Jemez y Sangre

Water Planning Council

Proceedings of the Jemez y Sangre Water Planning Council Cloud Seeding Workshop January 22/23, 2004 Santa Fe Hilton

Workshop Co-sponsors
Santa Fe Association of Realtors
Santa Fe Area Home Builders Association
Santa Fe County Chamber of Commerce
New Mexico Building Branch AGC
First National Bank of Santa Fe
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Executive Summary

The Jemez y Sangre Regional Water Plan recommended that a workshop be organized to develop partnerships, seek funding for one or more pilot cloud seeding projects, and work with ongoing state initiatives. The Regional Water Plan recognized that the effectiveness of cloud seeding in the Jemez y Sangre area would need to be demonstrated and that operational cloud seeding tests, specially designed for this area, need to be conducted to provide a credible assessment of cloud seeding potential.

A cloud seeding workshop was held, on the 22nd and 23rd of January, 2004, with the following goals:

- Educate the water planning community on the pros and cons of cloud seeding as a means for increasing precipitation
- Determine the level of local support for a cloud seeding pilot project
- Form a coalition to pursue such a pilot project/operational test

Thirteen leading speakers and panel members with local, regional, and international expertise in cloud seeding operations, cloud seeding evaluation, and climate processes were invited to the workshop. In addition to the experts on cloud seeding, personal invitations were sent to a broad group of individuals from the New Mexico Interstate Stream Commission (ISC), water planners and elected officials from local cities and countries, the Pueblos, ranchers and acequias, the ski resorts, environmental organizations, the media, professionals

from local industry and academia, and local businesses and organizations with an interest in the topic.

Additionally, a pre-workshop dinner was arranged with the water planners of Santa Fe City and County, Rio Arriba County, and the City of Espanola. Dr. Conrad Keyes' Jemez Mountains cloud seeding program in 1968-1972 was the main topic of discussion at the dinner.

The workshop was open to the public. Our current count of those who participated in the cloud seeding workshop is 84. It is believed that there may have been a few others who attended the workshop without registering. This level of participation clearly shows interest in understanding cloud seeding and using cloud seeding to increase precipitation.

The workshop program was designed to allow for 1) presentation of papers, 2) panel discussions, and 3) breakout sessions. The summaries extracted from the audiotaped sessions reflect that there was essentially unanimous agreement that cloud seeding may have the potential to enhance precipitation and that the potential may be realized in a very cost-effective way. Most participants seemed to agree that the body of evidence presented at the workshop was sufficient to try cloud seeding in the area. A copy of the audiotape can be made available to the interested reader upon request.

The speakers and panelists indicated, from experience gained in ongoing cloud seeding operations elsewhere, that the estimates of enhanced precipitation due to cloud seeding ranged from 10% to 30%. The operational costs involved in cloud seeding ranged from $1 to $10 per acre foot of additional water produced. These experts also indicated that such variability in precipitation augmentation and operational costs need to be expected and may critically depend on several factors, including the nature of the local terrain of the Jemez y Sangre area.

Benefit-to-cost ratios were presented as being an effective way to relate the benefits of cloud seeding to local stakeholders in successfully launching an operational cloud seeding program. However, such estimations are not easy to make for all the beneficiaries of increased precipitation. For example, in farming areas with summer cloud seeding, calculating the benefit to cost ratio in terms of pumping costs saved is straightforward. In the Jemez y Sangre area with diversified water use and, therefore, a wide range in the value of water, such calculations will be more complex.

There was a lot of discussion about the challenges of conducting unbiased and credible evaluations of cloud seeding projects. Some participants stated we currently lack a full understanding of exactly how cloud seeding works while others argued that there does indeed exist a lot of theory and understanding of cloud seeding processes. But just as it is difficult to accurately predict the weather even in a small area and for a short period of time, it is also difficult to translate the theory of cloud seeding into detailed step-by-step predictions of cloud seeding processes. The National Research Council Committee on the Status and Future Directions in U.S Weather Modification Research and Operations recently recommended increased research into weather modification approaches in order to better understand how this technology can be best utilized. The full report, "Critical Issues in Weather Modification Research", is

available at http://www.nap.edu/books/0309090539/html/. Additional useful information on this topic is contained in the response of the U.S. Weather Modification Association http://www.weathermodification.org/new_page_6.htm).

A lengthy discussion took place on the needed level of confidence in the estimates of enhanced precipitation resulting from cloud seeding. To gain scientific acceptance, one generally needs to show a high level of confidence, 95% or above. In other words, if the confidence level is less than 95%, which is the case in many cloud seeding efforts with confidence levels typically between 80% and 90%, the precipitation enhancement resulting from the seeding efforts has a 10% to 20% chance of being a result of good fortune i.e. it just happened to rain or snow a lot.

One must then ask the question: Is a level of confidence below 95% sufficient to risk private and public funds to attempt to enhance precipitation in the Jemez y Sangre area? What weight should we place on observing a succession of cloud seeding projects with confidence levels in the 80% to 90% range? How should we interpret the occasional cloud seeding project that has failed? Most importantly, are the chances for successful cloud seeding efforts in this area as good as in other areas? It was reported that farmers and ranchers, ski resorts and water boards generally accept levels of certainty less than 95%. It was felt that a lower but still high level of certainty was sufficient to justify moving forward with an operational test of cloud seeding in this area given the upside potential of cloud seeding and the value of such enhanced precipitation.

