote sensors from beneath the ocean to the stratosphere in all phases of storm development; model simulation, including simulation of boundary and cloud processes, with interacting air and ocean models; technological and tool development, ranging from improvement of treatment chemicals and dosage and delivery systems to formulation of statistical methodologies; full-scale seeding experimentation undertaken after the key scientific questions have been resolved and after a suitable statistical design has been formulated; and investigation of concepts other than seeding by feasibility studies, model simulations, measurements, and -- if promising after scrutiny -- pilot field tests.

Perhaps the most difficult application of cloud seeding attempted so far is in the suppression of hail. Many complex scientific issues must be resolved before randomized seeding experiments are justified. However, some useful knowledge can be gained by conducting research in connection with selected private operational hail-suppression projects and by devoting attention to hail research in the cumulus cloud field projects mentioned above.

The seeding of cold stratus clouds might have some applicability in the Great Lakes and northeastern areas of the United States. Maintaining a clearing in a winter overcast over an urban area during daylight could reduce heating requirements and improve the efficiency of solar collectors. The scientific basis for creating holes in certain larger clouds is firm and incontrovertible, but the technical and economic feasibility of doing so for several hours over large areas on a regular basis is not established. A feasibility study of this concept is warranted.

Other weather modification objectives -- such as tornado or flood prevention -- await development of testable hypotheses. Although these and other severe local storms may someday be found to be responsive to cloud seeding or some other form of manipulation, too little is known about them to justify seeding experimentation at this time. At this point, research is necessary in the form of good observational studies, laboratory experiments, and theoretical model development.

Finally, the Weather Modification Advisory Board also briefly examined a number of other weather management techniques "beyond cloud seeding" that might play a role in the future. They recommended that a small percentage of the national effort be devoted in the later stages of

a long-term research program to techniques of concentrating energies and moisture to penetrate stable atmospheric layers (to dissipate fog or smog), suppressing lightning discharges, enhancing convection by altering land surfaces (by dispersing carbon black or substances with similar radiative properties), and using space or surface power parks for enhancing rainfall or air circulation. As the Board recognized, research on these techniques is at such an early stage that current investment of substantial Federal funds cannot now be expected to produce returns in terms of practical weather modification technology to the same extent as investments in research of the types discussed above.

Other Research Requirements

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 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. These matters are discussed further in sections 3 and 4 of this chapter of the report.

Research Returns

The Weather Modification Advisory Board concluded that: "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 1980's, increased rainfall in areas like our High Plains and Midwest by the late 1980's, reduced hurricane winds and hail damage by the 1990's. 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." This report does not attempt to project specific quantitative research results within given time periods.

The lack of such predictions does not arise from disagreements about whether or not modification of the weather in useful ways is scientifically possible -- this report agrees with the Board's conclusion that it is. Rather it reflects less certainty about our ability to predict that the remaining questions will be answered within a specific time period.

It is important to recognize that such uncertainties are typical of the first stages of development of new technologies. As section 3 of this chapter of the report indicates, an operational weather modification capability would provide important economic benefits to the Nation. This report agrees with the Advisory Board's conclusion that the potential benefits are so substantial that they should be pursued through a well-organized Federal research and development program to resolve the outstanding scientific issues.

Major Findings - Item 3

Section 4(3) of the Act requires "A review and analysis of existing studies to establish the probable economic importance to the United States in terms of agricultural production, energy, and related economic factors if the present weather modification technology were to be effectively implemented."*

Introduction

This report concurs with the conclusion of the Weather Modification Advisory Board that, "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."

Weather-related losses in the United States total about \$12.7 billion annually. With a dependable weather modification technology, we would be able to reduce those losses significantly. The agricultural sector would benefit most, particularly from effective precipitation enhancement and hail suppression techniques -- the Board believes that "weather modification must be considered as one of the most important agricultural technologies awaiting development." The annual reduction in hurricane damage from storm surge and winds would also be substantial.

Existing Economic Studies

Few studies of the economic benefits of weather modification have been conducted. The most thorough and serious study thus far was the Technology Assessment of the Suppression of Hail, a cooperative effort involving five groups under the supervision of Stanley Changnon of the Illinois State Water Survey. This 18-month project, initiated in 1975 with support from the National Science Foundation (NSF), was limited to hail suppression and related rainfall changes. Another major effort was undertaken by Stanford Research Institute (SRI) in 1971 on snowpack augmentation in the Colorado Basin, also under NSF sponsorship. An independent review of all previously published economic weather modification reports was undertaken by Stephen T. Sonka, of the University of Illinois, as part of the study conducted by the Department of Commerce to fulfill the requirements of the Weather Modification Act.

*This subject is addressed in chapters 6 and 7 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

A major problem in conducting any economic evaluation of weather modification technology is related to the performance of the technology itself. Complete economic analyses must stem from knowledge of the details of altered weather -- when, how much, how often, and with what side effects. For the most part, this knowledge is not available today; as indicated in sections 1 and 2 of this chapter, scientific uncertainty currently exists regarding the effectiveness of such technologies. The results of the economic evaluation are likely to depend heavily on the assumptions made about the effectiveness of the technology, thereby assuring that an economic evaluation is also uncertain.

Another problem in evaluation arises from the complex nature of the results of any successful modification of the weather. Potential losses may also accompany purposeful efforts to alter weather. An obvious loss occurs when the physical change is contrary to that intended; precipitation in the target area in some circumstances may be decreased rather than increased by augmentation efforts, or unintended and undesirable physical changes may be caused in regions downwind of the target area. For example, additional water from snowpack augmentation may benefit irrigation, power generation, and municipal uses in the Lower Colorado River Basin. But additional snowfall may harm transportation, mining, and recreation activities in the Upper Colorado River Basin. Less obvious but equally legitimate are the costs associated with the environmental and ecological impacts of weather modification. All such costs, whether compensated or not, need to be considered in any economic analysis.

Such studies must also carefully differentiate between net national gains and regional gains. Part of any projected regional gains may be income from other regions. Such transfers must be specified in order to assess accurately the real impact of weather modification activity on a specific region or regions.

Agriculture

The agricultural sector of the United States would benefit most from an operational weather modification capability -- particularly from effective precipitation enhancement and hail suppression techniques.

Precipitation Enhancement. Crops generally respond positively to increased summertime rainfall only if that rain arrives at the proper time. Additional rainfall at inopportune times can decrease yields, and beneficial effects do not occur at the same time for all crops typically grown in a single region. However, rain enhancement would be broadly beneficial during droughts. Cloud seeding may be least effective during droughts because clouds are often scarce during these periods, but the value of even relatively small increments of moisture to agriculture and for water supplies may be quite large during drought periods.

The following two studies demonstrate the potential benefits of weather modification for agriculture as well as the limitations of currently available analyses:

A 1972 study by South Dakota State University considered the effects of additional rainfall on a regional level (the Southeastern Crop Reporting District in South Dakota). This study explicitly took into account price declines generated by additional production, costs of obtaining the additional precipitation, associated increases in other production costs, and the effects of induced shifts in types of farming. These effects were evaluated for ten situations, assuming an additional one inch of growing season rainfall in each case but differing rainfall timing and price effects. Assuming a base regional net farm income of \$65 million with no weather modification, the projected rainfall and price variations increased the base regional income by a range of 3.1 percent to 34 percent.

A study conducted by the National Academy of Sciences in 1976 evaluated the potential impact of a successful weather modification capability on key U.S. crops in the primary national production areas. Average production increases were projected for 10 percent increases in rainfall in the major producing areas for each major crop; these estimates are indicated in the following table.

Commodity	Additional Quantity Produced (in millions)
Corn	38.0 bu.
Wheat	34.0 bu.
Soybean	18.4 bu.
Western Range	
Forage	52,500.0 lb.
Range Cattle (10 lbs. beef/120 lbs. forage)	4,375.0 lb.

The crop production increases represent revenue increases of \$314 million based on September 1978 prices for corn, wheat, and soybeans. In many areas of the West a 10 percent increase in precipitation would produce an extra 120 pounds of forage per acre, which has the potential of producing about 10 pounds of steer beef. Realizing this potential over the available acreage would, according to the National Academy of Sciences, produce an additional 4,375 million pounds of beef. This translates into \$2.986 billion at 1978 prices.

The NAS report does not indicate whether competitive crop needs and other factors that affect price, such as those cited in the South Dakota study, were considered. In neither study were all the economic factors that affect benefits and costs considered. Despite these very real weaknesses, these studies strongly suggest that small increases in

precipitation, if obtained at appropriate times and places, can have important positive impacts on food production on both a regional and national scale.

The positive impacts are supported in a recent study by scientists at the Kansas State University, who calculated changes in crop yields in Kansas that might result from cloud seeding. The same study indicated that in some years and for some crops additional rain would not produce significant benefits.

Hail Suppression. Donald Friedman of Travelers Incorporated has estimated that crop losses due to hail average \$773 million a year based on 1975 dollar values, and that property damage due to hail averages \$75 million yearly. Because hail losses vary across the Nation, the incentives for farmers to engage in hail suppression activities also vary regionally. According to the 1977 Final Report of the Technology Assessment of the Suppression of Hail (TASH), 6 of the 10 states with greatest crop losses from hail are in the Great Plains area, and crop losses in those states represent about 5 percent of the annual crop value. Consequently, the major economic benefits of hail suppression, both in terms of increases in average income and reductions in variability of income, should occur for farmers in the Great Plains region.

The TASH team conducted a detailed analysis of the effects of hail losses on individual farmers in six specific agricultural areas -- northwestern Kansas, southwestern North Dakota, north-central Iowa, east-central Illinois, west-central Texas, and central North Carolina. The crops grown in those six areas -- wheat, corn, soybeans, and tobacco -- are crops for which hail losses are significant. Three hypothetical levels of reduction in hail damage were considered in the study -- 20, 50, and 80 percent. In addition, three levels of hail-season rainfall were considered for each level of crop damage reduction -- a 10 percent reduction, no change, and a 10 percent increase.

The results of the study indicated large differences in potential benefits from a suppression technology among the regions studied. The data for farmers in the two easternmost regions -- North Carolina and Illinois -- showed little potential for hail suppression benefits as compared with the no-hail-insurance, no-hail-suppression situation. In contrast, the data for the regions in Iowa, Kansas, Texas, and North Dakota indicated that economic incentives for hail suppression may exist. In these four areas, the postulated hail suppression capability with no rainfall effect was calculated to have potential benefits. Although only Texas would receive net gains when crop damage was reduced by 20 percent, all four areas would realize increases in net income when crop damages were reduced by 50 and 80 percent; the potential benefits would be even greater if the decreases in hail damage were accompanied by a 10 percent increase in rainfall.

The TASH study also computed benefit/cost ratios for the various hail damage reduction levels. In these computations only the benefits from reductions of variable production costs and transportation costs were considered. The cost estimates were composed of amortized expenditures for future research and development and for design, evaluation, and program information activities. In the cases of simultaneous decrease in hail and increase in rainfall, the benefit/cost ratios varied from 1:1 to 15:1.

Both benefits and costs were understated in this analysis. For example, the cost estimate did not include past expenditures for hail suppression research or the possible detrimental effects of additional rainfall. Benefits were understated because no benefits for reduction in variability of income or reduction in property damages were included, and indirect benefits associated with any increased crop output were not estimated. However, the TASH investigators concluded that "on balance, the positive impacts appear to outweigh the negative impacts if a high-level technology can be developed."

Water and Energy Enhancement

During the past 25 years, many small-scale experiments and operational programs have been conducted in which winter clouds have been seeded to increase the snowfall in high mountain areas of the western United States. When the augmented snowpack melts in the spring, the additional runoff supplies hydroelectric power as well as additional water for agricultural, municipal, and industrial uses.

In its 1972 Technology Assessment of Winter Orographic Snowpack Augmentation in the Upper Colorado River Basin, the Stanford Research Institute (SRI) found snowpack enhancement to be an inexpensive method of augmenting the water supply in the Colorado River Basin. SRI analysts estimated that in an average year a successful seeding technology could generate about 2.3 million acre-feet of augmented runoff within the Basin and 1.2 million acre-feet outside the Basin. Annual operating costs for such an operation were estimated to average \$2.37 per acre-foot for in-Basin runoff alone and \$1.58 per acre-foot overall. The direct cost of producing water in this manner was less than that for any other practical means of obtaining new water in the Basin. It was also less than the cost of most means proposed for reducing water losses.

Evaluating the benefits of such additional water is a complex problem. The economic benefits derived from any additional snow enhancement runoff are different for individual water users than for the Nation. The user's benefit depends on the specific way he or she uses water. The benefit to the Nation depends on the marginal use of water, which in the arid West is for agriculture.

The SRI study attempted to assess the potential benefits of enhancing winter snowpack in the Colorado River Basin. It assumed that such an enhancement project would generate slightly less than 2 million acre feet of additional water and derived dollar values for the additional water based on two different scenarios.

The first scenario assumed that no new facilities to store or use the additional water will be built, that there is currently no shortage of water in the river, and that without the construction of new facilities to use additional water there is no reason to believe there will be a shortage in the future. The chief benefits to be derived from the additional water generated by cloud seeding under these conditions are marginal decreases in the salinity of the water and the availability of additional hydroelectric power to replace more expensive power from thermal generating plants. These benefits combined with benefits to municipal, industrial, and agricultural concerns outside the Basin totaled about \$12.8 million. The overall cost of the enhancement project, after adjustments for economic detriments -- such as increased costs of mining operations and timber cutting; interference with road, rail, and air transport; and costs for avalanche control, flood forecasting, and environmental monitoring programs -- was estimated to be about \$9.5 million.

The second scenario assumed that additional storage projects and other facilities authorized by the Colorado River Basin Project Act of 1968 (P.L. 90-537) will be constructed and that the first obligation of these facilities will be to satisfy the water requirements of the Mexican Treaty, as stipulated by P.L. 90-537. If the facilities are built and enough natural water is available to satisfy all of the commitments of P.L. 90-537, the economic analysis is basically the same as in the first scenario. However, if the facilities are completed and there is insufficient natural water to meet the Treaty commitments, the snow augmentation program could "rescue" benefits that would otherwise be lost. In this situation, all the benefits rescued were attributed to the cloud seeding program and were assigned a value of \$30 million based on the minimum cost of satisfying the Treaty obligations by the next least expensive alternative (transferring the water from irrigation users).

Several other studies of the potential benefits of snowpack augmentation were examined by Sonka in his review of the economics of weather modification. Projected benefit/cost ratios for the projects he reviewed ranged from 1:1 to 21:1. Comparison of these studies is difficult, however, because of the varying degrees of comprehensiveness among them and the difficulties involved in assigning dollar values to both costs and benefits. Some of the studies compared only benefits and operational costs without including costs for research and development. Some did not consider the social costs that may be generated by additional snowpack. None considered the value of additional water for

energy-related purposes other than for the generation of hydroelectric power (such as cooling of additional thermal plants).

In summary, the value of a successful snow enhancement technology is difficult to determine. Irrigation and hydroelectric power seem to be the prime uses for the additional water produced, and the future value of irrigation water and the secondary benefits to agriculture are especially important to determining the overall benefits of the technology. But these variables are extremely sensitive to assumptions about the future demands for food and fiber. If these demands result in excess agricultural capacity, the value of augmented irrigation water may not be high. If future food demands lead to full employment of our agricultural resources, the value of snowpack enhancement may be very significant.

Hurricane Moderation

Hurricanes are one of the most destructive of all natural hazards. In the United States, the annual economic losses caused by hurricanes are about \$800 million, with three storms since 1965 each resulting in losses of more than \$1.4 billion; damages from one of these storms exceeded \$3 billion. Preliminary estimates place losses from 1979's hurricane Frederic well in excess of \$1 billion. Nearly a hundred lives are also lost annually as a result of hurricanes. With the increasing population and industry at risk in coastal areas, these losses are almost certain to escalate. Losses of this magnitude are not limited to the United States. In Bangladesh, a tropical cyclone killed about 200,000 persons in November of 1970. The City of Darwin, Australia, was virtually wiped out by cyclone Tracy in December of 1974.

The main causes of property damage by hurricanes are -- in order of decreasing importance -- storm tide or storm surge, flooding from precipitation associated with the storm, and winds. Precipitation-induced flooding appears to be essentially independent of the other two causes. While seeding may or may not have some effect on precipitation, the major economic benefits of seeding are expected to occur as a result of the reduction of storm surge and direct wind damages. Since the force of the wind varies with the square of the wind speed, a reduction of 15 to 30 percent in the maximum wind speeds by seeding could result in a reduction of 30 to 50 percent in the maximum force of the winds and could result in an equal reduction in wind damages.

Little information exists regarding economic aspects of hurricane suppression. In a 1973 study, William M. Gray of Colorado State University estimated the benefits from hurricane modification using a model developed by SRI. Assuming a 20 percent reduction in surface wind with no rain changes, he estimated the annual reduction in hurricane damage from storm surges and winds to be \$100 million in the United States and \$800 million globally, based on 1969 U.S. dollars.

Any estimate of the average potential reduction in hurricane damage by cloud seeding must be viewed with caution. The economic and meteorological data upon which the estimates are based are extremely crude -- accuracy varies substantially from place to place and with time, and there is no separation of the damages caused by storm surge, flooding, and wind. In addition, individual storms of the same physical characteristics can cause different amounts of damage depending on their landfalls. Even if two similar storms hit the same area the resulting damage might be different at different times because of changes in the area's development. Furthermore, it is not clear whether the damages associated with a 100 knot storm the winds of which have been reduced to 80 knots are the same as those associated with a natural 80 knot storm, since the wind distribution in the modified storm might differ from the natural case.

Despite these uncertainties, the magnitude of hurricane-induced damages is so great that a substantial economic incentive exists for the development of effective modification techniques.

Major Findings - Item 4

Section 4(4) of the Act requires "An assessment of the legal, social, and ecological implications of expanded and effective research and operational weather modification projects."*

Introduction

The past three decades of weather modification activity have provided a good basis for anticipating the general types of legal problems that will be created by expanding the number of weather modification research experiments and by effective operational weather modification projects. The precise manner of solving these problems remains to be resolved. However, with the exception of the issues created by hurricane modification activities, they are not novel problems, and the general framework of possible solutions can be foreseen. 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.

Legal Implications

Weather modification activities raise three major kinds of legal issues -- issues of atmospheric water rights ownership, liability, and regulation. Current law with respect to these issues stems from experience with 16 lawsuits relating to cloud seeding and from weather modification statutes passed by Congress and 32 states. A considerable body of periodical and legislative literature on this subject has also developed.

There are three major questions of atmospheric water rights ownership: Who has ownership rights in atmospheric moisture? Who has legal rights to precipitation from unseeded or seeded clouds? Who has a legal claim to runoff that can be identified as the product of precipitation management? Potential contenders over ownership issues include the persons who sponsor or conduct precipitation enhancement projects, other land owners in the the area affected, water rights holders on affected streams, and governmental entities affected. The right to use atmospheric waters, precipitation, and runoff may be

*This subject is addressed in Chapters 7, 8, and 9 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

allocated by legislation, administrative determination, or litigation. Disputes among states may be resolved by Federal legislation, interstate compacts or other agreements, and litigation in the Supreme Court of the United States.

There is no Federal law allocating atmospheric water rights, and no Supreme Court decision deals with the issue. Several states have made informal agreements about operations, but there are no interstate weather modification compacts. Four states have legislative provisions relating to private ownership rights and three court cases have dealt with the ownership question. These cases and laws present several options in determining ownership issues but do not show any trend toward adoption of a particular option; they merely demonstrate the possibilities.

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 Act precludes class actions on behalf of all claimants affected by a Federal weather modification activity. As discussed in section 5 of this chapter of the report, state liability rules are quite diverse, ranging from judicially developed principles of recovery for tortious conduct to statutory formulas dispensing with the requirement to demonstrate fault, and often including doctrines of governmental immunity. However, the courts have abolished state sovereign immunity in many states, and state-funded seeding projects are subject to liability on the same basis as privately funded projects. Class actions have been brought against both state-funded projects and privately funded projects in state courts. Despite these variations, however, the case law on liability for the results of weather modification activities has been quite consistent -- no plaintiff has been able to prove the causal relationship necessary to obtain a judgment for damages.

No Federal regulations govern the conduct of weather modification activities. Current Federal law contains only reporting requirements, which are discussed in section 6 of this chapter. State weather modification regulatory regimes contain a wide variety of content and complexity, ranging from a complete absence of regulation to elaborate requirements for state licensing of cloud seeders and permitting of weather modification activities. These state regulations are discussed in section 5 of this chapter.

Future legal problems arising from increased weather modification research activities on the local scale will be similar to the problems that have arisen in the past. Individuals or groups will continue to assert that experimental cloud seeding has caused floods, droughts, storms, crop losses, or ecological damage or has resulted in diversion of water resources from natural channels. The appropriateness of class

actions, issues of causation, the proper measure of damages, and the ability to recover for damages caused by governmental actions will continue to be issues which can be resolved by state and Federal courts as normal matters of common law development or statutory interpretation.

As the science of weather modification improves to the point where causation can be demonstrated, and as the number of local operational programs increases, the pressures will increase for legislation on these issues. Public regulation of the decision to permit weather modification activities and the manner in which such activities are conducted will be necessary. Increasing availability of class action remedies will be demanded, as will abolition of applicable doctrines of governmental immunity and development of new forms of private or government insurance. Courts may develop doctrines that shift the burden of proof to the defendant rather than the plaintiff in damage actions, and ultimately legislatures may enact some version of no-fault insurance or compulsory claims procedure that will remove the burden of assessing damages from the judicial system.

The legal implications of experimental and operational weather modification activities on regional, interstate, and international scales are more complex. The extra-area or down-wind effects of large cloud seeding projects may cross county, state, and international boundaries. Issues of water rights are complex and fiercely fought, especially in the Western states, and successful weather modification techniques will lead to pressure for judicial or statutory formulations of rights to enhanced runoff. Although problems have been resolved informally in the past, statutory methods may be required to resolve an increasing number of conflicts between states and between the state and Federal governments regarding the design and commencement of weather modification activities. These conflicts could involve not only the question of whether the Federal Government may proceed with a project over state objections, but also the question of whether states can conduct operations that affect federally owned lands without Federal consent. Methods of resolving disputes between Federal agencies in a timely manner will also be necessary; for example, disputes have already occurred between the Forest Service and the Bureau of Reclamation over the issue of cloud seeding affecting wilderness areas. Finally, as sections 7, 10, and 11 of this chapter discuss in more detail, the international problems created by modifications of the weather near national borders will require resolution through bilateral and multilateral treaties.