Given the strong consensus at the workshop for going forward with a cloud seeding project, the participants turned their attention to the practical considerations of how to move forward. A number of committees and groups were recommended to be formed to get a cloud seeding effort going in the Jemez y Sangre area. These committees and groups include a:

Funding and Operations (F&O) Committee to raise money for cloud seeding and either cause to be formed a coalition to conduct cloud seeding or become that organization.

Technical Advisory Group (TAG) to provide the technical inputs into any project in this area both in the initial and operational phases of a cloud seeding project. Winter and summer cloud seeding approaches are very different. Strategies may include a focus on improving precipitation efficiency by converting super-cooled liquid water (SLW), enhance vertical air currents, or focus on enhancing the collision and coalescence of rain droplets in clouds. There are many choices of chemical and mineral agents to stimulate these processes and many choices of delivery methods for these agents. Similarly, there are many choices of methods for assessing the effectiveness of cloud seeding.

Citizens Advisory Group (CAG) to educate the public on cloud seeding and to offer a public forum to provide input into any cloud seeding programs initiated, including a forum for concerns to be raised. Some known concerns about cloud seeding programs in other areas include concerns related to the effectiveness of cloud seeding, impact on downwind areas, unexpected consequences such as floods and avalanches, potential contamination due to the seeding agents, too

much precipitation at the wrong time (agricultural considerations), religious concerns about tampering with the weather, and a concern that more precipitation now might negatively impact long-term conservation efforts. Many of these concerns can be addressed by educating and by structuring the cloud seeding program in a way that reduces the risks.

New Mexico Weather Modification Association (NMWMA) to promote cloud seeding and to provide a professional society for those working in the field. Also this might be a good venue to address the economic development opportunities for New Mexico resulting from development of expertise in weather modification such as software development and modeling, radar and other equipment development, consulting both on cloud seeding operations and evaluation, and aviation.

In addition to the above committees and groups, there was recognized an immediate need for a full-time person or the equivalent to work on getting a cloud seeding project underway and an institutional framework in which multiple stakeholders can cooperate and share costs and human resources. Currently, there is no permanent Region 3 (Jemez y Sangre) institutional infrastructure. The Region 3 Water Plan was developed by an ad hoc organization, the Jemez y Sangre Water Planning Council, which continues as a volunteer organization.

A description of the January 22nd and 23rd program follows. It includes short summaries of each session.

Workshop Program and Summary of the Presentations, Panel Discussions, Breakout Sessions and Final Plenary Session

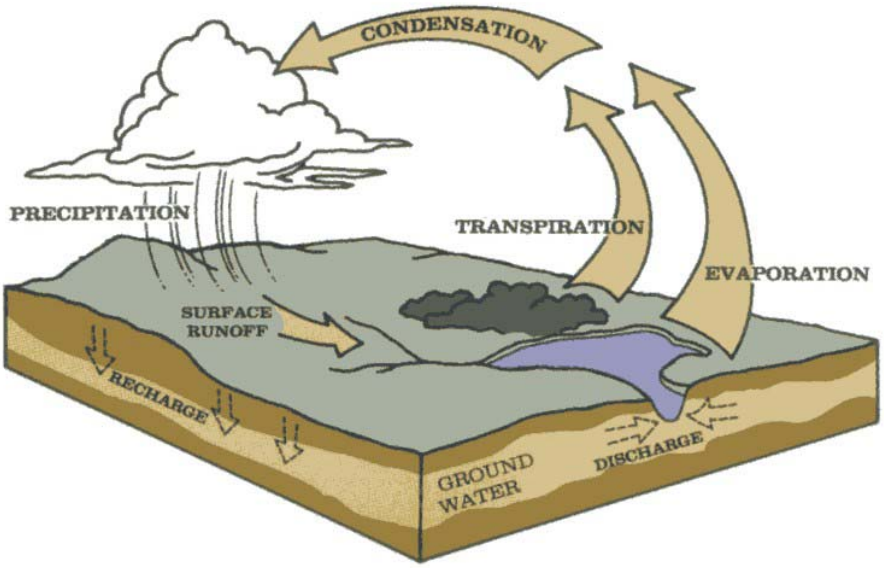
Thursday January 22

8:00 to 8:10 AM Welcoming Remarks by Elmer Salazar Co-chair Jemez y Sangre Water Planning Council.

The need for this workshop was recognized in the Jemez y Sangre Regional Water Plan which was prepared by a very broad-based coalition of constituencies and was accepted by the ISC on April 23, 2003. The Governor, the OSE Director, and the ISC Director are pleased that we are going to have a science-, technology-, and business-based discussion of our cloud seeding options.

MORNING----PRESENTATIONS
(Each presentation was followed by ten minutes of questions and answers)

8:10 to 9:05 AM Dr. WILLIAM L. WOODLEY (President, Woodley Weather Consultants). Organizing and Assessing Cloud Seeding Programs.



depiction of the hydrologic cycle. Precipitation is not "lost", but is recycled through runoff, evaporation, and transpiration. (Graphic by B. Hove, ND State Water Commission.)

The presentation began with a discussion of the importance of water to New Mexico and then raised the question whether cloud seeding might have some potential for augmenting New Mexico's water supply. A discussion followed of natural cloud processes and how seeding alters these processes to increase precipitation. Seeding with ice nuclei (e.g., silver iodide) is done to enhance the ice processes in the clouds while seeding with hygroscopic salts is done to promote the growth of raindrops. Examples of how each method is carried out were given in the context of the operational cloud seeding projects in Texas. It was emphasized that not all clouds are suitable for seeding and that seeding must be adapted to the cloud conditions in much the same way that physicians adapt their treatments to the needs of their patients.

Woodley then raised the question whether we have the right to do cloud seeding that alters the weather. He then demonstrated the many ways that humanity already inadvertently alters the weather. These ways range from the acceleration of global warming, to the alteration of the protective ozone layer in the upper atmosphere, to the suppression of precipitation by introducing into the atmosphere impurities from fires, industrial, and urban sources. Such suppression of precipitation was shown to be especially noticeable in Australia, California, Israel and much of Southeast Asia and Central Africa. The reality is that we already have weather modification whether we like it or not!

It was then noted that Mother Nature employs sea salt from evaporating sea spray to naturally seed clouds to enhance droplet coalescence and rainfall. This process taking place over the oceans cleanses the atmosphere of its pollutants and literally saves us from suffocating. Unfortunately, no such cleansing mechanism exists over the land and Woodley suggested that deliberate

hygroscopic cloud seeding with common salt might be used to increase rainfall and to decrease pollution over land areas. He noted that hygroscopic seeding appears to have great potential for increasing rainfall in New Mexico.

Woodley concluded his talk by outlining a program of research and operations for New Mexico, leading ultimately to enhancement of its water supply. This program would involve both glaciogenic (with silver iodide) and hygroscopic cloud seeding, the use of cloud models to predict the seeding outcome and an ambitious field program involving aircraft, radar and satellite measurement platforms. The importance of evaluating everything that is done was emphasized, because this facilitates the refinement of approaches and improvement in results over time.

9:05 to 9:45 AM DON GRIFFITH (President, North American Weather Consultants) "Review of Cloud Seeding in the Southwest---an Operators View"

Benefits from seeding include increased surface run-off for hydroelectric plants, hail suppression, increased rainfall for aquifer recharge and crops and increased snow-pack (summer run-off) for agricultural and municipal use. Orographic (mountainous areas) seeding has been done successfully in California for 50 years. In Utah, a long-term (since 1947) program utilizing 130 ground-based generators is funded by state and local organizations. It has been producing a 15% (4% to 19%) increase in precipitation or approximately 250,000 acre feet per year. Independent analysis by a state agency has shown the cost of increased precipitation by winter seeding projects to be as low as $1.00 per acre foot. The benefit of seeding has been shown to occur 50 to 75 miles downwind. NOAA reports an increase in cloud seeding in the Southwest over the past 10 years, with 66 programs conducted in 2001. During this period there were no programs conducted in NM (with the exception of a Texas Panhandle program which included two counties in southeastern NM).

9:45 to 10:25 AM Dr. CONRAD KEYES (retired NMSU Professor and now consultant) " A Winter Cloud Seeding Program in the Jemez Mts., 1968-1972"

The success of cloud seeding in the JyS area was demonstrated with a four-year winter seeding project which started in 1968 in the Jemez and Sierra Nacimiento Mountains. Five silver iodide ground generators sites were located along the west side of the Jemez Mountains and numerous snow gauges were placed upwind, in the target area, and downwind in the Jemez, Nacimiento, and western Sangre de Cristo Mountains. The generators were ignited as a function of wind direction and cloud top temperatures and real-time monitoring of snow gauges indicated which areas experienced increased precipitation and in what amounts.

Because it was randomized (50% of the forecasted precipitation days), the project came close to and may indeed have met the scientific standard of 95% confidence (meaning there was less than a 5% probability that the increased precipitation happened by chance). The benefit was at least a 13% increase in precipitation over the entire suggested target area. Had all storms been seeded effectively, the increase in precipitation in the Jemez Mountains. would have been nearly 30%. Significantly, several snow gauges in the foothills of the Sangre de Cristo Mountains, about 65 miles downwind to the east (not part of the designed target area), also showed increased precipitation, although in smaller

amounts. The 3-cm weather radar was moved to a high elevation for one month in the summer of 1972, and, while no clouds were seeded, radar suggested that summer seeding in the Jemez Mountains would also be successful.

Conrad suggested we consider a radar installation at a high elevation in the Jemez Mountains and a year-around seeding program. One interesting finding, based on partitioned results, of this 1969-1972 winter orographic project was what appeared to be a differential benefit of cloud seeding depending on cloud-top temperatures with the higher and lower temperatures producing better results than temperatures in the middle of the range. This information, based on two different seeding agents, might be helpful in planning projects in our geographic area.