Future hurricane modification operations will raise additional sensitive issues for which mechanisms of resolution must be adopted. What individual or agency should have the power to authorize modification of hurricanes? How, and by whom, can those adversely affected by "modified" hurricanes be compensated for losses of property or lives? Who will be accountable for the consequences of the decision not to modify a potentially dangerous hurricane if the demonstrated technology

to do so exists? What rights of compensation exist when a seeded hurricane behaves erratically (as many do without seeding) and causes loss of life or damage to property? Domestically, these issues will probably arise only when an effective technology has been demonstrated. At that time, better knowledge of the characteristics of modified storms and their modified damage patterns should enable meaningful answers to these questions. Internationally, some of these concerns have already surfaced. In either case, the issues are so substantial that domestic legislation or international agreements rather than judicial resolution will be necessary before experimental or operational activities that could affect land areas can be permitted.

Social Implications

Research to date on the social aspects of weather modification has focused on the processes leading to the decision to proceed with field projects and on local public responses to the decision. Surveys have indicated that most projects have not engendered organized opposition, and that such local controversies as have arisen are well publicized rather than wide-spread. At the same time, however, vocal public opposition has often arisen, emotions have run high, and a substantial level of public concern about modification of natural processes in the face of any scientific uncertainties can be expected. There is no assurance that such opposition would not increase greatly in the face of large-scale experimental and operational technologies.

A high degree of public acceptance and understanding is desirable before large-scale weather modification operations are initiated. Analyses of past conflicts, which have been conducted primarily by the National Science Foundation and the Bureau of Reclamation, indicate the need for thorough public explanation of plans for seeding (including a frank exposition of the scientific uncertainties), effective public participation in making decisions about particular projects, and explicit mechanisms to deal fairly with those whose interests might be damaged as a result of operations.

Attention should be given to the measurement and evaluation of the long-term, large-scale effects of applying successful weather modification technologies. The Bureau of Reclamation has prepared a three volume programmatic environmental impact statement which addresses the societal implications of widespread application of cloud seeding to augment precipitation. The Bureau plans to include such studies in its proposed large-scale demonstration project in the Colorado River Basin.

The potential social implications in the United States of an expanded operational weather modification capability are illustrated by the events of the winter of 1976-77. Severe drought in the West had widespread consequences; urban domestic water users, agriculture, industry and business, transportation, schools, and government were all

affected directly and indirectly. A variety of reactive measures to deal with the resulting crises were initiated, including snowpack augmentation to increase stream flows. The degree of success of these snowpack augmentation efforts has not been documented. However, if a proven technology for precipitation enhancement had been available, and if it had been utilized as part of a water management program both prior to and during the drought, the effects of the drought would certainly have been alleviated somewhat, and the impact on all segments of society would have been significant.

The long-range social impacts of large-scale operational weather modification technologies could be profound. Agricultural yields could be increased and cropping patterns altered. Additional hydro-electric power could supplement other energy supplies, and regional development in water-short areas such as the Colorado Basin could be affected. The quality of life for many citizens could be impacted by changes in precipitation and cloud cover patterns, by amelioration of the losses of life and property from hurricane and storm disasters and droughts, and by the legal and ecological matters discussed in this section of the report. Not all of these impacts are necessarily beneficial. And few of them are really understood.

The global impacts of weather modification technology could be equally great. Shortages of food, water, and energy are serious problems in many areas of the world. The prospect of successful international cooperation in this area itself has important social implications for cooperation in other areas, as does the prospect of increased international tension, dissension, and possible hostile use resulting from the existence of such technologies. These matters are discussed further in section 7, 10, and 11 of this chapter.

Ecological Implications

Information about the ecological implications of an operational weather modification technology is limited. Measuring the environmental changes resulting from weather modification is even more difficult than measuring the effects of seeding on the weather itself. Any ecological changes that may result from long periods of modified weather will evolve slowly, and most past cloud seeding projects have not been conducted for sufficient periods of time to allow for such evolution, or have not monitored such changes.

The long-term irreversible effects of weather modification on circulation patterns and the weather itself should be negligible. Weather patterns develop and move in systematic fashion and are dominated by the effects of the oceans and the continents. The effects of weather modification activities are local and transient -- there is no evidence that cloud seeding causes anything more than generally small and short-term weather changes. Studies have indicated that most of the seeding

material is recovered in the immediate precipitation area -- the remaining material is rapidly diluted by the normal diffusive turbulence in the atmosphere -- and that the effects of cloud seeding activities should not be expected to extend any great distance from the target area. Consequently, the very small changes in local weather caused by cloud seeding should have no effect on the forces driving the general atmospheric circulation and its associated weather systems.

Terrestrial weather modification effects can be both beneficial and adverse. Enhanced precipitation provides more water for cropland irrigation, and for natural plant growth through added soil moisture. At the same time, it may increase soil erosion, river and lake sedimentation, and flooding. Secondary effects also may be important. Increased forage production would benefit both domestic livestock and herbivorous wildlife, but it could also adversely impact the habitats of some other animals or contribute to the demise of endangered species. Less thermal generation of electricity would be required, but greater use of electricity might result; water quality may be improved, but increased industrial and domestic consumption of water and resulting pollution might occur.

The only Federal agencies that have sponsored research on the ecological implications of weather modification have been the National Science Foundation and the Bureau of Reclamation. NSF has sponsored studies involving the ecological aspects of weather modification at universities and non-profit institutions for over a decade, with emphasis on the environmental impacts of nucleating agents used in weather modification. In a 1976 NSF-sponsored workshop, a panel of 16 scientists analyzed the available information on the subject and concluded that the major issues regarding nucleating agents that had been matters of public concern to date represented negligible environmental hazards. However, they recommended that research and monitoring activities be continued. Since 1972 the Bureau of Reclamation has sponsored studies by university scientists on the environmental implications of winter cloud seeding over California's Sierra-Nevada Mountains; BuRec also supported similar studies earlier in the Rocky Mountains in Colorado. In neither case did the investigators find evidence that significant environmental changes would occur from winter seeding research programs.

Questions about the effects of silver iodide, the commonly used seeding agent, will continue to require attention as the scope of weather modification activities enlarges. No known environmental or biological hazards have been experienced from this agent. But the long-range effects of silver accumulation in principal components of the ecosystem, and the direct and indirect effects of such accumulation, have not been monitored thoroughly because projects have not lasted long enough.

Major Findings - Item 5

Section 4(5) of the Act requires the "Formulation of one or more options for a model regulatory code for domestic weather modification activities, such code to be based on a review and analysis of experience and studies in this area, and to be adaptable to state and national needs."*

Weather modification activities are currently regulated at the state level, but the extent of such regulations varies considerably. Eighteen states have no weather modification laws. Of the 32 states that have enacted statutes, 13 require cloud seeders to obtain professional licenses, 13 have created special weather modification regulatory boards, 23 require either registration of projects or operational permits, and 20 require operators to keep weather modification records or to report operational information to the agency regulating their activities.

Present state statutes are also quite diverse with respect to water rights and liability issues. In four states -- California, Colorado, Utah, and North Dakota -- atmospheric water resources have been declared the property of the people of the state and are subject to the same laws as natural precipitation. However, court decisions in weather modification lawsuits in other states have ruled that property owners have no vested property rights in the clouds or the moisture therein and that the right of every landowner to the clouds and water in them is subject to weather modification activities undertaken under governmental authority. West Virginia and Pennsylvania weather modification statutes do not require a plaintiff to prove fault to recover for losses caused by droughts or floods that are the results of cloud seeding (although the plaintiff must still prove causation). In Texas the general rule of strict liability for the effects of weather modification activities does not apply to licensed operations.

The Illinois Weather Modification Act, which was adopted in 1973, was designed as a model regulatory statute. It was prepared after extensive technical, economic, and legal research and reflects the contributions of interested professional groups. The Illinois Act was relied on heavily in formulating recently enacted Minnesota, Indiana, Wisconsin, and Michigan statutes.

*This subject is addressed in chapter 9 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

A copy of the Illinois Act is included in appendix B to this report. Under the Act, authority to regulate weather modification activities is delegated to a state administrative agency, which licenses weather modifiers only if they demonstrate, to the satisfaction of the agency, the necessary competence to engage in weather modification operations in accordance with the agency's regulations. In addition, no licensed operator may undertake a weather modification project without a specific permit for the project. To obtain the permit, the operator must furnish proof of his or her ability to pay any liabilities that might reasonably result from the operation (generally by filing an insurance policy or bond with the agency) and must demonstrate to the agency that the proposed plan of operation is reasonably conceived to produce beneficial results and contains adequate safeguards to minimize possible damages.

The Illinois Act authorizes the administrative agency to hold public hearings before granting a project permit and to impose conditions on the permit relating to matters such as area and timing of operations, materials and methods used in operations, and emergency shut-down procedures. The agency is authorized to adopt regulations to impose record keeping and reporting requirements for matters such as the places and times of operation and the equipment and methods used; such records and reports are available to the public.

The Illinois Act exempts from its regulatory scheme weather modification operations by the Federal Government and research operations by state and local agencies, educational institutions, and research corporations. It confirms state immunity for results of licensed operations but permits recovery of damages against private operators under normal rules of liability for intentionally harmful actions or negligent conduct. The Act also established a five-member advisory board, composed of residents with qualifications and practical experience in agriculture, law, meteorology, and water resources.

The Illinois Act leaves considerable discretion to the administering agency to adopt regulations providing the detail necessary to implement the statutory requirements. After 4 years of experience, the Illinois regulations were recently modified to strengthen the requirements for the plan to be submitted to qualify for a project permit. The new rules specify minimum facilities and equipment of communication, aircraft, radar, and seeding devices. The primary purpose of these recent modifications was to obtain data for evaluating the effectiveness of the project. A copy of the current Illinois regulations is included as appendix C to this report.

In 1977 the Council of State Governments (CSG) expanded the provisions of its proposed legislation published in 1953 and recommended new model weather modification legislation for use by states wishing to enact new or revised statutes. A copy of the model legislation is

included as appendix D to this report. The basic framework of the CSG model code is the same as that of the Illinois Act, but a number of additional refinements have been added. The CSG code provides for the legal right to use runoff resulting from precipitation enhancement, specifies advisory board recommendation functions in greater detail, prohibits operations intended to affect the weather in target areas in other jurisdictions unless they are conducted in full compliance with the laws of those jurisdictions, allows record keeping and reporting requirements to be imposed on exempted operations, and expressly requires emergency shut-down procedures as part of the operating plan.

The CSG model code represents the best formulation to date of a model regulatory code for domestic weather modifications activities. It is consistent with the current state of weather modification science and technology and leaves ample room for evolution through administrative regulations as the science and technology develop further. A review and analysis of experience to date indicates that the model code is adequate. Over time, consideration should be given to improving the model code as follows:

- o Public hearings could be mandatory before certain permits are issued, in order to maximize public understanding and acceptance of the process.
- o Permitting requirements could be applied to all weather modification projects, whether or not they are research projects and whether or not they are conducted by public authorities or universities. The public impacts of such projects are the same as those of private projects and require the same levels of public protection and understanding.
- o Environmental impact assessment requirements could be applicable to permit proceedings, either by operation of other laws or by specific reference in the model code.
- o A reasonable effort could be made to evaluate the consequences and effectiveness of appropriate projects, thereby providing state regulatory agencies with information needed to make decisions and to improve the regulatory process, as well as contributing to the information base required for further improvement of the technology.
- o Further consideration should be given to the questions of whether public entities should be liable for weather modification operations in the same manner and to the same extent as private operations, and whether class actions should be explicitly permitted to recover damages.

The concepts in such a model code could in theory be used at either the state or Federal levels although, as discussed in section 6 of this chapter, Federal regulation of weather modification activities at this time would be premature.

Major Findings - Item 6

Section 4(6) of the Act requires "Recommendations concerning legislation desirable at all levels of government to implement a national weather modification policy and program."*

Introduction

At this stage of the development of weather modification technology, voluntary enactment of legislation by states should be the vehicle for ensuring that projects are carried out professionally. Although the Federal Government will have principal responsibility for regulation of the impacts of weather modification as more effective technologies are developed, because of their interstate implications, comprehensive Federal legislation is not yet necessary. Some Federal legislation is desirable at this time, however -- to state clearly the national interest in weather resources management, identify the role of a national weather modification program, and set forth the respective roles of the state and Federal governments. A series of other Federal administrative actions should also be considered.

State Legislation

The Council of State Governments model weather modification control act, supplemented as discussed in section 5 of this chapter, should be voluntarily adopted and implemented by all states in which weather modification activities are conducted (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 perfunctory. In most states no special educational or technical qualifications are necessary to obtain a license, and only general good character and financial responsibility are examined. Standards for project design and operation are either non-existent or do not adequately reflect the state of the scientific, technical, and regulatory arts.

State enactment and implementation of the CSG model code should assure that weather modification projects are carried out professionally, with due regard for public safety and after adequate public discussion of

*This subject is addressed in chapters 9 and 10 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

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.

Federal Legislation

The Federal Government has enacted little weather modification legislation. In 1958 P.L. 85-510, which amended the National Science Foundation Act of 1950, contained the first Federal legislation on the subject. It was limited to authorization for research, reporting of projects, and annual reports to Congress by the National Science Foundation. The Act was rescinded by the National Science Foundation Reorganization Act of 1968, but the reporting responsibilities were reinstated in 1971 by the Weather Modification Reporting Act (P.L. 92-205) and assigned to the Department of Commerce. This Act requires that all non-Federal attempts to modify the weather must be reported to the Secretary of Commerce, who will maintain records of such activities and publish summaries of the information from time to time. Deliberate violation of the Act, or any rule issued under it, could result in a fine upon conviction. In 1972 the Secretary of Commerce delegated to NOAA the responsibility for administering the reporting program. In 1973 Federal agencies agreed to report their weather modification activities to NOAA, and since then NOAA has published periodic reports summarizing all weather modification activities in the United States.

A number of levels of Federal legislation are possible that this report concludes are not currently necessary:

Comprehensive legislation. Because weather does not respect either state or national boundaries, as more effective technologies are developed the Federal Government will have the principal responsibility for the health, welfare, and safety of the public with respect to the impacts of weather modification. However, despite this potential responsibility there is no need for the Federal Government to adopt a comprehensive legal regime for weather modification at this time. The private industry is small (less than \$6 million in gross annual contracts), and operations are generally localized within state boundaries and do not create major risks. In addition, maximizing local control of weather modification decisions is crucial to the development and acceptance of this potentially controversial technology.

Federal minimum standards. A greater assurance of acceptable levels of public safety in the conduct of weather modification experiments and projects might be achieved by promulgation of a comprehensive Federal regulatory system that would apply in any state that does not have its own regulatory system meeting minimum Federal standards. A comprehensive Federal regulatory regime will be needed in the future as private weather modification activities become more common and their results become more widespread. Such extensive Federal regulation is not desirable at this

time, however, in view of the relatively small levels and limited impacts of non-Federal weather modification activities.

Federal licensing. A system of Federal licensing of operators, as recommended by the Weather Modification Advisory Board, might provide some assurances of public safety in states without adequate standards of their own and could have the additional advantage of facilitating multi-state operations by providing for uniform licensing. In addition, enactment of a Federal licensing system now might avoid a proliferation of state regulatory regimes that might complicate the enactment of comprehensive Federal legislation at a later date. On the other hand, even a licensing system requires a Federal regulatory system -- for setting standards to renew and revoke licenses and to monitor performance -- that approaches a comprehensive system of regulation of operations.

The advantages of Federal licensing are small: non-Federal activities can currently be regulated by states that choose to do so to protect their citizens, and a state's failure to adopt regulations will currently impact only the citizens of that state. On balance, at this time the small advantages of instituting Federal licensing of all weather modification operators are outweighed by the costs of the regulatory scheme necessary to issue and monitor such licenses. However, the Federal Government should continue to periodically re-examine this issue so that comprehensive legislation can be adopted at the appropriate time.

Federal permitting of state operations. State weather modification operations occasionally affect federally owned lands, and Federal legislation could require that such operations be conducted only in accordance with Federal permits. However, Federal agencies have been able to resolve informally any problems that have arisen in the past from such state operations, and such problems are not likely to become more serious in the near future. Federal regulation of such state activities should await the institution of a comprehensive Federal regulatory regime.

State permitting of Federal activities. The Federal Government could be required to obtain state permits to conduct weather modification activities as a method of assuring full local control and acceptance of such activities. As a matter of policy, the Federal Government should not proceed with weather modification activities in any state unless state concerns about the safety of such activities are fully satisfied, except under extraordinary circumstances. No such problems have arisen in the past, and none is anticipated, since the states have generally been eager beneficiaries of Federal activities. However, some type of extraordinary disagreements can be envisioned -- a change in state administration or administrative personnel could lead to reversal of a prior approval, mid-way into a 10-year Federal experiment; the Federal Government may believe snowpack enhancement is necessary to meet its treaty obligations regarding the salinity levels of Colorado River water

flowing into Mexico; and states may disagree about the desirability of seeding a hurricane to reduce its impact, given any uncertainties that may attend the technology. Experience may indicate that full local control of all Federal weather modification activities is desirable, despite these potential problems. Until we have further experience, however, legislation negating the current Federal preemption of weather modification authority would be premature.

Federal liability legislation. The Advisory Board concluded that the Federal Tort Claims Act and the regulations implementing the Act should be amended to ensure that an individual affected by Federal weather modification activities may apply to the Federal Government on behalf of a class of similarly affected claimants for an administrative settlement of their claims, and to ensure that if the claims are denied by the Government that a class action can be brought in the courts on behalf of such claimants. This conclusion was based on the observation that the basic facts governing liability are common to all property owners affected by weather modification activities; only the amount of damages differentiates one claimant from another. In the view of the Department of Justice, settlement adjustment or litigation of personal injury claims is necessarily an individual matter, and the common nature of the causal factor is not enough to warrant class actions. In addition, in its view, ample authority already exists to consolidate mass tort actions for coordinated pretrial proceedings so that common matters can be addressed.

The Advisory Board also noted that legislation might be required to ensure that Federal experimental actions are not regarded as falling within the Federal Tort Claims Act's exemption from liability for "discretionary functions", as private parties who can demonstrate that they have been damaged as a result of Federal weather modification experiments should be appropriately compensated for such damage. The Department of Justice believes that the exemption is jurisdictional in nature and relates to the sovereign immunity retained by the United States Government and could not be waived as a matter of policy absent specific legislation, which would have to be carefully reviewed. This report concludes that in view of this concern, any such legislation should await further experience so that the extent of the problem created by the exemption, if any, can be better assessed.

However, Federal legislation should be enacted now that contains a statement of national weather modification policy indicating the importance of a national program for weather resources management, identifies the goals of a national weather modification program, and sets forth the respective roles of the state and Federal governments.

In addition, a series of Federal administrative actions, which do not require legislation to implement, should be seriously considered:

- o A new framework for the conduct of Federal weather modification activities should be established. This framework should provide for coordination of Federal weather modification research and development, and a public board to provide advice on the planning and conduct of the Federal program. The details of these recommended actions are set forth in chapter V of this report.
- o As a matter of policy, Federal field activities should be preceded by consultation with state and local authorities in the area to be affected and by one or more public hearings in the area. Public acceptance of field activities will be a necessary prerequisite to continued development of weather modification science and technology. This public acceptance can best be assured by procedures that guarantee consideration of the concerns of the public that will be affected by proposed Federal projects.
- o The interagency Weather Modification Subcommittee recommended in this report should develop a set of guidelines for sound weather modification practices to be followed in conducting Federal weather modification projects and in projects to which Federal funds are contributed. These guidelines should cover matters such as project design, environmental assessment, project operation, data collection, reporting, and evaluation. The Advisory Board recommended that legislation be adopted to permit the adoption of such guidelines for general dissemination to interested state regulators and private operators. For the same reasons discussed above with respect to regulation of private operations, such guidelines would be premature at this time.
- o As a matter of policy, all future Federal weather modification activities should be followed by an assessment of the environmental consequences of such activities. Such a requirement would complement the prospective assessment now made pursuant to the National Environmental Protection Act. Post-project analysis will help make the design of future weather modification projects more sensitive to environmental needs.
- o 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 is a cost effective way of providing more definitive information on the effects of weather modification activities with broad applications.
- o Federal programs should also consider technical assistance (on a reimbursable basis) to, and information exchange with, interested states, communities, and private operators. The Federal program

is a repository of knowledge and information about the changing state of the art in weather modification, and such information should be made available through publications and other methods of technology transfer.

- o Federal regulations should be amended to increase the advance notice of proposed projects now required by the reporting rules under P.L. 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 pre-project 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.

Major Findings - Item 7

Section 4(7) of the Act requires "A review of the international importance and implications of weather modification activities by the United States."*

Introduction

United States weather modification activities are of substantial international importance. The 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. In addition, 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 it to be U.S. policy to cooperate with other nations in atmospheric research and development. In this context, the fact that weather modification science and technology are at an early stage provides a unique opportunity to both achieve the benefits and minimize the tensions of the technology as it develops. As the Weather Modification Advisory Board concluded, "Much will be gained and little lost by forging now the links among scientists and nations that will better prepare us for the stresses and strains (of a successful technology) which, in the absence of well-rehearsed cooperation, could easily get out of hand."

International Importance

Effective weather modification programs could help alleviate shortages of food, water, and energy in other countries and help to moderate severe storm damages. Seventy-four countries have used weather modification techniques at some time, and 17 nations reported projects to the World Meteorological Organization (WMO) in 1978. The greatest interest is in precipitation enhancement for increasing yields in dry land farming. Targeting added rainfall into drainage basins and

*This subject is addressed in chapters 6 and 10 of Volume I of the Weather Modification Advisory Board Report (Appendix F).

reservoirs for water storage, and subsequent irrigation and hydro-electric power generation, has also been an aim of a number of foreign programs. In addition, cloud seeding to reduce hail damage to valuable crops has been practiced in over 20 countries.

Much of the weather modification research and technology development in the United States is applicable to other parts of the world. The results of U.S. research are made available to all interested scientists, and some U.S. agencies are now participating in international weather modification experiments and providing direct advice and technical assistance to foreign countries. In addition, private U.S. operators are conducting activities abroad for foreign governments and private interests.

The transfer of appropriate information and technology to other countries is important for humanitarian and economic reasons. It is also an aspect of international competition in scientific and technological matters. As the Weather Modification Advisory Board stated, "The emerging techniques of weather modification offer promise for helping cope with global and regional shortages of foods, water, energy, and other resources for a still growing world population. There are, moreover, attractive possibilities for technology transfer to developing countries by involving their scientists in the national experiments of industrialized countries and transferring this experience to those areas where the human needs for nearby food, usable water, and affordable energy are the greatest."