10:25 to 1:40 AM Break and mingle

10:40 to 11:20 AM DUNCAN AXISA (Project Director and Meteorologist, SOAR) "Summer Cloud Seeding on the Great Plains"

Duncan Axisa: "Summer Cloud Seeding on the Great Plains"
Summer programs using aircraft with silver iodide flares were conducted in 2002 and 2003 in west Texas and southeastern NM for recharge of the Ogallala aquifer (the Southern Ogallala Aquifer Rainfall, or SOAR program). NEXRAD (NEXt generation RADar) estimates of precipitation are considered superior to rain gauges and allow for a new assessment method. The computer-based method used radar to define floating targets and used a matching procedure to compare precipitation in seeded and non-seeded areas. Although not randomized, and therefore not meeting the scientific standard of 95% confidence, the method is considered highly credible because of techniques used to eliminate bias and re-randomize calculations. This analysis indicated that the program increased average rainfall in seeded units by 52% in 2002. SOAR is considering next year doing a randomized program to assure scientific acceptance and to try hygroscopic seeding, using finely ground salts.

11:20 to Noon GEORGE W. BOMAR (Texas State Meteorologist) “How Other States Look at Cloud Seeding, Status of Research, and Plans for the Future”

Technology in cloud seeding is being pursued because we are on to something! Reports of State Agencies responsible for licensing or oversight of seeding operations are likely to be conservative and less biased.

- Colorado: winter of 2002-3 at a cost of $1,200,000 reported seasonal increase of 17%.
- Vail achieved an increase of 24.5% seeding only specific clouds
- Utah: On 5 projects (some as old as 20 years.) showed increases of 4% to 15% at a cost of $1,300,000. Also found an increase of run-off of 250,000 acre feet, a 13% increase.
- North Dakota: In 2003 there were 678 seeding flights, dispersing 162 kilograms of Silver iodide. The result was a 46% reduction in hail damage on a long-term average.
- Kansas: A comparison of target and control areas for 15 years showed a benefit/cost ratio of 37 to 1, valued at $60,000,000.

- Texas: Since 1997 the State Legislature has provided $15,000,000 in matching funds to local projects (10 in 2003) seeding 51,000,000 acres, about 30% of the State. Texas Tech calculations show that if a 21% increase in rain were achieved this would result in an agricultural gain of $350,000,000 for seventeen West Texas counties, a 70 to 1 benefit to cost ratio. Texas randomized for several summers, 34 experimental units. Individual clouds showed a production of 2.5 times over un-seeded clouds which also lived twice as long as the unseeded. In 2003 seeding only single clouds showed an increase of 250,000 acre feet at a cost of $11.50 per acre foot. With funding from the Bureau of Reclamation, Texas is leasing and equipping an airplane that will, in 2004, measure and identify seasonal changes in natural kinds of CCN. The purpose is to determine the best kind of CCN to use, when to use and how to disperse and to test new material CCN .

Conclusion: Seeding has been worthwhile. We need to do a climatology review to discover our windows of opportunity and how long they last. How many clouds reach high enough to have super-cooled water? A lot of work needs to be done in operations i.e. to determine how much seeding material is getting to clouds with super-cooled water that need a nudge. A federal WMA Board to allocate federal funds and oversee projects is proposed in a bill by Sen. Hutchinson of Texas. To be in the loop we need to communicate with the NM member of the North America Interstate Weather Modification Council. (Editors note: Doug Murray is the representative from NM).
http://www.naiwmc.org/NAIWMC/Membership.html Federal money will come through State agencies therefore it is important to gain State support.

Noon to 1:00 PM Break for Lunch

AFTERNOON----PANEL DISCUSSIONS
(Each panel member spoke for 10 minutes, followed by a 20 minute question and answer session. Panel members were speakers from the morning session, plus other experts.)

1:00 to 2:00 PM "Anticipated Benefits, Costs, and Risks of Cloud Seeding" Session Moderator: Alan Jager 1:00 to 2;00 Panelists: George Bomar, Don Griffith, Gary Walker, and Pat Sweeney

Cloud seeding programs on the south plains of Texas are designed to augment the rain and groundwater where there is no surface water. The reliance on pumping from the Ogallala aquifer has caused the water level to drop 2-5 feet per year. The Ogallala aquifer is practically non-rechargeable due to tight formations. Only 20-30 feet of saturated aquifer remains. Rainfall of 10 inches occurs during the growing season from April to September. Pumping costs are $10 per acre-inch. If a farmer gains one inch or 10% from summer cloud seeding, he immediately saves $120 per acre foot of water used. If the cost of the program is $1 per acre foot of augmented precipitation, a 120:1 benefit to cost ratio is achieved. Risks of undertaking a cloud seeding program are mainly objections by people that don't believe in cloud seeding.

Programs in North Dakota have increased snow and rain and provided hail suppression, resulting in higher wheat yields. Five-year technological transfer programs overseas have trained local individuals in meteorology, atmospheric

sciences, commercial aviation, and electrical and software engineering. Costs for a New Mexico program cannot be estimated until the project size is defined. The greatest cost risk is that personnel and equipment remain idle waiting for clouds.

Silver Iodide used in cloud seeding is a negligible risk to the environment since less that 1/250th of acceptable public health levels are found in water samples from seeded areas. Cost estimates for large summer programs are generally $1 per acre or double if a cloud physics research aircraft is required. Indirect benefits are stream flow, filled reservoirs and savings of pumping costs. The number of participants can determine the size of the project and the target areas.

The importance of keeping good records was stressed for many reasons including the ability to evaluate the potential tie in with severe weather taking place anywhere in the vicinity of where cloud seeding took place.

2:00 to 3:00 PM "How Will We Assess the Results of the Pilot Project?" Session Moderator: Dr. John Brown; Panelists: Bill Woodley, George Bomar, Bruce Boe

Presentations and discussions centered around Cloud Seeding, its terms and location definitions. Differences in techniques for glaciogenic and hygroscopic seedings were noted. Areas to be identified included "operational", "target", "control" and "buffer". Randomization was reviewed with costs, benefits and alternative methods to establish acceptable evidence of accomplishments. Data for comparison purposes from ground precipitation measures, stream flow, radar (reflectivity), micro-wave radiometry (to assess cloud characteristics), tracing, crop yield, and modeling were presented. Modeling is especially important in establishing sites for ground-based generators, defining target areas etc.

Assessment of existing conditions data is available and historic data records can include all of the above measures and the amount of silver naturally found in snow, stream and soil. Good targeting is necessary to optimize probability of success. Actual upper air soundings on locations and exploratory seedings can be used to know when you do have super-cooled water. Data sources recommended included archived weather data, satellite data, climatology, cloud directions and durations. It was emphasized that "this is a precipitation enhancement program and not a drought abatement program". Pre-operational data enables us to better understand what we are doing and maximizes benefits. New technology and data from other disciplines improve current success in cloud seeding.

3:00 to 3:15 PM Break and mingle

3:15 to 4:15 PM "Alternative Approaches to Structuring the JyS Pilot Project". Session Moderator: Doug Murray ISC Project Manager; Panelists: Conrad Keyes, Duncan Axisa, Bill Woodley, and Roelof Bruintjes

A better understanding of alternatives will be aided when the tools are known e.g. radar. The Albuquerque radar is fine but it is partially blocked in the JyS area by mountains. A new Espanola radar with 4 degree inclination can cover almost all this area. A previous radar on Antonito Peak reached all but the valley. This overlaps the Albuquerque radar. Good modern radar is needed to monitor

operations, evaluate results and protect aircraft operations in clouds. Operations should be year round (winter and summer seasons) because of locations of reservoirs. Variations in where to seed will be affected by

- Desire for recharge or
- Desire for run-off.

While seeding will be upwind, wind direction etc. will vary measure-ment locations. Today's technology improves accuracy of measurements, which data , including aircraft instruments, can aid 3-D modeling and include measures for pollutants and silver iodide. Scientific and statistical analyses can result.

Note: Dr. Bruintjes "The National Center For Atmospheric Research panel was made up of very skeptical people but all came around to the decision that this is a very valuable field of study".

4:15 to 4:50 PM Discussion of the breakout sessions planned for Friday: Attendees interested in participating in Friday's working sessions reviewed the suggested assignments accepted them or changed them and Breakout Session Leaders met briefly with their teams.

4:50 PM End of Official Program for Thursday.

5:30 Reception

6:00 Welcoming Remarks by Estevan Lopez ISC Director

Mr. Lopez greeted the group that attended the dinner, welcomed the attendees, and expressed his interest in having more precipitation. The ISC has been given the responsibility for regulating cloud seeding. The State of New Mexico wants to explore cloud seeding but recognizes disagreement with respect to the prior results. The ISC wants to evaluate cloud seeding fully and in a way that we end up understanding what the results will be. He was encouraged that those at the workshop shared the same desire for objectivity.

6:10 Summary of Days Program by Sigmund Silber:

Cloud seeding was presented today as having great potential for providing enhanced precipitation in our area. Although there are difficulties in quantifying the additional precipitation to the level of confidence required in scientific research, as an engineering application there was a strong consensus that the technology works.

Many of the presentations and discussions demonstrated that "integration" is an important framework for thinking about cloud seeding. Success in cloud seeding depends on many factors including good modeling capability, ability to measure precipitation whether this be by traditional means or by the use of tracers which may tie in with other water management objectives, an understanding of the impacts of pollution, participation of the universities, the ability to collect additional precipitation, and the time phased requirements for additional precipitation by the full spectrum of potential users.

But just as integration is important so is phasing. Much analysis needs to be done prior to releasing a seeding agent into a cloud. These pre-seeding activities can start soon. If we can get these pre-seeding activities under way, the timeframe for being able to seed clouds and get more precipitation will be condensed.

6:25 PM Presentation of Award to Walton Chapman: Walt was the head of our fund raising committee. We decided to approach the private sector to fund this workshop because we felt they might be able to respond more quickly than the public sector and this proved to be correct thanks to Walt's leadership.

Dinner

After Dinner Presentation by David Gutzler: Climate Cycles Past Present and Projected.

Drought is hard to define, he knows one when he sees one.

There are two basic types of drought.

(1) Meteorological drought --- lack of precipitation in the area.
(2) Hydrological drought --- lack of water coming downstream. In our case lack of snow pack in the headwaters of the Rio Grande. For the last 4 years the water at the Otowi gage has been below normal.

We are having both kinds of drought. One might also talk about Agricultural drought --- lack of rain during the growing season. The current drought covers the entire west with the worst being in New Mexico. This is the most extensive area of drought in this century.

The last drought period was in the 1950s. The lead in to this drought resembles that one, but we are not at the 50s yet. It happened before and it can happen again! The previous drought was at the turn of the twentieth century. The 80s and 90s were abnormally wet periods.