International cooperation and a free flow of information about weather modification are important for other reasons as well. The United States is not the world leader in all aspects of weather modification research. Israel, Russia, Australia, and Switzerland, among others, have active experimental projects from which we can learn. Furthermore, the United States will not be able to conduct some aspects of weather modification research without cooperation from other nations. For example, U.S. hurricane experiments are currently limited to the North Atlantic Ocean, since that is the only location in which such storms are unlikely to affect other countries. However, a more rapid rate of experimental progress would be achieved by experimentation in the Western Pacific, which has the highest frequency of tropical cyclones. The United States has no plans to conduct such experiments at the present time because of past reservations about such activities on the part of the Japanese and Chinese governments.

Domestic Research Activities

U.S. weather modification research results are published and are regularly followed by scientists in other countries. As indicated in section 2 of this chapter, the first requirement of any weather modification research program for any country is to learn more about the

atmosphere itself. Thus all U.S. research into basic atmospheric science problems has implications for weather modification efforts abroad, particularly in the U.S.S.R., which rivals the United States as the most advanced country in the field of weather modification science.

Field experimental programs in the United States are directed at regional problems that are also relevant to foreign countries, although the resulting technology cannot be transferred to even similar geographical areas without extensive studies of local meteorological conditions and in many cases further testing. The Bureau of Reclamation (BuRec) of the Department of the Interior is planning snowpack augmentation experiments in the Sierra Nevada Mountains of California and the Rocky Mountains of Colorado, the results of which will be important to a number of mid-latitude countries (such as Iran) where mountain snows are a valuable resource. BuRec is also conducting preliminary studies for summertime seeding experiments in areas in Montana, Kansas, and Texas with somewhat different cloud structures and behavior that are basically similar to those of other continental regions around the world (such as the Soviet Union).

NOAA has pursued an experimental program since 1967 to study the potential for augmenting rainfall from subtropical cumulus clouds, the results of which will have important implications for developing countries in the tropics, where clouds of this type account for most of the rainfall. In addition, NOAA's Project STORMFURY is aimed at reducing the peak winds of hurricanes. As discussed in section 3 of this chapter, the U.S. is not unique in its exposure to these destructive storms. Single tropical cyclones have caused over 200,000 deaths in Asia, and a working technology to reduce peak winds by 15 to 20 percent has been estimated to result in worldwide savings of over \$1 billion per year.

Weather modification technology developed in the United States has also been important for other countries. For example, as discussed in section 9 of this chapter, the U.S. Navy developed the pyrotechnic seeding devices now used by many cloud seeders.

U.S. Activities Abroad

U.S. scientists have provided specialized advice and consultations on weather modification to many foreign countries through the WMO. Several Federal agencies have also provided advice for foreign governments regarding the potential for weather modification or the conduct of specific projects; for example, NOAA provided such advice to Niger in 1973 and Jordan in 1976. In addition, the Department of Defense has occasionally received requests from foreign governments to provide aircraft or personnel to seed clouds during drought emergencies. Such service was rendered by the U.S. Navy in India in 1967 and jointly with the Air Force in the Philippines in 1969 and in the Azores in 1972.

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

In 1968 Concurrent Resolution 67 of the 90th Congress declared that U.S. policy was to cooperate with other nations in atmospheric research and development. This policy is now being implemented in the weather modification field. The United States initiated negotiations with Mexico in 1978 toward the possibility of a joint experimental program on hurricanes in the Eastern Pacific. Technical discussions are underway with Australia which may lead to a similar joint research effort in that region. The United States has supported the establishment of an international program for weather modification research in the WMO. And we are now helping to organize and run the WMO's Precipitation Enhancement Program (PEP), which is pursuing the feasibility of a 5-year field experiment in Spain for seeding convective cloud systems in an area of several thousand square miles and so far involves participation by five other countries.

Potential International Tensions

U.S. weather modification activities have important implications for international peace as well as international prosperity. Unless countries use weather modification techniques with prudence and close consultation with the rest of the international community, such techniques could become sources of international tensions and the entire field could become highly politicized.

The United States attempted to use weather modification technology to inhibit passage of North Vietnamese troops along dirt roads. As a result of this experience, the Department of Defense concluded that "weather modification has little utility as a weapon of war." An International Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, which began as a joint U.S.- Soviet initiative in 1974, has been approved by the United Nations General Assembly and was opened for signature in 1977. It came into effect on October 5, 1978, when it was certified by the required total of 20 nations. Although it has been signed by both the United States and the Soviet Union, it has not yet been ratified by the Senate. The basic restriction against "hostile use of environmental modification techniques having wide-spread, long-lasting or severe effects as a means of destruction, damage or injury" is of limited scope, but it is a sound first step in removing all future threats from hostile use of weather modification technology.

International concerns can also arise from research, experimentation, and operations in weather modification for non-hostile purposes. For example, in 1971 the United States proposed transferring its project STORMFURY experiments from the Atlantic Ocean to the Western Pacific, and informal consultations were held with representatives of the scientific communities and Government agencies of potentially affected countries. These plans were canceled when strong reservations about the experiments became evident on the part of the Japanese and Chinese Governments.

Even activities conducted within the jurisdiction of the United States could be perceived to have an influence on its neighbors. For example, seeding projects have been carried out in the Virgin Islands and Puerto Rico as well as near the Canadian border. Concern in Canada regarding proposed commercial seeding in northern Washington prompted negotiations in 1975 of a U.S.-Canada agreement on weather modification information exchange. This agreement is discussed further in section 11 of this chapter.

Smaller nations with more neighbors than the United States will require even closer cooperation. An informal meeting of experts held by the WMO/United Nations Environment Program (UNEP) in April 1978 to establish legal principles for weather modification agreed that it was desirable for States to consult in advance with other States that might be affected by proposed weather modification activities but left to the potentially affected State the initiation of such consultation. The WMO has set up a voluntary system for reporting weather modification activities with which the United States complies, but these reports are circulated well after the activities have commenced and often after they are concluded. Other principles recommended by the WMO-UNEP meeting of experts included mandatory notice of major weather modification activities to WMO, assessment of the environmental impact of weather modification activities before they are implemented, and monitoring by each country of weather modification activities under its jurisdiction or control.

Major Findings - Item 8

Section 4(8) of the Act requires "A review and analysis of present and past funding for weather modification from all sources to determine the sources and adequacy of funding in the light of the needs of the Nation."*

Although Federal involvement in and support of weather modification research goes back to the beginning of scientific weather modification in 1946, no readily available accounting of Federal funding for those purposes existed until fiscal year (FY) 1959. At that time Congress directed the National Science Foundation "to initiate and support a program of study, research, and evaluation in the field of weather modification" and "to report annually to the President and the Congress thereon." Beginning with about \$3 million in FY 1959, Federal funding for research in deliberate and inadvertent weather modification rose to a peak level of \$18.6 million in FY 1972 and involved as many as seven Federal agencies. These funds supported research and experimentation in precipitation enhancement, fog and cloud modification, hail and lightning suppression, hurricane modification, and unintentional weather modification.

The following table sets forth the annual levels of Federal funding for deliberate weather modification and directly related cloud physics research since FY 1972 and identifies the principal participating agencies. It also presents total funding figures identified by the Interdepartmental Committee for Atmospheric Sciences (ICAS) agencies as supporting research on the inadvertent modification of both weather and climate.

The funding identified in the table as supporting deliberate weather modification research includes only those efforts that are aimed at problems constraining the development of weather modification science and technology. It therefore excludes some meteorological research efforts that could have possible application to aspects of weather modification. Such efforts include research in physical and dynamic meteorology, observations, instrumentation, and short-range weather prediction.

*This subject is addressed in chapter 11 of Volume I of the Weather Modification Advisory Board's Report (Appendix F).

The differences between unintended weather modification and unintended climate modification are subtle and hard to define. The Weather Modification Advisory Board used unintended weather modification to refer to "shorter term effects found to occur only during certain atmospheric conditions, and occurring over smaller geographic scales." Urban-induced changes in weather such as those studied by METROMEX are examples. Climate modification "implies a persistent bias imposed on the transient atmospheric events that comprise weather" and is usually thought of in terms of "hemispheric or global processes." The postulated change in the global radiation as a result of increased CO₂ in the atmosphere is an example of climate modification.

The funding for inadvertent weather modification and inadvertent climate modification are identified separately in the table for fiscal years 1972, 1979, and 1980 for purposes of comparison. Support for the intermediate years could not be differentiated between the two categories, so only the totals are given. For the purposes of this report only inadvertent weather modification is included as part of a national weather modification research program. Inadvertent climate modification is considered to be a concern of the National Climate Program as suggested by the Advisory Board.

Expenditures for two major weather modification-related equipment development and procurement programs are also not included in the table. The Air Force spent approximately \$4 million between FY 1975 and FY 1978 to build and test a prototype thermal system for dispersing warm fog; this project was terminated in FY 1978. NOAA spent \$28 million between FY 1974 and FY 1977 to improve its research aircraft capability by purchasing and instrumenting two new P-3D aircraft and updating the instrumentation on existing aircraft, primarily for use in Project STORMFURY.

In addition to these research and development expenditures, the Federal Government has funded some operational weather modification projects that are not included in the table. For several years the U.S. Air Force has conducted operations to clear supercooled fog over some of its airbases in this country and overseas; the cost of these ongoing operations averages approximately \$60,000 per year. As discussed in section 7 of this chapter, the Department of Defense conducted an operational precipitation enhancement project in Southeast Asia from March 1967 to July 1972, at an average annual cost of approximately \$3.6 million.

The Federal Research Program for Weather Modification --
Allocation of Funding (Millions of Dollars)^a

Department	FY 72	FY 73	FY ^b 74	FY 75	FY 76	FY 77	FY 78	FY 79	FY 80
Commerce	3.9	3.8	3.0	2.5	4.3	2.7	3.6	3.1	4.3
Defense	1.8	1.2	0.9	1.1	1.4	1.0	0.9	0	0
Interior	6.7	6.4	3.9	4.0	4.6	6.4	7.6	8.6	10.3
NSF	4.9	4.2	4.2	4.7	5.1	4.9	2.4	1.1 ^c	1.2 ^c
Other	0.8	0.8	0.3	0.1	0.1	0.1	0	0	0
Total	<u>18.1</u>	<u>16.4</u>	<u>12.3</u>	<u>12.4</u>	<u>15.5</u>	<u>15.1</u>	<u>14.5</u>	<u>12.8</u>	<u>15.8</u>
Deliberate									
Inadvertent									
Weather	0.5	-	-	-	-	-	-	1.1	1.4
Climate	1.3	-	-	-	-	-	-	2.0	3.2
Total	<u>1.8</u>	<u>3.3</u>	<u>3.8</u>	<u>5.2</u>	<u>4.8</u>	<u>3.7</u>	<u>4.2</u>	<u>3.1</u>	<u>4.6</u>
TOTAL	<u>19.9</u>	<u>19.7</u>	<u>16.1</u>	<u>17.6</u>	<u>20.3</u>	<u>18.8</u>	<u>18.7</u>	<u>15.9</u>	<u>20.4</u>

a FY 1972-79 figures are from the Interdepartmental Committee for Atmospheric Sciences (ICAS). FY 1980 figures are estimates from agency representatives.

b Distribution of funds expended are estimated for DOC and NSF; total is from ICAS.

c NSF has no specific budget request for weather modification. This is an estimate as to how much will be devoted to research directly related to weather modification.

While the research community works to place cloud seeding on a secure scientific foundation, private individuals and state and local governments continue to invest in operational cloud seeding. 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; of this total about \$2.5 million was appropriated by state governments.

The Federal weather modification research effort has not sustained the position it held in the early 1970's in the participating agencies' list of priorities. When the effects of inflation are considered, the total Federal FY 1979 research effort, and that projected for FY 80, are

well below half that of FY 1972 in terms of buying power. Seven agencies supported weather modification research in the early 1970's, but only three can now be considered active participants -- NOAA, BuRec, and NSF. The present weather modification research activities reflected in the table can hardly be considered a national program, as the activities lack an overall design or strategy.

During the 1970's the Federal weather modification research effort has been subject to criticism by various review groups, such as the National Advisory Committee on Oceans and Atmosphere, the National Academy of Sciences, and the General Accounting Office. The most consistent criticisms included the lack of a national policy, fragmented programs, and subcritical funding levels. The Weather Modification Advisory Board observed that "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."

Major Findings - Item 9

Section 4(9) of the Act requires "A review and analysis of the purpose, policy, methods, and funding of the Federal departments and agencies involved in weather modification and of the existing interagency coordination of weather modification research efforts."*

Introduction

To date, the Federal Government has preferred that weather modification research be undertaken by agencies and departments as their respective missions dictate and that such efforts be accompanied by interagency coordination. The most recent formulation of these policies was in a letter of June 5, 1975, from the Assistant Director of the Domestic Council to Representative Gilbert T. Gude. He indicated that weather modification may have the potential to assist in solving many different national problems, but that understanding of weather modification and its complexities is in its infancy. He also stated that the types of scientific research conducted by Federal agencies differ in approach, techniques, and types of equipment employed, depending on the particular weather phenomena being addressed, and that an agency charged with the responsibility for dealing with a national problem should be given the latitude to seek the best approach or solution to the problem. In his view, to the extent there were common problems and solutions among the programs, they should be and were being coordinated.

The majority of weather modification research in the Federal Government during recent years has been funded through four Departments or agencies -- the Departments of Commerce, Defense, and Interior, and the National Science Foundation. Other participants such as the Department of Agriculture's Forest Service, the Department of Energy, the Department of Transportation, and the National Aeronautics and Space Administration have conducted occasional small weather modification programs in support of specific mission efforts. For example, the suppression of lightning which may result in forest fires was investigated by the Department of Agriculture for many years.

*This subject is addressed in chapters 11 and 12 of Volume I of the Weather Modification Advisory Board's Report (Appendix F).

Department of Commerce

NOAA has broad responsibility to provide atmospheric and oceanic services and to undertake related research and development. As the Weather Modification 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."

NOAA is the repository of a substantial portion of the Federal Government's research and development talent in the oceanic and atmospheric areas. NOAA's Environmental Research Laboratories conduct a wide range of laboratory experiments and studies, field experiments, and computer modeling research in atmospheric sciences. These include the following activities:

- o 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 often associated with moderate or heavy precipitation.
- o 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 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.
- o NOAA's Atmospheric Physics and Chemistry Laboratory in Boulder, Colorado, is devoting special attention to the numerical modeling of mesoscale meteorological phenomena 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.

- o 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.
- o 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.
- o 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.
- o 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.

NOAA is also responsible for the Federal Government's civilian atmospheric services, including 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.

NOAA and its predecessor agencies (the Environmental Science Service Administration and the Weather Bureau) have conducted weather modification research since 1948. Since 1972 NOAA has collected and periodically reported on all weather modification activities in the United States pursuant to P.L. 92-205. NOAA, in concert with the Department of State, also provides Federal Government leadership in connection with those multinational organizations involved in areas most closely aligned with weather modification. The Associate Administrator of NOAA keeps the WMO informed regarding weather modification activities underway in the United States. NOAA is the initiator or major proponent of most of the international climate and weather modification programs

now being pursued by the United States, such as the Global Atmospheric Research Program and the Precipitation Enhancement Project. And, through the Department of State, NOAA has commenced formal negotiations with the Government of Mexico and informal discussions with representatives of the Government of Australia to conduct bilateral hurricane seeding programs.

The Weather Modification Advisory Board concluded that NOAA's past performance in weather modification was seriously deficient in certain respects. The Board was "not satisfied that the scientific commitment to weather modification (at NOAA) has been adequate to the job at hand," and noted that skepticism about weather modification efforts persists in some parts of NOAA. In addition, the Board noted that NOAA has been exclusively concerned with the scientific aspects of weather modification and has been oriented toward in-house activity in the atmospheric sciences -- thereby failing to use adequately the academic community and the private sector and to develop effective relationships with state and local weather modification constituencies. As a result of these factors and the Weather Bureau's early opposition to weather modification, the Board noted that "an attitude of hostility and suspicion on the part of the weather modification community...does not seem to have been fully overcome."

The majority of NOAA's weather modification research is conducted by its own staff. Some support activities are contracted out, and a small percentage of its limited weather modification funds support 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 the Weather Modification Advisory Board. NOAA is determined to remedy this situation.

During recent years, NOAA's weather modification efforts have concentrated on enhancing precipitation from tropical convective clouds through the Florida Area Cumulus Experiment (FACE), and on ameliorating hurricanes through Project STORMFURY. Exploratory planning and background observations have also been undertaken for the Precipitation Augmentation for Crops Experiment (PACE) -- a proposed major summertime experiment in the Midwest. In addition, NOAA has supported fundamental studies of ice nucleation and other aspects of cloud physics, lightning suppression studies, and U.S. efforts of the international Precipitation Enhancement Project (PEP) discussed in section 7 of this chapter.

Department of Interior

The Department of Interior's Bureau of Reclamation (BuRec) has broad Federal responsibility for managing water resources in 17 western states. It administers a water resources program covering municipal, industrial, and irrigation water supply; hydro-electric power generation; water quality monitoring and improvement; flood control; recreation, fish

and wildlife improvement; and support of the natural environment. In 1976, BuRec operated 320 storage reservoirs, 344 diversion dams, 14,400 miles of canals, and 900 miles of water pipelines. It managed 50 power plants and 145 pumping stations. BuRec delivered 27.9 million acre-feet of water during 1976 and served 18.1 million people -- 31 percent of the population of the 17 western states. This water irrigated 146,000 farms and generated 60.9 million kilowatt hours of electric energy, the latter bringing \$283 million in revenue to the U.S. Treasury. Flood control benefits of \$52.8 million have been estimated for the year.

BuRec's weather modification activities are motivated by the need for additional water in these western states. Increased population in many regions of the west has resulted in increased demand for water for municipal and commercial purposes. Increasing energy requirements are also placing greater demands on available water resources -- not only for cooling nuclear and thermal generating plants but also for coal slurry pipelines and oil shale development.

The BuRec program was initiated in 1962 by a Congressional appropriation for "research on increasing rainfall by cloud seeding." Overall, BuRec has maintained only a small technical staff and has contracted out most of its applied research efforts to universities and industry. BuRec has involved the public in all aspects of decision-making regarding its various cloud seeding programs under Project Skywater, the Bureau's weather modification program. This has been accomplished by conducting surveys of the population in the project areas, holding meetings of citizen advisory councils, sponsoring technical conferences, making environmental and ecological impact assessments, and cooperating with local and state authorities in joint projects. The Weather Modification Advisory Board recognized the value of this strong interaction with users. However, they also indicated that this "desire to maintain 'grass roots' support has resulted in emphasis on 'promises of result' while tending to underplay the scientific uncertainties and risks of disbenefits." According to the Board, "BuRec has not evidenced the interest in research that we believe is so central to the new National Program, although its concern with development and application is an asset that must be retained."

In recent years, BuRec has organized several large, randomized, winter orographic cloud seeding projects in the Rocky Mountains (the Colorado River Pilot Project) and the Sierra Nevada Mountains (the Sierra Cooperative Pilot Project), as well as a summertime cumulus convective program in the High Plains (HIPLEX -- High Plains Experiment). It has also supported related legal, social, and economic studies.

National Science Foundation

NSF is responsible for supporting and developing the underlying bases of all aspects of science in the United States, primarily at our

universities. In addition, in 1958, early in the development of weather modification, Congress instructed NSF (in P.L. 85-510) to make special efforts in weather modification research. NSF complied by establishing a special Weather Modification Program Office, which it maintained until 1977 although the special NSF mandate was dropped by Congress during the NSF reorganization of 1968. During that 20-year period NSF sponsored several field experiments, including the highly important Whitetop and Climax experiments.

In 1978, NSF merged its weather modification program into the Atmospheric Research Section of its Directorate for Astronomical, Atmospheric, Earth and Ocean Sciences. NSF currently supports unsolicited basic research proposals in the field through a Program for Experimental Meteorology and Weather Modification. Some of the projects contribute directly to weather modification research. For example, the NSF supervises a grant which provides for most of the U.S. participation in the WMO Precipitation Enhancement Project, now in its early stages in Spain. Other projects contribute indirectly to an understanding of clouds and cloud systems that is fundamental to long-term progress in weather modification.

During recent years, most of the NSF-supported work in weather modification consisted of the National Hail Research Experiment (NHRE), undertaken by the National Center for Atmospheric Research (NCAR) and cooperative university groups, and the Metropolitan Meteorological Experiment (METROMEX), an investigation of inadvertent weather modification conducted by a group of university and other laboratories. With the termination of both NHRE and METROMEX and the elimination of a specific weather modification program within NSF, the work now supported by NSF consists of a long-term study of convective storms at NCAR, a limited university grants programs in areas related to weather modification, and the previously mentioned WMO Precipitation Enhancement Project.

Department of Defense

DOD has been active in weather modification research and development since 1946. During World War II and for the following decade, DOD provided the impetus and much of the financial support for all phases of atmospheric research in the United States, including weather modification. Project Cirrus -- the original cloud seeding research efforts of Langmuir, Schaefer, and Vonnegut, who are generally credited as the founders of modern weather modification -- was supported by DOD.

DOD maintained a very active weather modification research program until a few years ago. It participated jointly with NOAA in hurricane moderation research and carried out operational raimaking efforts at the request of several foreign governments. The Navy has been the world's leader in the development of pyrotechnic seeding devices, now routinely used by all cloud seeders. The Air Force perfected the practice of

seeding cold fogs in winter to permit additional aircraft operations, a procedure now practiced at some civilian airports in the northwestern United States. The Air Force has also supported much of the weather modification research directed toward the modification of warm fog.

Following the Vietnam War, DOD gradually reduced its weather modification research effort. Because weather modification can enhance the effectiveness of aircraft and helicopter forces, DOD's most recent efforts were directed solely at fog and cloud dissipation. Although DOD no longer has a weather modification research program, it does plan to continue supporting a vigorous program of basic research in cloud physics and atmospheric dynamics.

Interagency Coordination

To date Federal weather modification efforts have not been coordinated as parts of a comprehensive national weather modification plan.

The Interdepartmental Committee for Atmospheric Sciences (ICAS) was formed in 1959 under authority of the President's Scientific Advisor to coordinate all aspects of the Federal Atmospheric Sciences program. Dr. Alan T. Waterman, Director of the National Science Foundation, served as its first chairman. An ICAS subcommittee on weather modification was formed in 1960, consisting of representatives of those Federal agencies having or contemplating active programs in weather modification. The subcommittee met periodically each year and acted primarily as an information exchange. It sponsored a yearly retreat of scientists and managers from all Federal agencies conducting weather modification activities to discuss their research and plans. ICAS was recently abolished and its functions were transferred to the Committee on Atmosphere and Oceans (CAO) of the Federal Coordinating Council for Sciences, Engineering and Technology. CAO consists of representatives from all scientific and engineering agencies of the Federal Government that have interests in the atmosphere or oceans. However, it has not been active in the weather modification area.