Droughts seem to come in cycles with the water temperatures in the Pacific Ocean having something to do with it. El Nino refers to warmer water along the equator from the international date line to the coast of South America. An El Nino usually portends a good snow pack upstream from us due to the movement of the jet stream from Japan. However the El Nino of last winter didn't help out.

There is an area in the northern Pacific called the Pacific Decadal Oscillation (PDO) which is now also thought to affect our weather. The temperature there varies on a slower time frame than El Nino. It doesn't actually oscillate, but rather flip-flops. When it flops the wrong way, El Nino is not as effective.

In order to get a long term look at the weather, growth rings in trees are studied. The wider the ring, the greater the precipitation. Growth rings were correlated with known weather data for periods in which records were kept, and a regression formula was set up. This formula was then used to compute precipitation from the growth rings of earlier periods (before 1800s).

It appears that droughts come in cycles of 50-80 years. We had a drought at the turn of the century and in the 1950s so 50 years puts us at the present.

There was a mega drought in the 16th century which covered the entire west, and lasted for decades. Since the current drought covers the entire west, we could be headed into such a drought. There was also a 13th century major drought.

Friday January 23

8 AM We Resume

8:00 to 8:10 AM Administrative arrangements for the Breakout Sessions were discussed.

8:10 to 10:30 AM Breakout Sessions.

Breakout Session A: "How to Prepare the Community for a Cloud Seeding Program"
Session Leader: John Buchser, Chair Conservation Committee, Rio Grande Chapter, Sierra Club. Facilitator: Ed Moreno

Out of the discussion came the following goals:

Goal 1: Establish an Outreach Program
An outreach program is essential to building community awareness and support and to address any community concerns.

- Localized – not "this is how we did it in (wherever)"
- Focused on public officials and agencies, local, state and federal
- Includes outreach to tribes and acequias (agriculture)
- Media relations \ especially television weather meteorologists
- Informal approach – open houses rather than formal hearings
- Pro-active and patient, especially with tribes and others that may be hard to reach
- Special emphasis on communication with the National Weather Service:
  - Science Operations Officer (SOO)
  - Meteorologist in Charge (MIC)
  - Warning Coordinating Meteorologist (WCM)

Goal 2: Establish the New Mexico Weather Modification Association
The purpose and activities of the organization would include:

- Speaker's bureau
- Educational programs for the public
- Resources and information for the public and for members
- Seminars for members
- Help members establish priorities for programs
- Build credibility for weather modification
- Coordinate programs and educational activities

Members would include business, higher education institutions and others

Goal 3: Conduct Weather Modification Projects

The execution of projects would be an effective way for the public to have some experience with cloud seeding. Elements would include:

- Identifying sponsors for projects
- Securing money from federal and state sources for research
- Monitoring and evaluation of projects
- Science and projects should be kept separate

Goal 4: Engage the Regulatory Process
The Interstate Stream Commission was given regulatory authority over weather modification and is in the process of revising the applicable regulations. Now is the time for the weather modification interests to have its voice heard in the regulatory process.

Breakout Session B: "How Might We Initiate a Cloud Seeding Pilot Project"
Session Leader: Sigmund Silber; Facilitator: Seth Cohen

Although Group B was small and did not have the breadth of representation that might be considered a community consensus, those there believed that the general consensus of those attending the workshop was that an attempt should be made to initiate a cloud seeding project. This then led to the following recommendations:

1. Identify a resource person. This individual should be paid for his/her position. Individual could be a professional lobbyist. Individual should be culturally competent (be able to relate to surrounding communities, acequia commissions, sovereign Pueblos, etc.)

2. Form a steering committee. The responsibility of initiating a Cloud Seeding project needs to be shared among interested stakeholders. **The steering committee should consist of interested parties who stand to benefit from the Cloud Seeding Project**. Potential members include: Ski Area representatives, owners of Golf Courses, acequia commissions, Chambers of Commerce, agriculturalists, environmentalists, developers, representatives of banks, representatives from the hospitality industry, local officials/public representatives, and Indian Pueblos.

a.) Identify a champion: After a core group is established, the Steering Committee should identify a champion for the project and the affected region.

b) Identify the target area. There are still questions and concerns about the geographical area represented by the Steering Committee and the size of the committee. A maximize of 25 members was recommended. The scope of a Cloud Seeding Project could be determined by stakeholder support and funding. Again, make sure the project target area benefits all parties on Steering Committee.

c.) Utilize local Chambers of Commerce. Initial steering committee members should utilize the support of local Chambers of Commerce to draft and send an invitation letter to potential Steering Committee members. A first step might be to set up a meeting with leaders from the four municipalities.

Breakout Session C: "How to Develop the Specifications for a Cloud Seeding Pilot Project"
Session Leader: Roy Stoesz: Facilitator: Lucy Moore

Issues discussed included:

Scientific Acceptance: The group discussed at some length the need for scientific acceptance of the design and results of a local cloud seeding program. Some felt that it was imperative to develop a program that could meet current international scientific standards, which include a confidence level of 95%. (The percentage is not a measure of the success of the program, but rather a measure of the confidence of being able to measure what you did.) Using this standard would almost certainly require a randomization program. Others felt that the program should be designed to produce precipitation, and evaluated based on those results. The 95% figure, some argued, was apparently derived from the medical field, and was inappropriate in this context.