United States international weather modification activities are reviewed and coordinated and decisions made through the National Security Council's ad hoc Working Group on Weather Modification, chaired by the Assistant Secretary of State for Oceans, International Environmental and Scientific Affairs. The Group examines U.S. international weather modification initiatives and positions from the standpoint of the Department of State's broader foreign policy framework while taking into account the views of the various Federal agencies involved.

Information exchange by scientists and administrators involved with weather modification activities has also taken place through publications, professional societies, presentation of papers at meetings, and informal discussion of plans.

Major Findings - Item 10

Section 4(10) of the Act requires "A review and analysis of the necessity and feasibility of negotiating an international agreement concerning the peaceful uses of weather modification."*

As the Weather Modification Advisory Board concluded, "The weather is inherently transnational." Even local weather modification projects may affect a neighboring country if the site is close to a border. Moreover, future efforts to influence the weather will doubtlessly involve projects intended to affect large areas, increasing the possibility of extended effects over other countries. For these and the other reasons discussed in section 7 of this chapter, the interests of the United States and all other countries favor international collaboration in the development of weather modification science and technology. We have a unique opportunity to build the framework for such collaboration as the science and technology develop.

Fortunately there is a long history of successful international cooperation in meteorology. The WMO and its predecessor, the International Meteorological Organization, have been actively supported as a forum for discussion of atmospheric issues for more than a century. The World Weather Watch began in 1961 and today is the central information system on which most forecasting in the United States and other countries is based. The Global Atmospheric Research Program (GARP), the research part of the World Weather Program, mounts special observational experiments designed to improve our understanding of the global atmosphere; these experiments involve scientists and technicians from many nations. The GARP Atlantic Tropical Experiment (GATE), for example, conducted a very large atmospheric research project in 1974 that included the United States and 60 other countries. The Global Weather Experiment, which began in late 1978, includes contributions by 147 countries. The global arrangements have worked to date because of the recognition by many countries of the need to cooperate in forecasting their weather and improving their understanding of weather and climate systems.

As indicated in section 7 of this chapter, discussions are taking place within the WMO and the United Nations Environment Program to

* This subject is addressed in Chapters 6, 10, and 11 of Volume I of the Weather Modification Advisory Board's Report (Appendix F).

develop a set of international principles to guide the conduct of countries performing weather modification activities. These principles deal with dedication to peaceful purposes, encouraging and facilitating information exchange, advance notification of activities, environmental impact assessment, and consultation with interested states. These discussions are not expected to lead to a specific international agreement but may result in generally recognized standards of behavior that can form the basis for more formalized commitments among nations concerned with this subject. In addition, international agreement has been reached on limiting some hostile uses of weather modification techniques through a Convention on Prohibition of Military or Any Other Hostile Uses of Environmental Modification Techniques. The United States is not yet a party to the convention, pending advice and consent of the Senate.

The first steps toward establishing international mechanisms to deal with weather modification problems should be taken in the area of research. The emphasis in future weather modification activities in this country and elsewhere is likely to move toward larger scale research enterprises that will require international cooperation. Furthermore, obtaining international cooperation in weather modification research is feasible. It builds on established patterns of activity. It can provide important benefits to all countries by encouraging the sharing of expenses and the transfer of information, technology, and expertise. And it can be perceived by all as an effective means of achieving common understanding on what can and cannot be done to modify the weather, thereby forming the groundwork for more comprehensive agreements that will stimulate development of the science, and creating an ambience in which more comprehensive multilateral agreements can be developed.

A comprehensive international framework for the peaceful uses of operational weather modification will eventually be necessary in order to maximize the benefits and minimize the tensions created by application of the technology. Reference to peaceful uses of weather modification is made in the previously mentioned Convention on prohibition of hostile uses of environmental modification. Article III of the Convention states that parties to the Convention should "undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technical information on the use of environmental modification techniques for peaceful purposes." However, a strong need for a comprehensive agreement on peaceful uses of the technology is not yet widely perceived because the scientific basis for widespread operations has not yet been established.

So far, international problems arising from experimentation and limited operations have been adequately dealt with through the established mechanisms and the WMO. No serious incidents between nations have occurred as a result of peaceful weather modification activities,

and in the near future any potential problems can probably be handled conveniently through bilateral agreements.

Thus, while our objective should be the the ultimate establishment of a comprehensive international framework, we will be required to move toward its accomplishment slowly in order to develop more shared international experience with weather modification activities and to build a consensus that such an approach is desirable. For now, U.S. efforts can best be devoted to developing an international accord with respect to the problems raised by weather modification research. This should involve acceleration of the current dialogue in the WMO, UNEP, and elsewhere, and advancing bilateral or regional research agreements open to all interested parties wherever possible, either under a WMO framework or otherwise.

Options for international cooperation concerning research and the regulation of weather modification include informal arrangements resulting from common declarations of weather modification activities undertaken by a number of countries, mandatory notification and non-proliferation agreements, multilateral research and development agreements, and a comprehensive multilateral treaty governing all aspects of weather modification. All are desirable, and all but the last may be constructively feasible.

Legislative Declaration of Policy

The United States Congress may adopt a legislative declaration of weather modification policy containing the following elements and could encourage other countries to adopt the same or similar policies:

- a. The atmosphere is a global resource, the use and protection of which is the legitimate concern of the entire international community.
- b. All U.S. research and operations in weather modification will continue to be conducted openly and with the objective of promoting peaceful uses of weather modification science and technology.
- c. Because of the desirability of carrying out theoretical and field research programs with wide participation in developing as well as developed countries, the United States will cooperate with other nations in weather modification research and development to the

This subject is addressed in chapters 6, 10, and 11 of Volume 1 of the Weather Modification Advisory Board's Report (Appendix 1).

Major Findings - Item 11

Section 4(11) of the Act requires the "Formulation of one or more options for a model international agreement concerning the peaceful uses of weather modification and the regulation of national weather modification activities; and a review and analysis of the necessity and feasibility of negotiating such an agreement."*

Introduction

Options for international cooperation concerning peaceful uses and regulation of weather modification include informal arrangements resulting from common declarations of weather modification policy adopted unilaterally by a number of countries, mandatory notification and consultation agreements, multilateral research and development agreements, and a comprehensive multilateral treaty governing all aspects of weather modification. All are desirable, and all but the last may be currently feasible.

Unilateral Declarations of Policy

The United States Congress could adopt a unilateral declaration of weather modification policy containing the following elements and could encourage other countries to adopt the same or similar policies:

- o The atmosphere is a global resource, the use and protection of which is the legitimate concern of the entire international community.
- o All U.S. research and operations in weather modification will continue to be conducted openly and with the objective of promoting peaceful uses of weather modification science and technology.
- o Because of the desirability of carrying out theoretical and field research programs with wide applicability in developing as well as developed countries, the United States will cooperate with other nations on scientific research and development to the

*This subject is addressed in chapters 6, 10, and 11 of Volume I of the Weather Modification Advisory Board's Report (Appendix F).

maximum extent practicable, through bilateral and multilateral agreements and through participation in internationally sponsored experiments and research institutions.

- o The United States will ensure that thorough environmental impact assessments are made of all Federal weather modification activities, including examinations of the possible impacts of such activities outside its borders.
- o The United States will notify in advance any country which it believes will be subject to a significant possibility of impact from a proposed U.S. Government weather modification activity and will consult with such country in advance of such activity if requested to do so. If there is objection to our proposed activity, the program will be reconsidered.

Adoption of such policy by the Congress would be feasible because it essentially restates current United States policy. The feasibility of adoption by other countries is less certain, but most would probably be willing to do so with our encouragement.

Adoption of such a policy by the United States would be a useful way of encouraging other countries to adopt similar policies. Adoption of such policies by a number of the major countries that conduct weather modification operations would establish internationally accepted practices of conduct that would ease the later institution of agreements and mechanisms concerning peaceful uses and regulation of weather modification.

Mandatory Notification and Consultation Agreements

One option, which would formalize the unilateral declarations of policy referred to above, is the negotiation of agreements concerning weather modification activities. A first step along these lines has already been taken between the United States and Canada. An agreement relating to the exchange of information on weather modification activities, reproduced in appendix E to this report, was signed by the two countries in March 1975. It provides for advance notification and consultation with respect to activities conducted within 200 miles of the international boundary or whenever either party believes the effects of weather modification activities are significant to the other party. Consultations under the agreement have not yet been necessary.

Acceptance of the principle of mandatory consultation is a necessary step toward ensuring that the tensions inherent in weather modification science are mitigated. The United States - Canada agreement demonstrates that the negotiation of such general bilateral agreements is feasible. U.S. negotiation of similar agreements with Mexico and other neighboring countries would be desirable, despite the fact that activities near our

borders have not been an issue to date. The feasibility of bilateral agreements between other countries and their neighbors depends on the state of their respective relationships.

Multilateral Research and Development Agreement

A still more comprehensive approach would be negotiation of an international convention on weather modification research activities. Such an agreement could include provisions such as the following:

- o A statement concerning what weather modification may be capable of achieving and what it is likely not to be capable of achieving.
- o Recognition of the inherent constraints and conditions on research resulting from the widespread effects of some weather modification projects, and procedures for dealing with such constraints and conditions.
- o Procedures for avoiding the impediments to research that can occur when experiments must be carried out over international waters.
- o Recognition that research programs must be carried out in such a way that a sufficient basis of scientific measurement and analysis exists to make possible the transferability of the results.
- o Creation of mechanisms to implement a cooperative internationally funded program for long-term weather modification research, perhaps including a fully integrated research institution.

As indicated in section 10 of this chapter, negotiation of such an agreement may be feasible in the near future and would be an important step toward establishment of a comprehensive international regime for weather modification. Meanwhile, some of these provisions may be subsumed by WMO decisions; others might be handled through a WMO Congress Resolution.

Comprehensive International Agreement

A comprehensive agreement would include mandatory notification and consultation provisions, mechanisms for international conduct or approval of large-scale research projects, and procedures to deal with problems of liability or compensation for transborder damages. If weather modification grows and succeeds as a technology, negotiation of a comprehensive international agreement will be necessary. However, as discussed in section 10 of this chapter, such negotiation is not yet feasible.

As a step in that direction it may be feasible to encourage efforts to adopt national legislation concerning weather modification experiments and operations. Guidelines for such legislation have been discussed within the United Nations Environment Program. The guidelines would contain provisions aimed at preventing damage to persons, property, and the environment. Suggested administrative provisions would include licensing of operators, authorization of specific projects, registration and monitoring of projects, and civil liability for damages. If promulgated, such guidelines should be a useful way of acquainting governments with the needs for regulation of weather modification activities and the ways of implementing such regulation.

II

Other Findings Which are Pertinent to the Determination and Implementation of a National Policy on Weather Modification

The Weather Modification Advisory Board discussed in detail one issue -- unintended weather modification -- not included within the definition of "weather modification" in the National Weather Modification Policy Act. Cities, power plants, and many agricultural activities modify the weather on local and regional scales, often dramatically. The Board concluded that "these unintentional effects are so important and pervasive that an analysis of their scale and nature, and their policy implications, is essential to judgments about a national policy and program for the management of weather."

Most unintentional modification of weather has resulted from land alteration and power generation. For example, agricultural fields have replaced forests, concrete and asphalt have covered natural fields, and artificial lakes have filled once arid valleys. Changes in surface color, texture, and topography cause changes in evaporation and solar radiation absorption, which in turn result in substantial differences in surface temperature and other low-level weather conditions. Changed roughness of the land surface, such as the erection of a major city in flat country or removal of a large forest, also affects the airflow mechanically -- altering wind speed and direction. Changes in the atmosphere's moisture content, usually increases in humidity from industrial processes, irrigation, or large artificial lakes, produce more clouds under some conditions. This in turn can affect temperatures and precipitation.

Changes are also caused by the release into the atmosphere of particulates and certain gases, such as SO_2 , that become particulates. These particulates form haze layers that affect the weather and may also affect the condensation-precipitation process in clouds. In addition, the total energy released by use of fossil fuels has resulted in a significant additional amount of energy that must be disposed of through radiation to space. Such a change in outgoing radiation produces heat changes and affects cloud growth.

The Metropolitan Meteorological Experiment (METROMEX), a major field investigation designed to study the linkage between urban land use and the overlying distribution of wind, heat, moisture, and aerosols and the formation and development of clouds and precipitation, has provided the most conclusive information on inadvertent weather modification to date. METROMEX, performed at St. Louis in the early 1970's under the sponsorship of the National Science Foundation, the Atomic Energy Commission, the State of Illinois, and the Environmental Protection

Agency, definitely 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. These effects were observed in a localized area within 25 miles of the city center.

Impacts of these inadvertent weather changes on society and the environment are difficult to assess with any degree of certainty. The METROMEX studies suggest that the urban-induced increases in rainfall and severe storm activity impact adversely on the urban-suburban lowlands and have mixed beneficial and adverse impacts on the rural uplands to the east of the city. Other than the more obvious impacts due to urban-induced weather changes, little is yet known specifically about the environmental effects resulting from unintended weather modification. Atmospheric scientists generally agree that the magnitude and extent of unintended weather modification are growing in the United States.

The Weather Modification Advisory Board identified seven general research needs that should be addressed by a comprehensive program to study unintended weather modification. They are, in order of priority, the following:

- o Field studies, modeling, laboratory work, and historical data investigations to identify and understand urban influences on weather.
- o Field measurements and modeling research into the weather influence of large power plants and future power parks.
- o Field investigations to determine the potential for weather modification from regional-scale land-use modifications such as large-scale irrigation, deforestation, large manmade lakes, and large-scale strip mining.
- o Cumulative studies of all the different land-use changes in an entire region to determine their synergistic effects.
- o Studies of the effects of unintended modification of the weather on health, on human behavior, on the environment, on the use of energy, on industrial production, and on structures.
- o Societal studies of organizational patterns for dealing with unintended weather modification.
- o Efforts to combine all of the foregoing research requirements to establish the total environmental effects of unintentional weather modification.

Knowing more about the causes and effects of unintended weather modification could assist in research aimed at intentionally modifying the weather. Studies leading to understanding urban influences and the effects of power generation would be the most useful for this purpose. In addition, however, the growing magnitude and extent of unintentional weather modification is a national problem that deserves study to ensure that we understand, and can plan for or counteract, the resulting effects. As the Board and others have observed, such studies have lacked coordination among Federal agencies in the same manner as those relating to deliberate weather modification. They should be conducted as part of the national weather modification program and should be closely coordinated with efforts of the recently established National Climate Program.

National Policy

A statement of national policy regarding weather modification should include the following elements:

- 1. Recognition of the potential benefits of a capability to regulate weather phenomena -- such as drought relief, increased water supply, and the development of new agricultural products -- and the need for research to determine the feasibility of such a capability, and the need for research to determine the potential benefits of such a capability, and the need for research to determine the potential benefits of such a capability.
- 2. The recognition that, in the absence of a national policy, the use and protection of weather modification technology is the legitimate concern of the entire world community, and that the atmosphere belongs to no nation or interest, and that the use of weather modification technology should not be carried out in the face of national objectives, or that it should be affected, whether in the form of a national policy or otherwise.
- 3. As such efforts are developed, the Federal Government will have primary responsibility for the regulation of weather modification within the United States. In the absence of such a national policy, the use of weather modification technology should be limited to the minimum necessary to meet the needs of the United States, and the international use should be restricted to the minimum necessary to meet the needs of the United States.
- 4. All United States agencies and operations in weather modification will continue to be conducted in accordance with the objectives of providing weather modification services to the United States and to other countries in accordance with the objectives of providing weather modification services to the United States and to other countries.

III

Recommendations for a National Policy and Research and Development Program for Weather Modification

Introduction

As discussed in chapter I, past policies regarding Federal weather modification activities have resulted in poor coordination of Federal programs, and lack of continuity of effort toward a clearly articulated set of goals. This chapter sets forth recommendations for a national weather modification policy, a national weather modification research and development program, and methods of administering such a program.

National Policy

A statement of national policy regarding weather modification should include the following elements:

- o Because of the potential benefits of a capability to manage weather resources -- even within the relatively narrow bounds that now appear feasible -- further research into the development of such a capability warrants a place in the Nation's research program. Such research should be devoted not only to the atmospheric processes to be modified but also to the full ecological, social, political, legal, and economic implications of weather modification technology.
- o The atmosphere is a global resource, the use and protection of which is the legitimate concern of the entire world community. Because the atmosphere belongs to no person or interest, its deliberate modification should not be carried out in the face of serious objection by those likely to be affected, whether in this country or elsewhere.
- o As more effective techniques are developed, the Federal Government will have principal responsibility for the regulation of weather modification within the United States. At the present stage in the development of the science, adequate protection of the public and the environment can best be achieved by allowing the states to maintain control of local activities.
- o All United States research and operations in weather modification will continue to be conducted openly and with the objective of promoting peaceful uses of weather modification science and technology.

- o Because of the desirability of carrying out theoretical and field research programs with wide applicability in developing as well as developed countries, the United States will cooperate with other nations on scientific research and development in weather modification to the maximum extent practicable, through bilateral and multilateral agreements and through participation in internationally sponsored experiments and research institutions.
- o The United States will ensure that thorough environmental impact assessments are made of all Federal weather modification activities, including examinations of the possible impacts of such activities outside its borders.
- o The United States will notify in advance any country that it believes will be subject to a significant possibility of impact from a proposed Federal Government weather modification activity and will consult with such country in advance of such activity if requested to do so.

A National Research and Development Program

The goal of a national weather modification research and development program is to develop weather modification science and technology in an environmentally sound and socially acceptable manner as a potential tool for exerting a beneficial influence over destructive weather events and for augmenting water supplies in areas where additional water is needed for energy, food, and fiber production. Attainment of this goal will require a well-coordinated, long-term research and development program. Essential elements of such a program are discussed in section 2 of chapter I of this report and include the following:

- o Basic research to provide the scientific foundation for all relevant forms of enhancement of the atmospheric environment -- particularly to improve our understanding of the interactions between cloud microphysics and cloud dynamics and of the origin and initial growth of ice in natural clouds and to develop more realistic measures of the ice-forming potential in those clouds.
- o A focused effort to prove and refine existing techniques, and to develop new ones, for increasing precipitation through cloud seeding. The areas of highest priority are snowpack augmentation from winter clouds and rain enhancement from convective clouds in agricultural regions during growing seasons. Experimental programs should include both exploratory field experiments and confirmatory field tests, as appropriate, to provide essential background measurements of cloud parameters using specially instrumented aircraft, to test the validity of particular seeding concepts, and to determine whether a particular concept or concepts can be applied usefully.

- o An effort to develop techniques for reducing peak winds in hurricanes, and possibly other damaging characteristics of hurricanes, through cloud seeding.
- o Basic studies aimed at developing an understanding of the formation of hail and other "severe weather" phenomena, with a view to their deliberate moderation.
- o The development of instruments and techniques needed to improve the conduct, monitoring, and evaluation of experiments and operations in weather modification.
- o A coordinated facilities program to develop specialized instrumentation and equipment that satisfy needs common to many field projects and to manage the efficient utilization of core facilities.
- o Studies to provide essential information on economic costs and benefits, environmental impact, and secondary benefits and costs of weather modification projects; to explore the institutional and legal framework for modifying the weather; and to assess the societal responses to operational programs.
- o Research on techniques other than cloud seeding to modify the weather, such as ocean surface temperature alteration and evaporation suppression in connection with hurricanes.

Administration of a National Program

A national research and development program for weather modification should be administered in accordance with the following principles as well as those specified above as elements of the national policy:

- o The Weather Modification Advisory Board expressed concern about the pressure that has existed in the past to give low priority to long-term exploratory inquiries and to prematurely convert them into confirmatory exercises. The design of any research and development program should recognize that a continuity of effort over a period of up to 20 years may be needed to reach definitive determinations. As the Statistical Task Force of the Board concluded, it should be "generally understood that the decade, not the year, is the time step within which we hope to make progress."
- o The research and development program should be planned to fully utilize the wide range of research skills and expertise already available in universities and industry, as well as in the Federal Government. The creation of one or more small, dedicated weather

modification laboratories at universities, as recommended by the Weather Modification Advisory Board, would help assure the utilization of the expertise.

- o A program of partial Federal support primarily for developing and implementing the experimental design of selected state and local weather modification projects should be pursued. As discussed in section 6 of chapter I of this report, this may be a cost-effective way of providing more definitive information. For example, the Weather Modification Advisory Board suggested that state and local managers may be willing to modify the designs of their projects to randomize what might otherwise be unrandomized exercises.
- o A program of technical assistance (on a reimbursable basis) to, and information exchange with, state and local communities to help them develop and evaluate weather modification operations should be pursued, as discussed in section 6 of chapter I of this report, to disseminate the knowledge and information developed by the national program with respect to the changing state of the art.
- o The civilian research and development programs carried out by the various Federal agencies should be coordinated as part of an overall Federal plan, the development and implementation of which should be assisted by a group of well-qualified public advisors, as discussed in chapter V of this report.

IV

Recommendations for Levels of Federal Funding Sufficient to Support Adequately a National Weather Modification Research and Development Program

A continuity of effort over a 20-year period may be needed to undertake and execute the tasks required for a national weather modification program. The funds necessary to implement the program will have to be requested and appropriated in the usual manner and will be subject to normal overall Federal budgeting limitations and policies.

During the six-month period in which the newly organized interagency Weather Modifications Subcommittee recommended by this report is developing a comprehensive Federal research and development plan, current authorization levels should provide sufficient flexibility to develop specific programs to meet the highest priority research needs. Thereafter, modest budget initiatives may be necessary to support the new program, especially for basic research. 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.

Precise levels of funding will depend on the development by the new Subcommittee of the detailed structure of the research and development program, which is likely to parallel in many respects the program details and research priorities recommended by the Weather Modification Advisory Board. Funding levels will also depend on the results in the early years of the program and regular mid-course evaluations of the direction and progress of the program by management and the national weather resources management board. Finally, they will depend on the extent to which the Federal Government succeeds in negotiating arrangements for states to share some of the costs of cooperative research and development and evaluation programs as recommended in this report.

The following is a brief description of the kinds of programs the Subcommittee should consider in developing a plan and budget for a national effort:

- o An invigorated research program to support application of a wide range of research skills and expertise now available in universities, industry, and the Federal Government to fundamental problems directly related to weather modification.
- o Experimental programs, including both exploratory field experiments and confirmatory field tests as appropriate, to provide essential background measurements of cloud physics data

using specially instrumented aircraft and remote sensing techniques, to test the validity of particular seeding concepts, and to prove that some particular concept or concepts may be usefully applied. Essential components of these experimental projects include supporting modeling and laboratory research, economic analyses and environmental assessments to evaluate the operational usefulness of the techniques, and studies to assess the societal impacts of the techniques.