Program Goals: Goals of the program are: 1) produce precipitation; 2) increase streamflow in the Santa Fe watershed, and perhaps the Pecos and Chama watersheds, as well; and 3) produce credible results – for either the scientific community, or public, or both.

Pre-program Preparation: Experts advised the group to gather and analyze data before designing a program. It is critical, they said, to build a physical understanding of the region and evaluate several factors, and to be clear about the goal of the program before creating the hypothesis and design for the program.

Data Needed: Baseline data needs to be analyzed. Some is available, some will need to be collected. Several people believe it may take a year to collect and interpret the data before a project could start.

Radar: The group agreed that radar installation at a key point is needed, both for a winter and summer program.

Summer Program: A summer program would benefit local agriculture, which depends heavily on unreliable summer monsoons. Acequias are fragile operations with significant political clout. Precipitation in the summer would also benefit city residents, with gardens, trees, etc. Fire and weather data, cloud process data, radar climatology, and an aircraft cloud probing program could all contribute to the database. There is no history of cloud seeding in high mountains in the region in the summer. Assessment would be based on radar, rain gauges, or stream flow measurements.

Winter Program: A winter program would require meso studies and modeling, Some said answering the randomizing question was premature for the winter program until data had been analyzed. There was a lengthy discussion of Dr. Keyes' successful four-year randomized project in the Jemez.

Reconsidering the Size of the Area: Initially the group had conceived of the area to be treated as that within the boundaries of the Jemez y Sangre water planning region (parts of Santa Fe, Los Alamos and Rio Arriba counties).

However, cloud seeding would probably result in precipitation on both sides of the Sangres, producing runoff into the Pecos basin as well as the Rio Grande. The group considered redefining the area of benefit as bounded by Las Vegas, Albuquerque, Taos and the Jemez Mountains. This would bring greater support to the project, as well as benefit to a greater area. At least for the purpose of gathering baseline data and modeling, the group decided to work with this larger area. Determining the size of the area will require communicating with neighboring regional water planners.

Interstate Stream Commission Requirements: A participant reminded the group of ISC permit requirements which include a public education component and an ecological/environmental impacts component. The draft regulations will be the subject of public hearings soon.

Need for Watchdog: A participant urged the group to remember unfortunate instances in the past when desperate farmers were taken advantage of by cloud seeding promoters. He hoped that there would be an entity formed to screen contractors in order to protect the community against fraud. Cloud seeding is extremely complicated and it requires expertise to determine the qualifications of cloud seeding contractors.

Next Steps: The group identified some next steps:
- Assess where we are now
- Workshop findings and direction will be summarized
- A "gray paper" will be produced. It will outline a plan for a program, and will be refined as experts and participants review it
- A Technical Advisory Group (TAG) will be formed, including consultants and stakeholders, and perhaps a university person, and perhaps a representative from the ISC

10:30 to 10:45 AM Break

10:45 to 11:45 AM We met again as a group.
Session Coordinator: Gary Ehlert
- Breakout Session Secretaries reported on conclusions reached and proposed next steps
- Group ratified Breakout Session reports
- Decisions were made on how to move forward on Cloud Seeding Pilot Project

The first question to be asked was the existence of a consensus for going forward with a cloud seeding project. Is there a consensus? There seemed to be broad support for gong forward. No one in attendance was opposed to moving forward.

It was recognized by all three breakout sessions that we needed to create new structures to move things forward. Cloud seeding could not remain as one out of a number of projects within a committee of the Jemez y Sangre Water Planning Council and receive the ongoing attention it would need to move forward.

Four new organizations were defined to test the waters to see if a cloud seeding project can be gotten off the ground. These organizations are shown in the attached organization chart.

One such structure was called a Steering Committee. After the workshop this name was changed to the Funding and Operating Committee. Gary Ehlert volunteered to organize this committee.

The key to getting a cloud seeding project started in our geographic area is to form a coalition of those who are prepared to move such a project forward. A preliminary step in doing so is the formation of a Funding and Organizing Committee. This committee will seek funding for a cloud seeding project. It will also address the need for a full-time person to be made available to work on the task of getting a cloud seeding project off the ground. The amount of volunteer time just to make this workshop happen was probably in the range of seven to nine man-months. It will not be possible to move forward based on volunteer time alone.

We had a lot of very generous sponsors from the private sector one of which also made available their Executive Officer, Gary Ehlert, to help us with coordinating the workshop with the Hilton Hotel. Gary also helped Walton Chapman with recruiting the sponsors for the workshop. We all worked on that important task but Gary and Walt took the lead. Gary has now volunteered to organize the Funding and Organizing Committee.

He invited interested participant to join him for lunch after the formal close of the workshop. All interested in the work of the Jemez y Sangre New and Expanded Water Technologies Committee were invited to attend the next meeting which was scheduled for Tuesday of the following week.

The breakout sessions also recognized the need for technical expertise.
A second part of the team is a Technical Advisory Group or TAG. It is from this group that advice will be provided on how to design or have designed the cloud seeding operations, the very important evaluation component, and any research component the program might also incorporate. The TAG will most like continue during the entire life of the project. Roy Stoesz has volunteered to organize the TAG. At some point the TAG may need to have resources that are greater than can be reasonably expected from volunteers. Perhaps a full time person can be made available to support the work of the TAG and the F&O Committees. How this person will be funded and how this person will be accommodated on an administrative basis remains to be determined. Will this person report to one of the six cities and counties involved? The ISC? This needs to be determined.