- o Field investigations and associated laboratory and modeling studies to identify and understand the inadvertent influences of local or regional activities on weather and the subsequent impact of those weather changes on society and the environment. This does not include research programs in inadvertent climate modification as defined in section 8 of chapter 1 of this report.
- o Participation in international cooperative weather modification efforts.
- o Studies to provide essential information on economic costs and benefits, environmental impacts, and secondary benefits and costs of weather modification activities; the institutional and legal framework for conducting the activities; the societal responses to the program; and alternative ways of approaching the problem to be solved by the proposed weather modification activities.
- o Establishing a program for partial Federal Government support of carefully selected state or local cloud seeding programs in which the long-term research benefits are substantial and the support can provide savings for the Federal program.
- o Developing and operating, either directly or under contract, those essential facilities common to many weather modification experiments and studies, such as calibration equipment, specialized radar and lidar, instrumented aircraft, and computer resources.
- o Administrative costs including normal administrative services (such as personnel and purchasing), scientific and technical leadership costs, senior management costs, technical monitoring of contracts, and planning and supervising the use of the core facilities.

Recommendations for Organizational Changes Needed to Implement Effectively the Recommended National Policy on Weather Modification and the Recommended Research and Development Program

As indicated in section 9 of chapter I of this report, to date the Federal Government has preferred that weather modification research be undertaken by agencies and Departments as their respective missions dictate, and that such efforts be accompanied by "voluntary" interagency coordination as necessary. In recent years, the majority of weather modification research in the Federal Government has been funded through four Departments or agencies -- the Departments of Commerce, Defense, and Interior, and the National Science Foundation. These efforts have not been coordinated as parts of a comprehensive national weather modification plan.

This report concludes that the present Federal strategy of viewing particular weather modification efforts as one of several possible approaches to achieving various agency missions must be changed in some respects. It has not sufficiently recognized that all weather modification efforts presently employ the same basic technology and can benefit from a centrally focused research effort on fundamental cloud processes. Nor has it resulted in sufficient coordination among the various agencies to ensure that program funds are spent in the most productive manner. If development of an effective weather modification science and technology is a national goal, this goal can best be achieved if all Federal civilian weather modification research and development activities are carried out in the context of a well-coordinated, coherent, long-range research plan.

To achieve these goals, this report recommends that a Weather Modification Subcommittee be established under the Committee on Atmosphere and Oceans of the Federal Coordinating Council for Science, Engineering and Technology. All agencies actively participating in weather modification research and development activities should be represented on the Subcommittee. The Subcommittee should be charged with developing within the next 6 months a 5- to 10-year Federal weather modification research plan that emphasizes fundamental research on cloud physics and mesoscale meteorology, as well as the effect of seeding on the structure and dynamics of cloud systems. The program should also include a careful analysis of required field experiments, especially with respect to effective monitoring and improved scientific and statistical design.

Once the plan is approved, the Subcommittee should provide a coordinating mechanism for the conduct of the plan. In addition, the

Subcommittee should assist the Office of Management and Budget in analyzing annual agency program budget submissions, to ensure consistency with the plan.

To ensure close public scrutiny and involvement in the planning and conduct of the Federal program as it is carried forward, this report also recommends the establishment under existing authorities of a committee of individuals knowledgeable in the field of weather modification, to act as a special advisory board to the Subcommittee.

Advisory Board Recommendations

The Advisory Board believed that such organizational arrangements would not be sufficient to implement effectively a national policy and program on weather modification. In its view, even a stronger "lead agency" designation that included some kind of budgetary authority over the entire program would only create responsibility without authority, because patterns of bureaucratic behavior, constituencies, and Congressional relations are so ingrained that it could not be effective. Furthermore, in the Advisory Board's view, even such authority is inevitably weakened over time by the forces that impel peer agencies to avoid controversy and maintain control over their own programs. And finally, by continuing a situation in which each agency's weather modification program is a very small part of its total budget, the Advisory Board believed that the necessary long-term funding continuity could not be assured, as the program would be required to compete for funds in each agency with other larger programs more central to the agency's mission.

Accordingly, the Advisory Board proposed that existing weather modification activities throughout the Federal Government be consolidated into a single national weather resources management program. It recommended that a newly organized Department of Natural Resources was a logical agency to conduct a centralized program but that, in the absence of such a Department, such activities should be centralized in NOAA.

The Advisory Board also proposed an unusual measure of autonomy for a newly reorganized Federal program -- "a situation in which the (national weather resources management program) would be given the authority, freedom, flexibility, and responsibility to determine its own destiny and to develop and execute its program as if it were an independent agency." To implement its recommendations about autonomy, the Board proposed creation of a six or nine member national weather resources management board ("NWRMB") with the following attributes and authority:

- o NWRMB members would be appointed by the President for six-year staggered terms. They would be distinguished professionals, with

responsible experience in or with the Government, who would be willing to devote a reasonable portion of their time and efforts to NWRMB activities.

- o The NWRMB would appoint the Director of the national weather modification program, with the concurrence of the head of the Federal agency in which the program was organizationally located.
- o The NWRMB, through its Director, would have full authority over personnel acquisition, classification, and allocation within the program, subject to arrangements assuring compatibility with the host agency as to personnel practices and compensation policies.
- o The NWRMB would have full responsibility for the design of a national weather modification program in consultation with responsible managers of affected Federal agencies.
- o The NWRMB would have full responsibility for the development of a budget to carry out on a timely basis the national program, and the full authority to carry out the program once the budget is approved. The President's budget would contain a separate line item for the program, and personnel ceilings and budgetary resources would not be determined as a result of tradeoffs or competition for such resources between other programs of the host agency and the national weather modification program. The management of the program would be responsible for defending its budget before the Congress.
- o The NWRMB would be responsible for the development of productive relationships with states and other potential and actual user groups, and for similar activities involving the universities and capabilities of the private sector and pertinent professional societies.
- o The NWRMB would arrange with the host Federal agency for provision of most administrative support functions such as office services and maintenance, payroll, custodial and security services, under appropriate supervisory and reimbursement arrangements worked out between the parties.
- o The NWRMB would be authorized to build, lease, or otherwise acquire laboratories, office accommodations, equipment, and other items necessary for the conduct of its research and development and experimental activities, including aircraft.
- o The NWRMB would be responsible for instituting and administering the Federal licensing and guideline procedures recommended by the Board.

- o The NWRMB would prepare for the President and the Congress an annual report of its activities and plans, which would be widely distributed.

This report does not adopt either of the Advisory Board's organizational recommendations. The Administration believes that because a number of Federal agencies have valid mission interests in the weather modification, and the field can benefit from a variety of approaches, advances in weather modification science and technology can best be achieved by well-coordinated programs carried out by a number of agencies. It believes that the development of a formal research plan under the Federal Coordinating Council for Science, Engineering and Technology structure, coupled with continuing scrutiny by a knowledgeable advisory committee and annual analysis by the Office of Management and Budget to ensure that agency funding submissions adhere to the plan, can ensure the high-level attention necessary to overcome established bureaucratic patterns and to ensure adequate long-term funding of programs.

The Administration recognizes the need for close public scrutiny and involvement in 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 advisory committee recommended by this report parallels others successfully established on other national research and development programs in the past under existing authorities. Such a committee can provide valuable scrutiny of the planning and conduct of the Federal program as it is carried forward.

VI

Recommendations Concerning Legislation to Implement the Proposed Weather Modification Policy and Programs and International Agreements Relating to the Proposed Uses of Weather Modification

As discussed in section 6 of chapter I of this report, most of the actions necessary to implement a national weather modification policy and program can be taken administratively, without the need for legislation. However, the Administration does support the enactment of legislation now that contains a statement of national weather modification policy indicating the importance of a national program for weather resources management, identifies the goals of a national weather modification program, and sets forth the respective roles of the state and Federal governments.

As indicated in section 10 of chapter I, negotiation of a comprehensive international agreement concerning all aspects of weather modification is not yet feasible. The following actions, however, would be feasible and important steps toward establishment of a comprehensive international regime for weather modification:

- o Adoption by the Congress of a unilateral declaration of weather modification policy.
- o Negotiation by the United States, with Mexico and other neighboring countries, of bilateral notification and consultation agreements like the agreement already in force with Canada.
- o Development of an international accord on weather modification research activities.
- o Promulgation through an appropriate international organization of principles of conduct for the guidance of States concerning weather modification experiments and operations.

The details of such agreements are discussed in section 11 of chapter I of this report.

APPENDIX A

PUBLIC LAW 94-490-OCT.13, 1976
Public Law 94-490
94th Congress

An Act

To authorize and direct the Secretary of Commerce to develop a national policy on weather modification, and for other purposes.

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 "National Weather Modidication Policy Act of 1976".

SEC. 2. DECLARATION OF POLICY.

(a) FINDINGS.-- The Congress finds and declares the following:

(1) Weather related disasters and hazards, including drought, hurricanes, tornadoes, hail, lightning, fog, floods, and frost, result in substantial human suffering and loss of life, billions of dollars of annual economic losses to owners of crops and other property, and substantial financial loss to the United States Treasury;

(2) Weather modification technology has significant potential for preventing, diverting, moderating, or ameliorating the adverse effects of such disasters and hazards and enhancing crop production and the availability of water;

(3) The interstate nature of climatic and related phenomena, the severe economic hardships experienced as the result of occasional drought and other adverse meteorological conditions, and the existing role and responsibilities of the Federal Government with respect to disaster relief, require appropriate Federal action to prevent or alleviate such disasters and hazards; and

(4) Weather modification programs may have long-range and unexpected effects on existing climatic patterns which are not confined by national boundaries.

(b) PURPOSE.-- It is therefore declared to be the purpose of the Congress in this Act to develop a comprehensive and coordinated national weather modification policy and a national program of weather modification research and development--

(1) to determine the means by which deliberate weather modification can be used at the present time to decrease the adverse impact of weather on agriculture, economic growth, and the general public welfare, and to determine the potential for weather modification;

(2) to conduct research into those scientific areas considered most likely to lead to practical techniques for drought prevention or alleviation and other forms of deliberate weather modification;

(3) to develop practical methods and devices for weather modification;

(4) to make weather modification research findings available to interested parties;

(5) to assess the economic, social, environmental, and legal impact of an operational weather modification program;

(6) to develop both national and international mechanisms designed to minimize conflicts which may arise with respect to the peaceful uses of weather modification; and

(7) to integrate the results of existing experience and studies in weather modification activities into model codes and agreements for regulation of domestic and international weather modification activities.

SEC. 3. DEFINITIONS.

As used in this Act:

(1) The term "Secretary" means the Secretary of Commerce.

(2) The term "State" means any State of the United States, the District of Columbia, or any Commonwealth, territory, or possession of the United States.

(3) The term "weather modification" means any activity performed with the intention and expectation of producing changes in precipitation, wind, fog, lightning, and other atmospheric phenomena.

SEC. 4. STUDY.

The Secretary shall conduct a comprehensive investigation and study of the state of scientific knowledge concerning weather modification, the present state of development of weather modification technology, the problems impeding effective implementation of weather modification technology, and other related matters. Such study shall include--

(1) a review and analysis of the present and past research efforts to establish practical weather modification technology, particularly as it relates to reducing loss of life and crop and property destruction;

(2) a review and analysis of research needs in weather modification to establish areas in which more research could be expected to yield the greatest return in terms of practical weather modification technology;

(3) a review and analysis of existing studies to establish the probable economic importance to the United States in terms of agricultural production, energy, and related economic factors if the present weather modification technology were to be effectively implemented;

(4) an assessment of the legal, social, and ecological implications of expanded and effective research and operational weather modification projects;

(5) formulation of one or more options for a model regulatory code for domestic weather modification activities, such code to be based on a review and analysis of experience and studies in this area, and to be adaptable to State and national needs;

(6) recommendations concerning legislation desirable at all levels of government to implement a national weather modification policy and program;

(7) a review of the international importance and implications of weather modification activities by the United States;

(8) a review and analysis of present and past funding for weather modification from all sources to determine the sources and adequacy of funding in the light of the needs of the Nation;

(9) a review and analysis of the purpose, policy, methods, and funding of the Federal departments and agencies involved in weather modification and of the existing interagency coordination of weather modification research efforts;

(10) a review and analysis of the necessity and feasibility of negotiating an international agreement concerning the peaceful uses of weather modification; and

(11) formulation of one or more options for a model international agreement concerning the peaceful uses of weather modification and the regulation of national weather modification activities; and a review and analysis of the necessity and feasibility of negotiating such an agreement.

SEC. 5. REPORT.

(a) IN GENERAL.-- The Secretary shall prepare and submit to the President and the Congress, within 1 year after the date of enactment of this Act, a final report on the findings, conclusions, and recommendations of the study conducted pursuant to section 4. Such report shall include:

(1) a summary of the findings made with respect to each of the areas of investigation specified in section 4;

(2) other findings which are pertinent to the determination and implementation of a national policy on weather modifications;

(3) a recommended national policy on weather modification and a recommended national weather modification research and development program which is consistent with, and likely to contribute to, achieving the objectives of such policy;

(4) recommendations for levels of Federal funding sufficient to support adequately a national weather modification research and development program;

(5) recommendations for any changes in the organization and involvement of Federal departments and agencies in weather modification which may be needed to implement effectively the recommended national policy on weather modification and the recommended research and development program; and

(6) recommendations for any regulatory and other legislation which may be required to implement such policy and program or for any international agreement which may be appropriate concerning the peaceful uses of weather modification, including recommendations concerning the dissemination, refinement, and possible implementation of the model domestic code and international agreement developed under the specifications of section 4.

Each department, agency, and other instrumentality of the Federal Government is authorized and directed to furnish the Secretary any information which the Secretary deems necessary to carry out his functions under this Act.

(b) OPERATION AND CONSULTATION.-- The Secretary shall solicit and consider the views of State agencies, private firms, institutions of higher learning, and other interested persons and governmental entities in the conduct of the study required by section 4, and in the preparation of the report required by subsection (a).

SEC. 6. AUTHORIZATION FOR APPROPRIATIONS.

(a) There is authorized to be appropriated to the Secretary for the purposes of carrying out the provisions of this Act not to exceed \$1,000,000.

(b) Section 6 of the Act entitled "An Act to provide for the reporting of weather modification activities to the Federal Government", approved December 18, 1971 (85 Stat. 736; 88 Stat. 1212; 15 U.S.C. 330e), is further amended by striking out "1973, 1974, 1975, 1976, and 1977," and inserting in lieu thereof " 1973 through 1980,".

Approved Oct. 13, 1976.

APPENDIX B

WEATHER MODIFICATION CONTROL ACT
ILL. Rev. Stat. 1973, ch. 146 3/4, Sec. 1 to 32
STATE OF ILLINOIS

AN ACT to regulate weather modification in this State and amending certain Acts therein named in connection therewith.

Be it enacted by the People of the State of Illinois, represented in the General Assembly:

ARTICLE I. WEATHER MODIFICATION CONTROL ACT

Section 1. (Short Title.) This Act shall be known and may be cited as the "Weather Modification Control Act."

Section 2. (Declaration of Purpose.)

(a) The General Assembly hereby declares that weather modification affects the public health, safety and welfare and the environment, and is subject to regulation and control in the public interest. Properly conducted weather modification operations can improve water quality and quantity, reduce losses from weather hazards and provide economic benefits for the people of the State. Therefore weather modification operations and research and development shall be encouraged. In order to minimize possible adverse effects, weather modification activities shall be carried on with proper safeguards, and accurate information concerning such activities shall be recorded and reported to the Department of Registration and Education.

(b) This Act shall be liberally construed to carry out these objectives and purposes.

Section 3. (Definitions.) As used in this Act unless the context otherwise requires, the terms specified in Sections 3.01 through 3.11 have the meanings ascribed to them in those Sections.

Section 3.01. "Department" means the Department of Registration and Education.

Section 3.02. "Director" means the Director of Registration and Education.

Section 3.03. "Board" means the Weather Modification Board appointed pursuant to this Act.

Section 3.04. "Weather Modification" means any activity performed with the intention of producing artificial changes in the composition, motions and resulting behavior of the atmosphere.

Section 3.05. "Person" means any individual, corporation, company, association, firm, partnership, society, joint stock company, any State or local government or any agency thereof, or any other organization, whether commercial or nonprofit, who is performing weather modification operations or research and development, except where acting solely as an employee, agent or independent contractor of the United States of America or any agency thereof. "Person" does not include the United States of America or any agency thereof.

Section 3.06. "Operation" means the performance of any weather modification activity undertaken for the purpose of producing or attempting to produce any form of modifying effect upon the weather within a specified geographical area over a specified time interval.

Section 3.07. "Research and Development" means exploration, field experimentation and extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes.

Section 3.08. "License" means a professional license issued by the Director indicating that a specified person has met the standards for certification as a weather modifier and is approved to conduct weather modification operations for which permits have been issued under this Act.

Section 3.09. "Licensee" means a person who holds a professional weather modification license issued under this Act.

Section 3.10. "Permit" means an operational permit issued by the Director indicating that approval has been given for conducting a specified weather modification operation within the State subject to the conditions and within the limitations established under the provisions of this Act.

Section 3.11. "Permittee" means a person who holds an operational permit issued under this Act.

Section 4. (Administration.)

(a) The powers and duties enumerated in this Act shall be exercised by the Director.

(b) The Director shall exercise the powers and duties enumerated in this Act, except those enumerated in Section 5, only upon the recommendation and report in writing of the majority of the members of the Board.

Section 5. (Weather Modification Board.) There is created the Weather Modification Board to be composed of 5 residents of the State who shall be appointed by the Director. In selecting members of the Board the Director shall include individuals with qualifications and practical experience in agriculture, law, meteorology and water resources.

The Director shall appoint one member of the Board to a term of one year, 2 members to terms of 2 years and 2 members to terms of 3 years, commencing January 1, 1974. After expiration of the terms of the members first appointed pursuant to this Act, each of their respective successors shall hold office for a term of 3 years and until their successors are appointed and qualified. Members of the Board shall be eligible for re-appointment.

In the event a member of the Board shall be disqualified from considering business before the Board because of a conflict of interest, the Director may appoint a resident of the State to serve temporarily on the Board. After the Board decides upon its recommendation to the Director concerning such business, the member will resume his position on the Board.

The chairman of the Board shall be designated by the Director from among the members.

Each member of the Board shall be paid the sum of \$25 for every day he is actually engaged in its services, and shall be reimbursed for such actual and necessary expenses as he may incur in performance of the functions of the Board.

The Board shall hold an annual meeting at Springfield, Illinois, and such other meetings at such times and places and upon such notice as the Board may determine. Three members of the Board shall constitute a quorum for performance of its functions.

Section 6. (Regulations.) The Department shall make reasonable rules and regulations necessary to the exercise of its powers and the performance of its duties under this Act.

In order to effectuate the objectives and purposes of this Act, the Department shall make reasonable rules and regulations establishing qualifications, procedures and conditions for issuance, renewal, revocation, suspension, refusal to renew, refusal to issue, restoration and modification of licenses and permits.

In order to minimize possible adverse effects to the public health, safety and welfare and the environment, the Department shall make reasonable rules and regulations establishing standards and instructions to govern weather modification operations and research and development.

In order to make accurate information available concerning weather modification operations and research and development in the State, the Department shall make reasonable rules and regulations requiring record keeping and reporting and shall establish procedures and forms for such record keeping and reporting.

Section 7. (Investigations.) The Department shall have the power to investigate the weather modification operations and research and development of any person holding or claiming to hold a license or a permit issued under this Act.

Duly authorized agents of the Department shall have the power to enter and inspect any place in which there is reasonable belief that weather modification operations or research and development is taking place, in which weather modification operations or research and development is in fact taking place and the premises of any person holding a permit issued under this Act.

Section 8. (Hearings.) Except for emergency modifications of operational permits as provided for in Section 21 (b) of this Act, before suspending, revoking, refusing to renew or modifying a license or a permit, the Department shall issue a citation notifying the licensee or permittee of the time and place when and where a hearing of the matter shall be had. Such citation shall contain a statement of the reasons for the proposed action. Such citation shall be served on the licensee or permittee at least 10 days prior to the date therein set for the hearing, either by delivery of the citation personally to the licensee or permittee or by mailing it by registered mail to his last known place of business.

The Department shall hear the matter at the time and place fixed in such citation unless the licensee or permittee waives his right to a hearing. Both the Department and the licensee or permittee shall be accorded ample opportunity to present, in person or by counsel, such statements, testimony, evidence and argument as may be pertinent to the matter.

The Department may continue such hearing from time to time. If the Department shall not be sitting at the time and place fixed in the citation or at the time and place to which a hearing shall have been continued, the Department shall continue such hearing for a period not to exceed 30 days.

Any circuit court or any judge thereof, upon the application of the licensee or permittee or of the Department, may by order duly entered, require the attendance of witnesses and the production of relevant books, records, documents and instruments before the Department in any hearing relative to refusal to renew, suspension, revocation or modification of a license or a permit, and the court or judge may compel obedience to its or his order by proceedings for contempt.

In conducting any hearing, the Department or a representative designated by it may administer oaths and examine witnesses.

The Department, at its expense, shall provide a stenographer to record the testimony and preserve a record of all proceedings at the hearing of any case wherein a license or permit is revoked, suspended, not renewed or modified. The notice of hearing and all other documents in the nature of pleadings and written motions filed in the proceedings,

the transcript of testimony, the report of the Board and the orders of the Department constitute the record of such proceedings.

Section 9. (Interstate Compacts.) The Department may represent the State in matters pertaining to plans, procedures or negotiations for interstate compacts relating to weather modification.

Section 10. (License and Permit Required.) Except as provided in Section 11 of this Act, no person may engage in weather modification activities:

(a) Without both a professional weather modification license issued under Section 12 of this Act and a weather modification operational permit issued under Section 18 of this Act; or

(b) In violation of any term, condition or limitation of such license or permit.

Section 11. (Exemptions.)

(a) The Department may provide rules and regulations for exemption of the following activities from the license and permit requirements of this Act:

(1) Research and development conducted by the State, its subdivisions and agencies of the State and of its subdivisions, institutions of higher learning and bona fide research corporations;

(2) Activities for protection against fire, frost or fog; and

(3) Activities normally conducted for purposes other than inducing, increasing, decreasing or preventing hail, precipitation, or tornadoes.

(b) Exempted activities shall be so conducted as not to interfere with weather modification operations conducted under a permit issued in accordance with this Act.

Section 12. (Issuance of license.)

(a) The Department shall provide by rules and regulations the procedure and criteria for issuance of licenses. Criteria established by rules and regulations shall be consistent with the qualifications recognized by national or international professional and scientific associations concerned with weather modification and meteorology, and shall be designed to carry out the objectives and purposes of this Act.

(b) The Department, in accordance with its rules and regulations, shall issue a weather modification license to each applicant who:

(1) Pays the license fee established by Section 13 of this Act; and

(2) Demonstrates, to the satisfaction of the Department, competence necessary to engage in weather modification operations.

(c) If an applicant for a license does not pay the license fee established by Section 13 of this Act or does not demonstrate, to the satisfaction of the Department, competence necessary to engage in weather modification operations, the Department shall deny the application for the license.

Section 13. (License Fee.) The fee for an original license is \$100. The fee for a renewal license is \$20.

Section 14. (Expiration Date.) Each original or renewal license shall expire on October 31 of each year.

Section 15. (Renewal of License.) At the expiration of the license period, the Department shall issue a renewal license to each applicant who pays the renewal license fee established by Section 13 of this Act, and who has the qualifications then necessary for issuance of an original license.

Section 16. (Suspension, Revocation, Refusal to Renew A License.) The Department may suspend, revoke or refuse to renew a license for any one or any combination of the following causes:

- (a) Incompetency;
- (b) Dishonest practice;
- (c) False or fraudulent representation in obtaining a license or permit under this Act;
- (d) Failure to comply with any of the provisions of this Act or any of the rules and regulations of the Department made under this Act; and
- (e) Aiding other persons who fail to comply with any of the provisions of this Act or any of the rules and regulations of the Department made under this Act.

Section 17. (Issuance of Permit.)

(a) The Department shall provide by rules and regulations the procedure and criteria for issuance of permits. Criteria established by rules and regulations shall be designed to carry out the objectives and purposes of this Act.

(b) A person applying for a weather modification operational permit shall file with the Department an application which shall contain such information as the Department by rules and regulations may require and which in addition shall:

- (1) List the name and address of the applicant;
- (2) List the name and address of the person on whose behalf the operation is to be conducted;
- (3) Indicate that the applicant holds, or if the applicant is an organization rather than an individual, demonstrates that the individual in control of the project holds a valid professional weather modification license issued under Section 12 of this Act;
- (4) Furnish proof of financial responsibility in accordance with Section 20 of this Act; and
- (5) Set forth a complete operational plan for the project which includes a specific statement of its nature and object, a map of the proposed operating area which specifies the primary target area and shows the area reasonably expected to be affected, a statement of the approximate time during which the operation is to be conducted, a list of

the materials and methods to be used in conducting the operation, an emergency shut down procedure which states conditions under which operations must be suspended because of possible danger to the public health, safety and welfare or to the environment, and such other detailed information as may be required to describe the operation.

(c) The Department may give public notice by newspaper, radio or television announcement in the area of the State reasonably expected to be affected by operations conducted under a permit that it is considering an application for a permit, and may hold a public hearing for the purpose of obtaining information from the public concerning the effects of issuing or refusing to issue the permit.

(d) The Department may issue the operational permit if it determines that:

(1) The applicant holds, or if the applicant is an organization rather than an individual, demonstrates that the individual in control of the project holds a valid professional weather modification license issued under Section 12 of this Act;

(2) The applicant has furnished proof of financial responsibility in accordance with Section 20 of this Act;

(3) The project is reasonably conceived to improve water quality or quantity, reduce losses from weather hazards, provide economic benefits for the people of the State, advance or enhance scientific knowledge or otherwise carry out the objectives and purposes of this Act;

(4) The project is designed to include adequate safeguards to minimize possible damage to the public health, safety or welfare or to the environment;

(5) The project will not adversely affect another operation for which a permit has been issued;

(6) The applicant has complied with the permit fee requirement established by Section 18 of this Act; and

(7) The applicant has complied with the project conforms to such other criteria for issuance of permits as have been established by rules and regulations of the Department made under this Act.

(e) In order to carry out the objectives and purposes of this Act, the Department may condition and limit permits as to primary target area, time of the operation, materials and methods to be used in conducting the operation, emergency shut down procedure and such other operational requirements as may be established by the Department.

(f) A separate permit shall be required for each operation.

(g) The Department shall issue only one permit at a time for operations in any geographic area if 2 or more operations conducted within the conditions and limits of the permits might adversely interfere with each other.

Section 18. (Permit Fee.)

(a) The fee for each permit or renewal thereof shall be a minimum of \$100.

(b) If the operation will be conducted under contract and the value of the contract is more than \$10,000, the fee for the permit or renewal thereof shall be equivalent to one per cent of the value of the contract.

(c) If the operation will not be conducted under contract and the estimated costs of the operation are more than \$10,000, the fee for the permit or renewal thereof shall be equivalent to one percent of the estimated costs of the operation. The costs of the operation shall be estimated by the Department from information given to it by the applicant for the permit or renewal thereof and such other information as may be available to the Department.

(d) The permit fee is due and payable to the Department prior to issuance of the permit or renewal thereof.

Section 19. (Scope of Permit.)

(a) A separate permit is required for each operation. When an operation is conducted under contract, a permit is required for each separate contract.

(b) Except as provided in subsection (c) of this Section, each permit or renewal permit shall expire one year from the date of its issuance.

(c) The Department may conditionally approve a project for a continuous time period in excess of one year's duration. Permits for such operations must be renewed annually. In approving the renewal of a permit for a continuous program the Department shall review and approve the permittee's operational record, and then may issue a renewal of the permit for the operation to continue.

(d) The permittee shall confine his activities within the limits specified in the permit, except to the extent that the limits are modified by the Department. The permittee shall comply with any conditions of the permit as originally issued or as subsequently modified by the Department.

Section 20. (Proof of Financial Responsibility.) Proof of financial responsibility is made by showing to the satisfaction of the Department that the permittee has the ability to respond in damages to liability which might reasonably result from the operation for which the permit is sought. Such proof of financial responsibility may, but shall not be required to, be shown by:

(a) Presentation to the Department of proof of a prepaid noncancellable insurance policy against such liabilities in an amount set by the Department; or

(b) Filing with the Department a corporate surety bond, cash or negotiable securities in an amount approved by the Department.

Section 21. (Modification of Permits.)

(a) The Department may revise the conditions and limits of a permit if:

(1) The permittee is given notice and a reasonable opportunity for a hearing on the need for a revision in accordance with Section 8 of this Act; and

(2) It appears to the Department that a modification of the conditions and limits of a permit is necessary to protect the public health, safety and welfare or the environment.

(b) If it appears to the Department that an emergency situation exists or is impending which could endanger the public health, safety or welfare or the environment, the Department may, without prior notice or a hearing, immediately modify the conditions and limits, of a permit, or order temporary suspension of the permit. The issuance of such an order shall include notice of a hearing to be held within 10 days thereafter on the question of permanently modifying the conditions and limits or continuing the suspension of the permit. Failure to comply with an order temporarily suspending an operation or modifying the conditions and limits of a permit shall be grounds for immediate revocation of the permit and of the license of the person controlling the operation.

(c) It shall be the responsibility of the permittee to notify the Department of any emergency which can reasonably be foreseen, or of any existing emergency situations which might be caused or affected by the operation. Failure by the permittee to so notify the Department of any such existing emergency, or any impending emergency which should have been foreseen, may be grounds, at the discretion of the Department, for revocation of the permit and of the license of the person controlling the operation.

Section 22. (Renewal of permit.) At the expiration of the permit period, the Department shall issue a renewal permit to each applicant who pays the permit fee and whose operational record indicates that an original permit would be issuable for the operation.

Section 23. (Suspension, Revocation, Refusal to Renew Permit.)

(a) The Department may suspend or revoke a permit if it appears that the permittee no longer has the qualifications necessary for the issuance of an original permit or has violated any provision of this Act or of any of the rules and regulations issued under this Act.

(b) The Department may refuse to renew a permit if it appears from the operational records and reports of the permittee that an original permit would not be issuable for the operation, or if the permittee has violated any provision of this Act or of any of the rules and regulations issued under this Act.

Section 24. (Restoration of License or Permit.)

(a) At any time after the suspension or revocation of a license or permit the Department may restore it to the licensee or permittee upon a finding that the requirements for issuance of an original license or permit have been met by the licensee or permittee.

(b) At any time after the refusal to renew a license or permit the Department may renew it upon a finding that the requirements for issuance of an original licensee or permit have been met by the licensee or permittee.

Section 25. (Judicial Review.)

(a) All final administrative decisions of the Department are subject to judicial review pursuant to the provisions of the "Administrative Review Act", approved May 8, 1945, and all amendments and modifications thereof, and the rules adopted pursuant thereto. The term "administrative decision" is defined as in Section 1 of the "Administrative Review Act".

(b) Such proceedings for judicial review shall be commenced in the circuit court of the county in which the party applying for review resides, but if such party is not a resident of this State, the venue shall be in Sangamon County.

(c) The Department shall not be required to certify any record to the circuit court or file any answer in the circuit Court or otherwise appear in any court in a judicial review proceeding, unless there is filed in the court with the complaint a receipt from the Department acknowledging payment of the costs of furnishing and certifying the record. The costs shall be computed at the rate of fifty cents per page. Failure on the part of the plaintiff to file such receipt in court shall be grounds for dismissal of the action.

Section 26. (Records and Reports.)

(a) In order to aid in research and development of weather modification and to aid in the protection of the public health, safety and welfare and the environment, any person conducting any weather modification in Illinois or elsewhere by undertaking operations within Illinois, shall keep such records and file such reports at such time or times and in the manner and form as may be required by the rules and regulations made under this Act.

(b) Record and report forms may be developed by the Department showing the method of weather modification employed in the operation, the type of equipment used, the kind and amount of each material used, the times and places the equipment was operated, the times when there was modifiable weather but the permittee did not operate and the reasons therefor, the name and address of each individual, other than the licensee, who participates or assists in the operation, the manner in which operations do not conform to the conditions and limits of the permit as established according to Section (17) (e) or as modified under Section 21, weather observations and records specified by the Department and any other necessary data the Department may require under its rules and regulations.

(c) The records and reports which are in the custody of the Department and which have been filed with it under this Act or under the rules and regulations made under this Act shall be kept open for public examination as public documents.

Section 27. (State Immunity.) Nothing in this Act shall be construed to impose or accept any liability or responsibility by the State, its agencies and the officers and employees thereof for any injury caused by any persons who conduct weather modification operations.

Section 28. (Liability.)

(a) An operation conducted under the license and permit requirements of this Act is not an ultrahazardous or an abnormally dangerous activity which makes the licensee or permittee subject to liability without fault.

(b) Dissemination of materials and substances into the atmosphere by a permittee acting within the conditions and limits of his permit shall not give rise to the contention that such use of the atmosphere constitutes trespass.

(c) Except as provided in subsections (a) and (b) of this Section and in Section 27 or this Act, nothing in this Act shall prevent any person adversely affected by a weather modification operation from recovering damages resulting from intentional harmful actions or negligent conduct by a permittee.

(d) Failure to obtain a license and permit before conducting an operation, or operational activities which knowingly constitute a violation of the conditions or limits of a permit, shall constitute negligence per se.

(e) The fact that a person holds a license or was issued a permit under this Act, or that he has complied with the rules and regulations made by the Department pursuant to this Act, is not admissible as a defense in any legal action which may be brought against him.

Section 29. (Penalty for Violations.) Any person violating any of the provisions of this Act or of any valid rule or regulation issued under this Act is guilty of a Class B misdemeanor, and each day such violation continues constitutes a separate offense.

Section 30. (Suits to Recover Fines, Penalties or Fees.) All suits for the recovery of any of the fines, penalties or fees prescribed in this Act shall be prosecuted in the name of the "People of the State of Illinois", in any court having jurisdiction, and it shall be the duty of the State's Attorney of the county where such offense is committed to prosecute all persons violating the provisions of this Act upon proper complaint being made. All fines, penalties and fees collected under the provisions of this Act shall inure to the Department.

Section 31. (Injunction to Restrain Violations.) The Department may, in its discretion, in addition to the remedy set forth in the preceding Section, apply to a court having competent jurisdiction over the parties and subject matter, for a writ of injunction to restrain repetitious violations of the provisions of this Act.

Section 32. (Partial Invalidity.) If any portion of this Act is held invalid, such invalidity shall not affect any other part of this Act which can be given effect without the invalid portion.

APPENDIX C

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
RULES AND REGULATIONS PROMULGATED FOR
ADMINISTRATION OF THE ILLINOIS
WEATHER MODIFICATION CONTROL ACT
(As amended June 21, 1978)

FOREWORD:

These Rules are issued under the authority of Sections 6, 11, 12, 17, 20 and 26, Chapter 146 3/4, Illinois Revised Statutes, 1973, The Weather Modification Control Act.

RULE 1 - CONCEPT OF RULES

1. Purpose of Rules:

These Rules are adopted to promote properly conducted weather modification operations and research and development, to minimize possible adverse effects from weather modification activities and to facilitate the administration and enforcement of the Weather Modification Control Act. These Rules shall be liberally construed to carry out these objectives and purposes.

2. Use and Effect of Rules:

These Rules are prescribed for the performance of the statutory powers and functions vested in the Department of Registration and Education. In no event shall any Rule or Rules be construed as a limitation or restriction upon the exercise of any statutory power of the Department.

3. Suspension or Modification of Rules:

These Rules may be suspended or modified by the Director of the Department of Registration and Education, in whole or in part, in the interest of Justice. The Department of Registration and Education by and through the Director reserves the right to waive compliance with any of these Rules whenever in the Director's judgement, no party will be injured thereby.

4. Construction of Rules:

These Rules should not be construed to abrogate, modify or limit any rights, privileges, or immunities granted or protected by the

Constitution or laws of the United States or the Constitution or laws of the State of Illinois nor to deny any person life, liberty, or property without due process of law.

RULE 2 - DEFINITIONS

As used in these Rules, unless the context otherwise requires, the terms specified herein have the meanings ascribed to them herein or by the Weather Modification Control Act, whichever shall be applicable, as same may be, at any time or from time to time, amended.

1. Act or Weather Modification Control Act:

"Act" or "Weather Modification Control Act" means "An Act to regulate weather modification in this State and amending certain Acts therein named in connection therewith" (P.A. 78-674, effective October 1, 1973), as same may at any time or from time to time, be amended.

2. Weather Modification Apparatus:

"Weather Modification Apparatus" means any apparatus used with the intention of producing artificial changes in the composition, motions and resulting behavior of the atmosphere.

3. Sponsor:

"Sponsor" means any person who enters into an agreement with a permittee to perform an operation.

4. Target Area:

"Target Area" means the surface area within which the effects of an operation are expected to be found.

5. Operations Area:

"Operations Area" means the area in which an operation is conducted to produce or attempt to produce the desired effect within the target area.

6. Control Area:

"Control Area" means a preselected, untreated surface area in which no effects are expected and which is used for comparison with a target area.

7. Professional Level:

"Professional Level" means a level of responsibility for direct supervision and conduct of operations or substantial parts thereof.

8. Department's Address:

628 East Adams Street, Springfield, Illinois 62786, or such other address as shall at any time or from time to time, be designated by the Director or his duly designated Representative.

RULE 3 - ADMINISTRATION

1. Director:

The powers and duties of the Department enumerated in the Illinois Civil Administrative Code, where applicable, the Act and these Rules shall be exercised by the Director.

2. Board:

Reports from the Board, except in emergencies, shall be in writing. The Chairman of the Board shall be responsible for forwarding to the Director reports from the Board promptly and for keeping other members of the Board advised of pending business of the Board. The Director shall act promptly upon receipt of reports from the Board.

RULE 4 - HEARINGS

1. Hearings Required:

Except for emergency modifications of operational permits as provided for in Section 21 (b) of the Act, before suspending, revoking, refusing to renew or modifying a license or a permit, the Department shall conduct a hearing in conformity with Section 8 of the Act.

2. Stenographic Record:

The stenographic record of a hearing shall be retained for at least five years. It need not be transcribed unless there is judicial review of the final administrative decision under Section 25 of the Act.

RULE 5 - LICENSE AND PERMIT REQUIRED

1. Requirement:

Except as provided in Subsection 2 of this Rule, no person may engage in weather modification activities;

(a) Without both a professional weather modification license issued under Rule 6 and a weather modification operational permit issued under Rule 7; or

(b) In violation of any term, condition or limitation of such license or permit.

2. Exemptions:

The following activities are exempted from the license and permit requirements of the Act:

(a) Research and development conducted by the State, its subdivisions and agencies of the State and of its subdivisions, institutions of higher learning and bona fide research organizations;

(b) Activities for protection against fire, frost or fog; and

(c) Activities normally conducted for purposes other than inducing, increasing, decreasing or preventing hail, precipitation, clouds or tornadoes.

3. Conduct of Exempt Activities:

Exempted activities shall be so conducted as not to interfere with weather modification operations conducted under a permit issued in accordance with the Act and these Rules.

4. Notice of Exempt Activities:

Persons conducting exempted operations and research and development shall file with the Department the original of a notice form available from the Department and with the chairman of the Board at the Department's address a copy of the form indicating their intent to engage in such activities. Information from notice forms will be used in ascertaining the extent to which records should be kept for exempted activities under Rule 8 (6) and reports should be filed on such activities under Rule 9 (5). Notice forms will require the following data:

(a) Name and address of the person giving notice;

(b) Name and address of the sponsor (if any) of the operation or research and development;

(c) Whether the activity is operational or research and development;

(d) Nature and object of the activity;

- (e) The legal description of and a map showing the operations area, target area and control area, if the activity involves any such areas;
- (f) The approximate starting date of the activity and its anticipated duration;
- (g) The kind of weather modification agent(s) intended for use; and
- (h) The kinds of weather modification apparatus which will be used.

RULE 6 - LICENSES

1. Criteria for Issuance:

Issuance of licenses shall be based on the applicant's character, knowledge of weather modification principles and techniques and experience in their application. The following shall be the minimum educational and experience criteria;

- (a) A minimum of two years' field experience at the professional level in weather modification field operations or research; and
- (b) One of the following three requirements:

- (1) Six additional years' experience in weather modification field operations or research; or
- (2) A degree in engineering, mathematics, or the physical sciences plus two additional years' experience in weather modification field operations or research; or
- (3) A degree in meteorology, or a degree in engineering, mathematics, or the physical sciences which include or is in addition to at least twenty-five semester hours of meteorological course work.

2. Application for License:

An applicant for a license shall fill out and file with the Department the original of an application form available from the Department and a copy thereof with the Chairman of the Board at the Department's address no later than thirty days before the applicant plans to use the license. The form shall require relevant information about the applicant's character, knowledge of weather modification principles and experience in their application. Among the data required is information about the applicant's:

- (a) Educational background at the college and graduate level. This includes the dates of attendance and of graduation, the major and minor subjects (including the number of semester hours of meteorological course work), the degrees received, and the titles of any thesis and/or dissertation.
- (b) Experience in weather modification or related activities. Attention should be given to experience with reference to meteorological conditions typical of Illinois. The applicant should list the dates of each position held, the title of the position

(indicate whether it was of sub-professional or professional level), the name and address of the employer, a description of the work done (indicate both the magnitude and complexity of the work and the duties and degree of responsibility for the work), and the name and address of the supervisor.

(c) Scientific or engineering society affiliations and the grade of membership in and certification by each.

(d) Publications, patents and reports.

(e) Three references who will attest to the applicant's character, knowledge of weather modification principles and experience in their application.

(f) A list of all jurisdictions in which the applicant has previously filed application for a professional weather modification license. The outcome of such applications should be indicated.

(g) A list of all law suits relating to weather modification from any jurisdiction in which the applicant was a party or where the applicant was employed by a party thereto at the time involved therein.

(h) Indication whether a professional weather modification license issued to the applicant in any jurisdiction has ever been suspended, revoked, placed on probationary status or subjected to any other disciplinary actions or whether there has been refusal to renew such a license by any jurisdiction. If there has been any such suspension, revocation, placement on probationary status or other disciplinary action or refusal to renew, the circumstances must be explained in full.

3. Procedure for Issuance:

The Department shall evaluate the applications, including the responses from references, and such other relevant data about applicants as it possesses or discovers. The Department in its discretion shall also have the right to interview any applicant. On the basis of that information the Department shall, within sixty days of receipt of an application, determine whether the applicant meets the educational and experience criteria established by Subsection 1 of this Rule and whether the applicant possesses the character, knowledge and experience necessary to engage in weather modification operations. The Director shall issue a license to each applicant who pays the license fee established by Section 13 of the Act and who demonstrates to the satisfaction of the Department the competence, by virtue of character, knowledge and experience, necessary to engage in weather modification operations. If an applicant for a license does not pay the license fee established by section 13 of the Act or does not demonstrate to the satisfaction of the Department the competence, by virtue of character, knowledge and experience, necessary to engage in weather modification operations, the Department shall deny the application for the license.

4. Renewal of License:

Forty-five days before expiration of licenses the Department shall mail license application forms to all licensees and request each licensee to complete the form and file the original with the Department and a copy with the Chairman of the Board at the Department's address. The Department shall evaluate the available data about the licensee and shall issue a renewal license within thirty days of receipt of the application to each applicant who pays the renewal fee established by Section 13 of the Act and who has the qualifications necessary for issuance of an original license. The Department shall deny a renewal license within thirty days of receipt of the application of each applicant who does not pay the renewal fee or who does not possess the qualifications necessary for issuance of an original license.

RULE 7 - PERMITS

1. Criteria for Issuance:

A. Issuance of permits to conduct weather modification operations shall be based on the following factors:

(a) The applicant holds, or if the applicant is an organization rather than an individual, the individual who will be physically present in Illinois in control of the operation and under whose direction on a day-by-day basis it will be carried out holds, a valid professional weather modification license issued under Section 12 of the Act and Rule 6;

(b) The applicant has furnished proof of financial responsibility in accordance with Section 20 of the Act and under Rule 7 (6);

(c) The operation has technical and scientific feasibility and is reasonably conceived to do all or any of the following: improve water quality or quantity, reduce losses from weather hazards, provide economic benefits for the people of the State, advance or enhance scientific knowledge or otherwise carry out the objectives and purposes of the Act and these Rules;

(d) The operation does not involve a high degree of substantial risk to persons or property, is designed to include adequate safeguards to minimize possible damage to the public health, safety or welfare or to the environment and includes an emergency shutdown procedure which states conditions under which operations must be suspended because of possible danger to the public health, safety and welfare or to the environment;

(e) The operation will not adversely affect another operation for which a permit has been issued;

(f) The operation will not adversely affect any existing research and development project exempted from the licensing and permit requirements by Rule 5 (2) (a);

- (g) The applicant has complied with the permit fee requirement established by Section 18 of the Act;
- (h) The applicant has an acceptable plan for evaluation of the operation by using available surface data from sources such as the United States Department of Agriculture county crop yield reports, the United State Geological Survey stream flow gauges, the National Weather Service temperature and precipitation gauges and reports and the hail loss insurance records for the region; and
- (i) The project conforms to such other criteria as are set forth in the objects and purposes of the Act and of these Rules.