A Citizens Advisory Group will provide a convenient and effective way for the general public to have an impact on any cloud seeding project initiated. A cloud seeding project will need to be supported by the general public and citizens need a way to have their points of view taken into consideration. There can be legitimate concerns about cloud seeding and these concerns need to be addressed on an ongoing basis and a CAG will facilitate this. At this point we do not know who will be organizing the CAG. It may not be required immediately but the sooner it exists the better.

One of the new structures suggested, the New Mexico Weather Modification Association would study and promote cloud seeding throughout New Mexico.

This may need the universities to take the lead. There exists a nationwide organization on which this might be modeled, the Weather Modification Association (WMA) http://www.weathermodification.org/ It is not clear if New Mexico can support a mini-version of the WMA.

11:45 AM Workshop Ends

SPEAKERS' PROFESSIONAL BIOGRAPHIES

(In order of presentation)

Dr. William L. Woodley "Organizing and Assessing Cloud Seeding Programs"

After receiving his Ph.D. at Florida State University, Bill spent 27 years with NOAA/ERL Labs in Miami, Florida and Boulder, Colorado as Group Chief, Precipitation Enhancement. He left federal service 20 years ago to form Woodley Weather Consultants, where he continued his research in weather modification and served as a scientist/consultant on projects in Illinois, Texas, California and Thailand. He has published 22 papers since 1993. Bill is an authority on cumulus clouds, having logged thousands of hours directing research flights alongside or behind the pilot into large cumulus clouds throughout the world.

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Mr. Don A. Griffith "Review of Cloud Seeding in the Southwest- - - An Operator's View"

Don has degrees in Industrial Construction and Management from Colorado State University, Mathematics from Westmont College and Meteorology from the University of Utah. He was a Weather Officer in the Air Force for three years, including a tour of duty in Vietnam, served for a year as a meteorologist for Booz-Allen Applied Research, Inc. and for five years was Meteorologist/Asst. Director, Atmospheric Resources Research at Fresno State College Foundation in California. He joined North American Weather Consultants 20 years ago and is now President of the company. He has operated or directed cloud seeding programs throughout the West and in a number of foreign countries, and has authored or co-authored 18 journal article and over 130 technical reports.

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Dr. Conrad G. Keyes, Jr. "A Winter Cloud Seeding Program in the Jemez Mountains, 1968-1972"

Conrad served many years as a Professor at New Mexico State University, and for eight years was the Department Head of the combined Civil, Geological and Agricultural Engineering Departments. He received his ScD (Civil Engineering-Water Resources) from New Mexico State University and for 20 years conducted a wide variety of research projects there, including one which he will talk about today, "Jemez Atmospheric Water Management." He has twice served as the Engineer Advisor to the Texas Rio Grande Compact Commissioner and worked several years for Boyle Engineering Corp. as Branch Manager in their El Paso office. Among his many professional awards are two awards as the Outstanding

Engineering Alumnus at New Mexico State University. He currently consults for the US Corps of Engineers, the New Mexico Interstate Stream Commission and Sandia National Laboratories.

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Mr. Duncan Axisa "Summer Cloud Seeding on the Great Plains"

Duncan is from the island of Malta and received his early education there, with an undergraduate degree from the University of Malta. He came to the US four years ago and graduated as a meteorologist from Texas A&M. For the past two years he has been Project Director/Meteorologist for SOAR (Southern Ogallala Aquifer Rainfall) in Plains, Texas. He has worked closely with Woodley Weather Consultants to develop weather radar monitoring systems to assess summer cloud seeding programs in West Texas and Southeast New Mexico. He has developed an active weather modification outreach program in Texas, and last year made more than 40 presentations state-wide.

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Mr. George W. Bomar "How Other States Look at Cloud Seeding, Status of Research and Plans for the Future"

Since receiving undergraduate and graduate degrees in Meteorology from Texas A&M, George has devoted 30 years to development and utilization of weather modification in Texas. He was instrumental in establishing a state-wide rainfall-enhancement program in Texas 10 years ago, which grew to a program in 2003 covering 51 million acres (30 percent of Texas), the largest rainfall-enhancement effort in the world. George is now State Meteorologist in the state of Texas, in which capacity he is responsible for licensing, permitting and monitoring all cloud seeding projects in the state. He is the author of three books on Texas weather and the impact of global warming on Texas.

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Dr. David Gutzler **“**History of Precipitation in Northern New Mexico”

Dave received his PhD (Meteorology) from Massachusetts Institute of Technology and worked in his early career as a Staff Scientist at Atmospheric & Environmental Research, Inc. in Cambridge, Mass. and as a Physicist at the NOAA Aeronomy Lab in Boulder Colorado. Since 1995 he has been a Professor in the Earth & Planetary Sciences Department and Water Resources Program at the University of New Mexico. For seven years he was Associate Editor or Editor of *Journal of Climate* (American Meteorological Society), and for the past four years he has been a member of the New Mexico State Weather Control & Cloud Modification Commission. He has more than 50 publications to his name and is a Certified Consulting Meteorologist.

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Organization of Jemez y Sangre Cloud Seeding Project and the relationship among the four Committees and with the Jemez y Sangre Council and JyS New and Expanded Water Technologies Committee