B. Projects must meet the following requirements before permits will be issued:

(a) Facilities and Equipment - General

(1) Aircraft, forecast facility, radar system, or any other equipment must be capable of replacement or repair within 72 hours in case of failure.

(2) The permittee shall provide an "operational center," with space adequate for all personnel and equipment. He shall record all aircraft-to-center-to-aircraft communications during seeding operations. These tapes shall be retained for the Department.

(b) Facilities and Equipment -- Aircraft

(1) Recognizing that the number of seeding aircraft is critical, the permittee shall provide for warm season (March to October) projects one aircraft per 500 square miles for the initial 1000 square miles and one aircraft for each 1000 square miles over the initial 1000 square miles if the intent of the project is to attempt to modify all potential precipitation elements in an area.

(2) Aircraft must be capable of both cloud-base seeding and mid-cloud seeding, with operational ceilings of up to 20,000 feet MSL.

(3) Each aircraft shall be complete with modern safety equipment and radio systems for communication with other project aircraft and the radar center of the project in conformance with the regulations of the Federal Aviation Administration.

(4) Project aircraft positions during seeding shall be indicated on the radar scope and photographed at least once every 5 minutes. Separate detailed records of aircraft position shall also be kept by pilots.

(5) Seeding devices, whether pyrotechnics or other commercial products, must document rated nuclei production output rates (tested within the past 2 years at Colorado State University laboratory). Proof of safe usage and performance must be offered. Equipment for carrying pyrotechnic flares shall be comparable to those commonly used and proven in past operations.

(c) Facilities and Equipment -- Forecast System

(1) There shall be a weather forecast facility at the project operational center containing a weather circuit teletype or weather map facsimile machine or the data and information from such equipment collected elsewhere and posted at least once during each hour.

(2) Criteria involving specific atmospheric conditions that must be achieved in 1) declaring a potential seeded period (alert), and 2) in deciding to launch a seeding mission will be listed and described in detail.

(3) Records shall be kept indicating how and what forecast and radar data were used to choose an operational period and the seeding method.

(4) Emergency shutdowns of operations must occur when severe storm watches (for flash floods or tornadoes) are issued by the National Weather Service for any or all parts of the operations area; when the tops of any radar echoes in or within 20 miles of the project area exceed 50,000 ft MSL; and/or when the Project Director decides that damaging severe weather will occur.

(d) Facilities and Equipment -- Radar System

(1) There must be a 5-cm or 10-cm wavelength radar system for directing operations and for recording all echoes in and around the target area. Detailed operational logs are to be kept showing times of all events, calibrations, problems, etc. These logs are to be given to the Department. A calibration of the radar must be performed at least once each month and recorded on radar film.

(2) Radar operations and data collection must be conducted until all echoes that existed in the target have dissipated or disappeared from the scope, and regardless for at least 60 minutes after seeding ends. Radar operations and data collection shall precede all seeding operations by at least 60 minutes; however, this requirement shall not restrict or limit the start of seeding operations when precipitation elements develop unexpectedly in the project area.

(3) Radar scope photography at 1° or less antenna tilt, at 3° antenna tilt, and of the maximum echo top are to be taken not less than every 10 minutes, using 16 mm or larger film. A copy of this film shall be given to the Department. Signal intensity differences (step gain or quantitative reflectivity contours) are to be photographed every 10 minutes at the specified elevations. Antenna tilt, time, date, range, azimuth, gain setting (signal intensity), and any other relevant data (such as any relectivity contours in use) are to be indicated and clearly depicted on each scope photograph. The scope for this photography shall be separate from the operational scope. Scope tracings by the operator shall be made at least every 20 minutes.

(4) All film shall be removed, developed, and reviewed weekly to ensure the quality of photography.

(5) If there are 2 or more widely separate target areas, an additional radar scope and an additional operator shall be provided.

(6) If a standard radar set is in use, coverage must extend out 20 miles to the SW, W, NW, of any target area. All such pre-target and target areas must be within 80 miles. Otherwise, another radar must be provided.

(7) The radar for data collection shall not be located within the target area unless suitable facilities do not exist within 25 miles of the target area.

(e) Personnel

(1) Project staff, including all meteorologists and personnel who direct seeding operations, shall have the skill and facilities needed to determine which of the possible seeding methods should be invoked on any given weather situation.

(2) Project pilots must have the experience and capability to recognize aloft both cloud-base and cloud-top seeding opportunities and to do both types of seeding, have evidence of knowledge and experience in use of both techniques.

(3) Two people are to be working at the forecast-radar center during all seeding operations. All must be trained and capable of radar operations and in weather forecasting with training equivalent to an associate degree in atmospheric sciences.

2. Application for Permit:

An applicant for a permit shall fill out and file with the Department the original of an application form available from the Department and a copy thereof with the Chairman of the Board at the Department's address no later than thirty days before the applicant plans to use the permit. The form shall require relevant information about the applicant and the proposed operation from which the Department can make an informed judgement whether or not to issue the permit and, in case of issuance of the permit, what conditions and limitations should be placed upon it. Among the data required is the following information about the applicant and the project:

(a) Name and address of the applicant;

(b) Whether a weather modification operational permit issued to the applicant in any jurisdiction has ever been suspended, revoked, placed on probationary status or subjected to any other disciplinary action or whether there has been refusal to renew such a permit by any jurisdiction. If there has been any such suspension, revocation, placement on probationary status or other disciplinary action or refusal to renew, the circumstances must be explained in full;

(c) If the applicant is a corporation, whether it is licensed to do business in Illinois;

(d) Names, addresses and numbers of all professional licenses issued under Section 12 of the Act and Rule 6 of the individuals in control of the operation and under whose direction on a day-by-day basis it will be carried out;

(e) Whether professional weather modification licenses issued to such licensees in any jurisdiction have ever been suspended or revoked or placed on probationary status or subjected to any other disciplinary action or whether there has been refusal to renew such licenses by any jurisdiction. If there has been any such suspension, revocation, placement on probationary status or other disciplinary action, or refusal to renew, the circumstances must be explained in full;

(f) Whether proof of financial responsibility has been furnished in accordance with Section 20 of the Act and Rule 7 (6);

(g) If the operation will be conducted under a contract, the value of the contract;

(h) If the operation will not be conducted under a contract, an estimate of the costs of the operation and information as to how the estimate was made;

(i) A copy of any promotional and advertising material used in connection with negotiations for the contract with the sponsor (if any);

(j) A complete and detailed operational plan for the operation which includes:

(1) The nature and objects of the operation;

(2) The legal description of and a map showing the operations area, the target area and the control area (if any);

(3) The approximate starting date of the operation and its anticipated duration;

(4) The kind of seeding agent(s) intended for use and the anticipated rate of their use;

(5) The kinds of weather modification apparatus which will be used and the method(s) of seeding for which they will be used;

(6) An emergency shutdown procedure which states conditions under which operations must be suspended because of possible danger to the public health, safety and welfare or to the environment;

(7) The means by which the operation plans will be implemented and carried out, such as the location of the main operational office and any other offices used in connection with the operation, the location of such ground equipment as seeding generators, radar and evaluation instrumentation, the number and kinds of aircraft which will be used and the extent to which weather data will be made available to the licensees and other personnel carrying out the project; and

(8) How conduct of the operation will interact with other projects;

(k) An acceptable plan for evaluation of the operation prepared in compliance with Rule 7 (1) (h); and

(l) Such additional information as will assist the Department in deciding whether or not to issue the permit.

3. Procedure for Issuance:

The Department shall evaluate all fully executed applications, using not only information derived from the completed application forms and accompanying them but also such other relevant data about the applicants and the proposed operations as it possesses or discovers. The Department may give public notice by newspaper, radio or television announcement in the area of the State reasonably expected to be affected by operations conducted under a permit that it is considering an application or more than one application for a permit, and may hold a public hearing for the purpose of obtaining information from the public concerning the effects of issuing or refusing to issue the permit. The Department may issue a permit in response to an application for an operation if it determines that there has been substantial compliance with Section 17 of the Act and Rule 7 (1). Otherwise it shall deny the application for the permit. The Department shall complete its action upon applications within thirty days of receiving them.

4. Conditions and Limits of Permit:

The permittee shall confine weather modification activities within the conditions and limits specified in the permit and those imposed by the Act and these Rules, except to the extent the conditions and limits are modified by the Department. The Department may condition and limit permits as to target area, time of the operation, materials and methods to be used in conducting the operation, emergency shutdown procedure and such other operational requirements as may be established by the Department. The Department shall condition and limit all permits in the following respects:

- (a) A permit may cover only one operation;
- (b) When an operation is conducted under contract, a separate permit is required for each contract; and
- (c) Only one permit will be issued at a time for operations in any geographical area if two or more operations conducted within the conditions and limits of the permits might adversely interfere with each other.

5. Duration of Permits:

Within thirty days of the end of each yearly permit period the permittee shall file a permit application form available from the Department, an original for the Department and a copy thereof for

the Chairman of the Board, at the address of the Department. The Department shall complete its action upon applications within thirty days of receiving them.

6. Proof of Financial Responsibility:

Proof of financial responsibility is made by showing to the satisfaction of the Department that the permittee has the ability to respond in damages to liability which might reasonably result from the operation for which the permit is sought. Such proof of financial responsibility may, but shall not be required to be, shown by:

- (a) Presentation to the Department of proof of purchase of a prepaid noncancellable insurance policy or a corporate surety bond issued by a company approved by the Department against whom service of legal process may be made in Illinois against such liabilities in an amount ten times the value of an operation conducted under contract or in an amount ten times the estimated costs of an operation not conducted under contract; or
- (b) Depositing with the Department cash or negotiable securities in an amount ten times the value of an operation conducted under contract or in an amount five times the estimated costs of an operation not conducted under contract.

7. Renewal of Permit:

At the expiration of the permit period, the Department shall issue a renewal permit to each applicant who:

- (a) At least thirty days before expiration of the permit period files the original of a permit application form available from the Department with the Department and a copy with the Chairman of the Board at the Department's address;
- (b) Meets the criteria for issuance of a permit under Section 17 of the Act and Rule 7 (1), including payment of the permit fee; and
- (c) Has an operational record which indicates that an original permit would be issuable for the operation.

RULE 8 - RECORDS

1. Daily Log:

Each permittee must fill in and retain a daily log of weather modification activities for each unit of weather modification apparatus used during an operation. The log form which will be available from the Department requires:

- (a) Date of the weather modification activity;
- (b) Each aircraft flight track and location of each item of weather modification apparatus during each modification mission. Maps may be used;

- (c) Local time when modification activity began and ended. For intermittent operations, the start and end of the total sequence are acceptable;
- (d) Duration of operation of each unit of weather modification apparatus, in hours and minutes;
- (e) Description of type of modification agent used;
- (f) Rate of dispersal of agent during the period of actual operation of weather modification apparatus, by hour or other appropriate time period;
- (g) Total amount of modification agent used. If more than one agent was used, report total for each type separately;
- (h) Local time when any radar monitoring operation was turned on and turned off;
- (i) Type of clouds modified, that is whether they were stratiform, isolated cumuliform, organized cumuliform or other types of clouds;
- (j) Remarks indicating such operational problems as equipment failure, weather conditions not conducive to successful performance of the operation, personnel problems and the like; and
- (k) Monthly totals from daily logs listing the total:
 - (1) Days during month in which operation conducted;
 - (2) Time of operation;
 - (3) Amount of each kind of agent used;
 - (4) Average rate of dispersal of each kind of agent used;
 - (5) Time of operation of radar; and
 - (6) Days of each type of cloud treated.

2. Weather Records:

Each permittee must obtain and retain copies of all daily precipitation total records available from the National Weather Service stations in the target area and other sources.

3. Summary Records:

Each permittee must prepare a monthly summary of the monthly totals from the daily logs of all units of weather modification apparatus used during an operation.

4. Addresses of Participants:

Each permittee must keep a roster of the names and Illinois addresses of all employees participating in the State on an operation for which a permit has been issued.

5. Inspection:

Duly authorized agents of the Department shall have the power to enter and inspect the records required by this Rule and to make copies of them.

6. Exempted Weather Modification Activities:

The Department may in its discretion require persons operating weather modification activities exempted under Rule 5 (2) to keep all or part of the records required of permittees by this Rule. These records shall be kept in such manner as the Department may indicate.

RULE 9 - REPORTS

1. Monthly:

Within ten days after the conclusion of each calendar month the permittee shall submit a report to the Department which shall consist of:

- (a) A copy of the summary record prepared under Rule 8 (3);
- (b) A copy of the roster of the names and Illinois addresses of all employees participating in the State on an operation which was prepared under Rule 8 (4);
- (c) A copy of the federal interim activity report form filed for that month with the National Oceanic and Atmospheric Administration in accordance with the rules adopted under the authority of Public Law 92-205; and
- (d) A narrative account of the manner in which operations during the month did not conform to the operational plan filed in accordance with Rule 7 (2) (j).

2. Final:

Within thirty days after completion of the operation the permittee shall file with the Department a final report on the operation which shall consist of:

- (a) Copies of the logs prepared in accordance with Rule 8 (1), of the weather records obtained in accordance with Rule 8 (2) and of the totals for the entire operational period from the monthly summary records prepared under Rule 8 (3);
- (b) A copy of the federal final activity report form filed with the National Oceanic and Atmospheric Administration in accordance with the rules adopted under the authority of Public Law 92-205; and
- (c) A narrative account of the manner in which the operation did not conform to the operational plan filed in accordance with Rule 7 (2) (j).

3. Evaluation:

Within sixty days after completion of the operation the permittee shall file with the Department a narrative evaluation of the

operation. The data for this report should be assembled and evaluated in accordance with the evaluation plan prepared in compliance with Rule 7 (1) (h).

4. Reports to Sponsors:

The permittee shall file with the Department a copy of all reports made by the permittee to sponsors of the operation.

5. Exempted Weather Modification Activities:

The Department may in its discretion require persons operating weather modification activities exempted under Rule 5 (2) but who have been required under Rule 8 (6) to keep certain records to file all or part of the reports required of permittees by this Rule. These records shall be kept in such manner as the Department may indicate.

6. Public Records:

All reports which are in the custody of the Department and which have been filed with it under the Act or Rule 9 shall be kept open for public examination as public documents during regular business hours of the Department's office located at the Department's address.

RULE 10 - PARTIAL INVALIDITY

If any portion of these Rules is held invalid, such invalidity shall not affect any other part of these Rules which can be given effect without the invalid portion.

APPENDIX D

The Council of State Governments' Weather Modification Control Act

Weather modification technology has been applied during the past 25 years to enhance precipitation, suppress hail and fog, and otherwise minimize adverse weather conditions. Almost two thirds of the states have enacted some legislation relating to weather modification activities. These statutes vary widely in completeness and approach. Most of them do not adequately address the issues created by use of weather modification technology.

The purpose of this suggested act is to provide a source which can be drawn upon by states wishing to enact legislation or fill the gaps in weather control laws. Adoptions of portions of it will result in greater uniformity of weather modification control in the country. The act establishes an administrative structure composed of a weather modification board as a division within an existing umbrella agency. Power is delegated to administrators to regulate weather modification through use of professional licenses for weather modifiers, operational permits for projects, and recordkeeping and reporting requirements to give the regulators and the public information. State and local agencies are allowed to engage in weather modification operations, if funds are appropriated and they meet the license and permit requirements. Provisions are made for establishing the legal right to use runoff resulting from precipitation enhancement and the legal liability of weather modifiers whose fault results in harm.

This suggested act expands considerably upon the provisions of the Weather Modification Act published in the 1953 volume of Suggested State Legislation. It has been taken from a draft weather control act prepared by Ray Jay Davis, Professor of Law, University of Arizona, with financial support from an allotment grant to Arizona by the Office of Water Research and Technology, U.S. Department of the Interior, as authorized under the Water Resources Research Act of 1964. A full report containing the original draft legislation and a section-by-section commentary on it may be obtained from the College of Law, University of Arizona, Tucson, Arizona 85721.

Suggested Legislation

(Title, enacting clause, etc.)

Article 1 [General Provisions]

Section 101. [Short Title.] This act may be cited as the [state] Weather Modification Control Act.

Section 102. [Definitions.] As used in this act:

(1) "Commission" means the [state] Water Commission.

(2) "Director" means the executive director of the [state] Water Commission.

(3) "Board" means the Weather Modification Advisory Board appointed pursuant to this act.

(4) "Weather modification" means any activity performed with the intention of producing artificial changes in the composition, motions, and resulting behavior of the atmosphere or clouds within the atmosphere, including fog, by placing or attempting to place any substance in the atmosphere or clouds within the atmosphere, including fog, or inducing changes in the atmosphere by use of electrical devices to charge the atmosphere, by lasers, or by alterations of the earth's surface. "Weather modification" does not mean any activity performed in connection with American Indian ceremonies.

(5) "Person" means any individual, corporation, company, association, firm, partnership, society, joint stock company, any state or local government or any agency thereof, or any other organization, whether commercial or nonprofit, performing weather modification operations or research and development, except where acting solely as an employee, agent, or independent contractor of the federal government or any agency thereof. "Person" does not include the federal government or any agency thereof.

(6) "Operation" means the performance of any weather modification activity undertaken for the purpose of producing or attempting to produce any form of modifying effect upon the weather within a specified geographical area over a specified time interval.

(7) "Research and development" means exploration, field experimentation, and extension of investigative findings and theories of a scientific or technical nature for purposes that may lead to practical application for experimental or demonstration purposes, including the experimental production and testing of models, agents, apparatus, and processes.

(8) "License" means a professional license issued by the commission indicating that a specified person has met the criteria for certification as a weather modifier and is approved to conduct weather modification operations for which permits may be issued under this act.

(9) "Licensee" means a person who holds a professional weather modification license issued under this act.

(10) "Permit" means an operational permit issued by the commission indicating that approval has been given for conducting a specified weather modification operation during a specified period of time within the state, subject to the conditions and within the limitations established under this act.

(11) "Permittee" means a person who holds an operational permit issued under this act.

(12) "Sponsor" means any person who enters into an agreement with a permittee to have weather modification activities performed.

(13) "Target area" means the surface area within which the effects of weather modification activities are intended to be found.

(14) "Operations area" means the area in which weather modification activities are conducted to produce or attempt to produce the desired effects within the target area.

(15) "Control area" means a selected, untreated surface area in which no effects of weather modification activities are expected and which is used for comparison with a target area.

(16) "Professional level" means a level of responsibility for direct supervision and conduct of operations or substantial parts thereof.

Article 2

[Administrative Provisions]

Section 201. [Administration.]

(a) The powers and duties enumerated in this act shall be exercised in the name of the commission.

(b) The director shall exercise the powers and duties enumerated in this act, except those enumerated in Section 202.

(c) The board shall assist the director by making recommendations concerning:

(1) Administration of and amendments to this act.

(2) Research and development

(3) Governmental operations

(4) Rules and regulations developed pursuant to this act.

(5) Notice, application, record, and report forms.

(6) Issuance, renewal, suspension, revocation, refusal to renew, and restoration of licenses.

(7) Issuance, renewal, duration, scope, modification, suspension, revocation, refusal to renew, and restoration of permits.

(8) Investigation and evaluation of operations.

(9) Other matters as may be requested by the director.

Section 202. [Weather Modification Advisory Board.]

(a) The Weather Modification Advisory Board is established, composed of five residents of the state appointed by the governor.

Members of the board as a group shall have qualifications and practical experience in agriculture, law, meteorology, and water resources.

(b) The governor shall appoint one member of the board to a term of two years, two members to terms of four years, and two members to terms of six years, commencing on the date this act takes effect. After expiration of the terms of the members first appointed pursuant to this act, each of their respective successors shall hold office for a term of six years and until their successors are appointed and qualified.

Members of the board shall be eligible for reappointment.

(c) The chairman of the board shall be designated by the director from among the members.

(d) Each member of the board shall be reimbursed for actual and necessary expenses incurred in performance of the functions of the board.

(e) The board shall hold an annual meeting at [date] and other meetings at times and places and upon notice as the board may determine. Three members of the board constitute a quorum for performance of its functions. The chairman of the board may contact other members of the board by telephone and they may conduct their business, except for the annual meeting, by telephone conference call.

(f) A record shall be maintained of all proceedings of the board. The record shall indicate which members of the board participated in the business of the board, what actions the board took, and how the members participating voted. This record shall be available for public inspection as a public document.

Section 203. [Governmental Operations.]

(a) Any county, city, town, district, authority, or other public body, agency, or political subdivision which has the power to produce, conserve, control, or supply water for beneficial purposes or to operate transportation facilities shall have the power, subject to this act, to expend its funds for and to engage in operations for the general benefit of the territory served by it.

(b) The commission may carry on operations and research and development activities by its own staff, by contract with permittees, or in cooperation with other agencies or persons.

(c) The commission may receive and accept any gift, grant, funds, or property from the federal government, or from the state or any other federal or state public body or political subdivision, or from any person and may expend the funds for the expense of administration of this act, including conducting operations and research and development activities under subsection (b) of this section.

Section 204. [Interstate Relations.]

(a) The commission may represent the state in matters pertaining to plans, procedures, or negotiations for interstate compacts relating to weather modification.

(b) The commission may represent the state in organizations concerned with weather modification, regulation of weather modification, or allocation of benefits and losses from weather modification.

(c) The commission may represent the state in matters pertaining to plans, procedures, or negotiations with agencies of the federal government relating to weather modification.

(d) In exercising the powers and duties enumerated in this act, the commission may consider the effect outside [state] which appears likely to occur as the consequence of weather modification operations and research and development activities conducted in [state].

(e) Weather modification operations and research and development activities conducted in [state] which are intended to affect the weather in a target area in another jurisdiction are prohibited, except upon full compliance with the laws of that jurisdiction as well as the provisions of this act.

Section 205. [Regulations and Forms.] In order to effectuate the objectives and purposes of this act, the commission shall adopt, amend or rescind reasonable rules, regulations and forms.

Section 206. [Hearings.]

(a) Except for emergency modifications of operational permits as provided in Section 409 (b), before suspending, revoking, refusing to renew, or modifying a license or a permit, the commission shall afford the licensee or permittee an opportunity for hearing. The notice of hearing shall be served on the licensee or permittee at least 10 days prior to the date set for the hearing, either by delivery of the notice personally to the licensee or permittee or by mailing it by registered mail to his last known place of business.

(b) The notice shall include:

(1) A statement of the time, place, and nature of the hearing.

(2) A statement of the legal authority and jurisdiction under which the hearing is to be held.

(3) A reference to the particular sections of this act and to the rules made under it which are involved.

(4) A statement of the reasons for the hearing.

(c) The commission and the licensee or permittee shall be afforded ample opportunity to respond and present, in person or by counsel, statement, testimony, evidence, and argument as may be pertinent to all issues involved.

(d) Informal disposition may be made of any contested case by stipulation, agreed settlement, consent order, or default.

(e) In contested cases the matter shall be heard by a hearing officer who shall conduct the hearing in accordance with the procedure established by [appropriate state statute].

(f) The record in a contested case shall include:

(1) A copy of the notice of hearing and all pleadings, motions, and interlocutory rulings.

(2) Evidence received or considered.

(3) A statement of matters officially noticed.

(4) Objections and offers of proof and rulings thereon.

(5) Proposed findings and exceptions.

(6) The decision and any opinion or report by the hearing officer presiding at the hearing.

(7) All staff memoranda, other than privileged communications, and data submitted to the hearing officer in connection with his consideration of the case.

(g) Oral proceedings or any part thereof shall be recorded manually or by a recording device and shall be transcribed on request of any party. The cost of the transcript shall be paid by the party making the request, unless assessment of the cost is waived by the commission.

(h) Findings of fact shall be listed in a written report by the hearing officer. Findings shall be based exclusively on the evidence and on matters officially noticed. The report shall also state what action the hearing officer recommends the commission take with respect to the license or permit in question.

(i) The final administrative action in contested cases shall be made by the director on behalf of the commission.

Section 207. [Investigations.]

(a) The commission shall have the power to investigate the operations and research and development activities of any person holding or claiming to hold a license or a permit issued under this act.

(b) Duly authorized agents of the commission shall have the power to enter peacefully and to make reasonable inspections of any place in which there is reasonable belief that operations or research and development activities are taking place, in which operations or research and development activities are in fact taking place, and the business premises of any person holding a permit issued under this act.

Section 208. [License and Permit Requirements.]

(a) Except as provided in subsections (b) and (c) of this section, no person may engage in operations or research and development activities unless such person acts under, and in accordance with, a license and a permit issued under this act.

(b) The following operations and research and development activities are exempt from the license and permit requirements of this act:

(1) Activities for protection against frost perpetuated and contained within the limits of the area to be protected.

(2) Operations conducted by the commission under the authority of Section 203.

(c) The following operations and research and development activities may be exempted by the commission through rules and regulations from the license and permit requirements of this act or payment of fees in connection with the license and permit requirements of this act:

(1) Research and development conducted by the state and its subdivisions, agencies of the state and its subdivisions, institutions of higher learning, and nonprofit research organizations.

(2) Activities normally conducted for purposes other than inducing, increasing, decreasing, preventing, or otherwise altering hail, precipitation, clouds, fog, cyclonic storms, or lightning.

(d) Except when authorized by the commission, operations and research and development activities exempted from license and permit requirements shall be conducted so as not to interfere with weather modification operations conducted under a permit issued under this act.

(e) Persons conducting exempted operations and research and development activities, other than activities for protection against frost, shall give the commission notice of their intent to engage in such activities so the commission can determine to what extent, if any, it will require them to comply with the recordkeeping and reporting requirements under Article 5 of this act. Notice shall be given by use of a form which shall be developed by and made available from the commission. The form will require the following data as a minimum:

- (1) Name and address of the person giving notice.
- (2) Name and address of the sponsor, if any.
- (3) Whether the activity is operational or research and development.
- (4) Nature and object of the activity.
- (5) A map showing the operations area, target area, and control area, if the activity involves any such area.
- (6) The approximate starting date of the activity and its anticipated duration.
- (7) The kind of weather modification agent(s) intended for use.
- (8) The kinds of weather modification apparatus which will be used.

Article 3 [Licenses]

Section 301. [Licensing Criteria.]

(a) Issuance of licenses shall be based on the applicant's character, knowledge of weather modification principles and techniques, experience in their application, and related education.

(b) In order to effectuate the objectives and purposes of this act, the commission shall make reasonable rules and regulations defining the character, knowledge, experience, and educational criteria for issuance of licenses.

Section 302. [Application for License.]

(a) The commission shall prepare a license application form which shall be designed to obtain data concerning the applicant's conformity with the licensing criteria established by Section 301 and rules and regulations made under it.

(b) Among the data required by the form is information about the applicant's:

- (1) Educational background at the college and graduate level.
- (2) Experience in weather modification or related activities, including indication as to what positions were held at the professional level.
- (3) Scientific or engineering society affiliations and the grade of membership in and certification by each.
- (4) Publications, patents, and reports.
- (5) References who will attest to the applicant's character, knowledge, experience, and education.

Section 303. [Licensing Procedure.]

(a) The commission shall evaluate license applications, including the responses from references, and other relevant data about applicants it possesses or discovers in order to determine whether applicants have the character, knowledge, experience, and education necessary to engage in operations.

(b) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations establishing procedures for evaluation of the character, knowledge, experience, and education of applicants.

(c) The commission shall issue a license to each applicant who pays the license fee established by Section 304 and who meets the criteria established by this article and rules and regulations made under it for issuance of a license.

(d) The commission shall deny a license to any applicant who fails to pay the license fee established by Section 304 or who fails to meet these criteria established by this article and rules and regulations made under it for issuance of a license.

Section 304. [License Fee.] The fee for an original license is \$[100]. The fee for a renewal license is \$[20].

Section 305. [Duration of License.] Each original or renewal license shall expire on [September 30] of each year.

Section 306. [Renewal of License.]

(a) Forty-five days before expiration of licenses, the commission shall mail license renewal application forms to all licensees and request them to complete the forms and return them with the renewal fee if they wish to have their licenses renewed.

(b) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations establishing criteria and procedures for renewal of licenses.

(c) The commission shall issue a renewal license to each applicant who pays the renewal license fee and who meets the criteria established by this article and rules and regulations made under it for renewal of a license.

Section 307. [Suspension, Revocation, Refusal to Renew a License.] The commission may suspend, revoke or refuse to renew a license for any one or any combination of the following causes:

- (1) Incompetency.
- (2) Dishonest practice.
- (3) False or fraudulent representation in obtaining a license or permit under this act or rules and regulations made under the authority of this act.
- (4) Failure to comply with any of the provisions of this act or of rules and regulations made under the authority of this act.
- (5) Aiding other persons who fail to comply with any of the provisions of this act or rules and regulations made under the authority of this act.

Section 308. [Restoration of License.] At any time after the suspension or revocation of a license or after refusal to renew a license, the commission may restore it to the licensee upon a finding that the requirements for issuance of an original license have been met by the licensee.

Article 4
[Permits]

Section 401. [Permit Criteria.]

(a) Issuance of permits to conduct weather modification operations shall be based on the following factors:

- (1) The applicant holds or, if the applicant is an organization rather than an individual, the individual who will be physically present in control of the operation holds a valid professional weather modification license issued under Section 303(c).
- (2) The applicant has furnished proof of financial responsibility in accordance with Section 405.
- (3) The operation is reasonably conceived to improve water quality or quantity, reduce losses from weather hazards, provide economic benefits for the people of the state, advance or enhance scientific knowledge, or otherwise carry out the objectives and purposes of this act.
- (4) The operation does not involve a high degree of substantial risk to persons or property, includes adequate safeguards designed to avoid possible damage to the public health, safety, or welfare, or to the environment, and includes an emergency shutdown procedure which states conditions and establishes procedures under which operations must be suspended because of possible danger to the public health, safety, or welfare or to the environment.
- (5) The operation will not adversely affect another operation for which a permit is under consideration or has been issued or any existing research and development project exempted from the licensing and permit requirements by Section 208(b) or (c).

(6) The applicant has complied with the permit fee requirement established by Section 404.

(7) The applicant has knowledge of any federal rules or regulations applicable to weather modification activities.

(8) The operation conforms to criteria established by rules and regulations promulgated pursuant to subsection (b) of this section.

(b) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations defining the criteria for issuance of permits.

Section 402. [Application for Permit.]

(a) The commission shall prepare a permit application form which shall be designed to obtain data concerning the applicant's and operation's conformity with the criteria for issuing permits established by Section 401 and rules and regulations made under it.

(b) Among the data required by the form is information about the applicant and the operation such as:

(1) Name and address of the applicant.

(2) Name, address, and license number of the individual who will be physically present and in control of the operation.

(3) Proof of financial responsibility in accordance with Section 405.

(4) If the operation will be conducted under a contract with a sponsor, the contract price.

(5) If the operation will not be conducted under a contract, an estimate of the costs of the operation and information as to how the estimate was made.

(6) A copy of any promotional and advertising material used in connection with negotiations or solicitation of the contract with the sponsor.

(7) A complete and detailed operational plan for the operation.

(8) Such additional information as will assist the commission in deciding whether or not to issue the permit.

Section 403. [Permit Issuance Procedure.]

(a) The commission shall evaluate all fully executed applications, using not only information derived from the completed application forms and materials accompanying them, but also other relevant data about the applicants and operations as it possesses or discovers, in order to determine whether applicants and operations meet the criteria necessary to engage in operations.

(b) The commission may hold a public hearing to obtain further information concerning the effects of issuing or refusing to issue a permit. The commission shall give notice to the public of such a hearing by newspaper, radio, or television announcement in the area of the state reasonably expected to be affected by operations conducted under a permit for which an application has been made. If no hearing is held, public notice of a proposed activity shall be given in the area of concern.

(c) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations establishing procedures for evaluation of applicants for permits and of the operations for which permits are sought.

(d) The commission may issue a permit to each applicant who pays the permit fee established by Section 404 and who meets the criteria established by this article and rules and regulations made under it.

(e) The commission shall deny a permit to any applicant who fails to pay the permit fee established by Section 404 or who fails to meet the criteria established by this article and rules and regulations made under it. The action of the director on behalf of the commission shall be the final administrative action of the commission in denial of a permit.

Section 404. [Permit Fee.] The fee for each permit or renewal shall be a minimum of \$[100]. If the operation will be conducted under contract and the value of the annual contract is more than \$[10,000], the fee for the permit or renewal shall be the equivalent of [1] percent of the value of the contract up to a maximum fee of \$[500]. The costs of the operation shall be estimated by the commission from information provided in the application for the permit or renewal and other information as may be available to the commission.

Section 405. [Financial Responsibility.] Proof of financial responsibility is made by showing to the satisfaction of the commission that the permittee has the ability to respond to damages which might reasonably be expected to result from the operation for which the permit is sought. Proof of financial responsibility may be shown by presentation to the commission of proof of purchase of a prepaid, noncancellable insurance policy or a corporate surety bond by a company against whom service of legal process may be made in [state] in an amount established by the commission.

Section 406. [Duration of Permit.] Except as otherwise provided, each permit or renewal permit shall expire [one] year from the date of issue. The commission may conditionally approve an operation for a continuous period not to exceed [four] years. Permits for conditionally approved operations must be renewed annually.

Section 407. [Renewal of Permit.] At the expiration of the one-year permit period, the commission shall issue a renewal permit to each applicant who:

- (1) Files a permit application form with the commission.
- (2) Meets the criteria for issuance of a permit under Section 401, including payment of the permit fee.
- (3) Has an operational record which indicates that an original permit would be issuable for the operation.

Section 408. [Scope of Permit.]

(a) The permittee shall confine weather modification activities within the conditions and limits specified in the permit and those imposed by this act and rules and regulations made pursuant to it, except to the extent the conditions and limits are modified by the commission.

(b) The commission may condition and limit permits to target area, time of operation, materials and methods to be used in conducting the operation, emergency shutdown procedures, and other operational requirements deemed appropriate by the commission.

(c) The commission shall condition and limit all permits in the following respects:

(1) A permit may cover only one operation.

(2) When an operation is conducted under contract, a separate permit is required for each contract.

(3) Only one permit will be issued at a time for operations in any geographical area if, in the judgment of the commission, two or more operations conducted within the conditions and limits of the permits might adversely interfere with each other.

Section 409. [Modification of Permit.]

(a) The commission may revise the conditions and limits of a permit if:

(1) The permittee is given notice and a hearing, in accordance with Section 206, on whether there is a need for the revision.

(2) The commission finds that a modification of the conditions and limits of a permit is necessary to protect the public health and safety or the environment.

(b) If it appears to the commission that an emergency situation exists or is impending which could endanger the public safety, health, or welfare, or the environment, the commission may, without prior notice or hearing, immediately modify the conditions and limits of a permit or order temporary suspension of the permit. The order shall include notice of a hearing to be held within [10] days on the question of permanently modifying the conditions and limits, continuing the suspension of the permit, removing the changes, or lifting the suspension.

(c) Failure to comply with an order temporarily suspending an operation or modifying the conditions and limits of a permit shall be grounds for immediate revocation of the permit and of the license of the person controlling the operation.

(d) The permittee shall notify the commission of any emergency which can reasonably be foreseen, or of any existing emergency situations which might be caused or affected by the operation. Failure by the permittee to notify the commission may be grounds, at the discretion of the commission, for revocation of the permit and of the license of the person controlling the operation.

Section 410. [Suspension, Revocation and Refusal to Renew Permit.]

(a) The commission may suspend or revoke a permit if it appears that the permittee no longer has the qualifications necessary for the issuance of an original permit or has violated any provision of this act or of any rules or regulations made pursuant to it.

(b) The commission may refuse to renew a permit if it appears from the operational records and reports of the permittee that an original permit would not be issuable for the operation, or if the permittee has violated any provision of this act or of any rules or regulations made pursuant to it.

Section 411. [Restoration of Permit.] At any time after the suspension or revocation of a permit or refusal to renew a permit, the commission may restore it to the permittee upon a finding that the requirements for issuance of an original permit have been met by the permittee.

Article 5
[Records and Reports]

Section 501. [Records.]

(a) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations requiring persons conducting weather modification operations in [state] to keep records in the manner and form required by the commission. The commission also may, by appropriate rule, require recordkeeping for operations and research and development activities exempted from the license and permit requirements of this act by Section 208(b) and (c).

(b) The commission shall develop and supply to permittees and other persons required to keep records by rules and regulations made pursuant to subsection (a) of this section, record forms which shall be designed to facilitate recording data about weather modification activities.

(c) Among the data required by such forms is the following information:

- (1) Date of the activity.
- (2) Position and location of each item of weather modification apparatus being used.
- (3) Time when the the weather modification activity began and ended.
- (4) Type, dispersal rate, method of dispersal, and amount of all weather modification agents used.
- (5) Weather conditions.
- (6) Instances when there was weather of types similar to those which the permittee is attempting to modify but in which there was no attempt to modify, and the reasons therefor.
- (7) The names and addresses of all individuals participating at the professional level in the operation or research and development.

(8) Other information which will assist the commission in the performance of its duties and responsibilities under this act.

Section 502. [Reports.]

(a) In order to effectuate the purposes of this act, the commission shall make reasonable rules and regulations requiring persons conducting weather modification operations to make reports to the commission in the manner and form required by the commission. The Commission also may, by appropriate rule, require reporting for operations and research and development activities exempted from the license and permit requirements of this act by Section 208(b) and (c).

(b) The commission shall develop and supply to permittees and other persons required to make reports by rules and regulations made pursuant to subsection (a) of this section, report forms which will facilitate reporting data, including that recorded in accordance with Section 501 and rules and regulations made under it.

(c) Reports in the custody of the commission which have been filed under the requirements of this act or under rules and regulations made pursuant to it shall be kept open for public inspection as public documents.

Article 6
[Judicial Provisions]

Section 601. [Judicial Review.]

(a) All final administrative decisions of the commission are subject to judicial review pursuant to the provisions of [appropriate state statute]. The term "administrative decision" is defined as in [appropriate state statute].

(b) Proceedings for judicial review shall be commenced in the superior court of the county in which the party applying for review resides. If the party is not a resident of [state] the venue shall be in the Superior Court of [] County.

Section 602. [Immunity.] Nothing in this act shall be construed to impose or accept any liability or responsibility by the state, the commission, and the officers and employees of the state and the commission for any injury caused by persons granted permits under this act or exempt from the permit requirement under Section 208(b) and (c).

Section 603. [Liability.]

(a) An operation or research and development activity conducted under the license and permit requirements of this act or exempt from them is not an ultrahazardous or an abnormally dangerous activity.

(b) Dissemination of weather modification agents into the atmosphere or clouds within the atmosphere, including fog, by a licensee

or a person exempt from the license and permit requirements of this act acting within the scope of the permit or exemption shall not in itself give rise to a cause of action.

(c) Except as provided in subsections (a) and (b) of this section and in Section 604, nothing in this act shall prevent any person adversely affected by a weather modification operation or research and development activity from recovering damages resulting from intentional harmful actions or negligent conduct by a person conducting weather modification operation or research and development activity.

(d) Other than in legal actions charging failure to obtain a license and permit, the fact that a person holds a license or was issued a permit under this act, or that a person has complied with the rules and regulations made by the commission pursuant to this act, is not admissible as a defense in any legal action which may be brought under this section against that person.

Section 604. [Penalty for Violations.] Any person violating any of the provisions of this act or of any valid rule or regulation issued under this act is guilty of a misdemeanor, and each day the violation continues constitutes a separate offense.

Section 605. [Suits to Recover Fees.] The commission shall have power to commence suit for the recovery of any fees due under the provisions of this act but unpaid.

Section 606. [Injunction.] The commission may, at its discretion, in addition to the other remedies provided in this act, apply to a superior court having venue and jurisdiction for an injunction to restrain repetitious violations of the provisions of this act and of any valid rule or regulation promulgated by the commission pursuant to this act.

APPENDIX E

Agreement Between the United States of America
and Canada Relating to the Exchange of
Information on Weather Modification Activities

The Government of the United States of America and the Government of Canada,

Aware, because of their geographic proximity, that the effects of weather modification activities carried out by either Party or its nationals may affect the territory of the other;

Noting the diversity of weather modification activities in both the United States and Canada by private parties, by State and Provincial authorities, and by the Federal Governments;

Believing that the existing state of knowledge warrants the expectation of further development over a period of time in the science and technology of weather modification;

Taking into particular consideration the special traditions of prior notification and consultation and the close cooperation that have historically characterized their relations;

Believing that a prompt exchange of pertinent information regarding the nature and extent of weather modification activities of mutual interest may facilitate the development of the technology of weather modification for their mutual benefit;

Recognizing the desirability of the development of international law relating to weather modification activities having transboundary effects;

Have agreed as follows:

ARTICLE I

As used in this Agreement:

- (a) "Weather modification activities", means activities performed with the intention of producing artificial changes in the composition, behavior, or dynamics of the atmosphere;
- (b) "Weather modification activities of mutual interest" means weather modification activities carried out in or over the territory of a Party within 200 miles of the international boundary; or such activities wherever conducted, which, in the judgment of a Party, may significantly affect the composition, behavior, or dynamics of the atmosphere over the territory of the other Party;
- (c) "Responsible agencies" means the National Oceanic and Atmospheric Administration of the United States and the Atmospheric Environment Service of Canada, or such other agencies as the Parties may designate;

- (d) "Reporting requirements" means the requirements established by the domestic laws or regulations of the Parties for reporting to the responsible agencies information relating to weather modification activities by persons or entities engaged in weather modification.

ARTICLE II

- (1) Information relating to weather modification activities of mutual interest acquired by a responsible agency through its reporting requirements or otherwise, shall be transmitted as soon as practicable to the responsible agency of the other Party. Whenever possible, this information shall be transmitted prior to the commencement of such activities. It is anticipated that such information will be transmitted within five working days of its receipt by a responsible agency.
- (2) Information to be provided by the responsible agencies shall include copies of relevant reports received through the reporting procedures after the effective date of this Agreement, and such other information and interpretation as the responsible agency might consider appropriate.
- (3) Nothing herein shall be construed to require transmission to the other responsible agency of information, the disclosure of which is prohibited by law, or of information which, in the judgment of the responsible agency, is proprietary information.

ARTICLE III

The responsible agencies shall consult with a view to developing compatible reporting formats, and to improving procedures for the exchange of information.

ARTICLE IV

In addition to the exchange of information pursuant to Article II of this Agreement, each Party agrees to notify and to fully inform the other concerning any weather modification activities of mutual interest conducted by it prior to the commencement of such activities. Every effort shall be made to provide such notice as far in advance of such activities as may be possible, bearing in mind the provisions of Article V of this Agreement.

ARTICLE V

The Parties agree to consult, at the request of either Party, regarding particular weather modification activities of mutual interest. Such consultations shall be initiated promptly on the request of a Party, and in cases of urgency may be undertaken through telephonic or other rapid means of communication. Consultations shall be carried out in light of the Parties' laws, regulations, and administrative practices regarding weather modification.

ARTICLE VI

The Parties recognize that extreme emergencies, such as forest fires, may require immediate commencement by one of them of weather modification activities of mutual interest notwithstanding the lack of sufficient time for prior notification pursuant to Article IV, or for consultation pursuant to Article V. In such cases, the Party commencing such activities shall notify and fully inform the other Party as soon as practicable, and shall promptly enter into consultations at the request of the other Party.

ARTICLE VII

Nothing herein relates to or shall be construed to affect the question of responsibility or liability for weather modification activities, or to imply the existence of any generally applicable rule of international law.

ARTICLE VIII

Each Party shall conduct an annual review of this Agreement while it remains in force, and shall inform the other of its views regarding the Agreement's operation and effectiveness and the desirability of its amendment to reflect the evolution of the science and technology of weather modification and of international law. The Parties shall meet periodically, by mutual agreement, or at the request of either, to review the implementation of this Agreement or to consider other issues related to weather modification.

ARTICLE IX

This Agreement shall enter into force upon signature. It may be amended by mutual agreement of the Parties and may be terminated by either Party upon six months written notice to the other Party.

APPENDIX F

The Management of Weather Resources

Volume I

Proposals for a National Policy and Program

This 229 page document, a Report to the Secretary of Commerce from the Weather Modification Advisory Board, accompanies this report as a separate volume. It was published on June 30, 1978. A limited number of copies are available from the Atmospheric Programs Office (RD2), National Oceanic and Atmospheric Administration, 6010 Executive Blvd., Rockville, Maryland 20852. Copies are also for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 003-018-00090-3).

APPENDIX G

The Management of Weather Resources Volume II

The Role of Statistics in Weather Resources Management

This 106 page document, a Report of the Statistical Task Force to the Weather Modification Advisory Board, accompanies this report as a separate volume. It was published on June 30, 1978. A limited number of copies are available from the Atmospheric Programs Office (RD2), National Oceanic and Atmospheric Administration, 6010 Executive Blvd., Rockville, Maryland 20852. Copies are also for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 003-018-00091-1).