

Approved: Carl Dean Holmes  
Date 3-7-95

## MINUTES OF THE HOUSE COMMITTEE ON ENERGY AND NATURAL RESOURCES.

The meeting was called to order by Chairperson Carl Holmes on January 30, 1995 in Room 526-S of the Capitol.

All members were present except: Representative Aurand - Excused  
Representative Kline - Excused

Committee staff present: Raney Gilliland, Legislative Research Department  
Mary Torrence, Revisor of Statutes  
Shirley Wilds, Committee Secretary

Conferees appearing before the committee: Stephen A. Hurst - KS Water Office

Others attending: See attached list

Chairperson Holmes advised the Committee they would work the gas gathering bill at tomorrow's meeting (HB 2097).

### Hearing on HB 2040:

**Stephen A. Hurst.** (See Attachment #1.) Mr. Hurst gave a brief background and history of the Western Kansas Weather Modification Program. He explained that weather modification involves the use of aircraft to seed cloud formations with particles of silver iodide or dry ice in an attempt to either enhance precipitation or suppress hail formation. He reported that the Western Kansas Modification Program has been solely locally funded with financial support typically ranging between \$150,000 and \$250,000 per year. The state support has been limited to the annual issuance of a permit to operate the program by the Kansas Water Office. Mr. Hurst furnished the Committee with an excerpt from the *Kansas Water Plan, The Role of the State in Weather Modification*; and a detailed review copy of the Western Kansas Weather Modification Program

Mr. Hurst said that the Western Kansas Modification Program has been evaluated on several previous occasions by various entities, but that the previous evaluation methodology and/or results have been viewed as somewhat inconclusive by the Kansas Water Office. The recently-completed evaluation of the Program by the Kansas Water Office determined 1) the general methodology to be used for conducting the Kansas Water Office evaluation was distributed to the three Western Kansas Groundwater Management District Managers and was endorsed by the Managers and the Kansas Water Office; 2) the counties receiving cloud seeding should consist of the six counties who had participated in the Program for every year included in the evaluation time period; and 3) the control area did not include any counties that used cloud seeding during any portion of the evaluation time period.

Originally Mr. Hurst said the Program was designed around the best use of the available funding, a concept that has allowed it to expand or contract each year, depending on the number of participating counties. The Water Office has concluded that the dollar value of the crop-hail damage reduction, to date, has been very significant (despite funding limitations). As a result of the most recent evaluation, the Water Office and Water Authority have requested adequate funding in FY 1996 to match Western Kansas county participation in hail suppression weather modification activities at \$10,000 per participating county. Mr. Hurst reported that the Governor has recommended \$190,000 for this purpose.

In conclusion, Mr. Hurst requested two technical amendments: On page 3, line 41 and Page 4, line 4, the word "year" should be replaced with "seasons." He explained that the National Weather Modification Association requires experience based on growing seasons, which may not equate with years.

The Kansas Water Office supports passage of **HB 2040**.

Upon completion of the hearing on **HB 2040**, Chairperson Holmes opened the meeting to action on several bills.

CONTINUATION SHEET

MINUTES OF THE HOUSE COMMITTEE ON ENERGY AND NATURAL RESOURCES, Room 526-S Statehouse, at 3:30 p.m.. on January 30, 1995.

**Action on HB 2039:**

Representative Sloan moved to pass **HB 2039** favorably, and place on the Consent Calendar. Representative Freeborn seconded. Motion carried.

**Action on HB 2059:**

Representative Freeborn recommended **HB 2059** favorable for passage and to place on the Consent Calendar. Representative Lawrence seconded. Motion carried.

**Action on HB 2060:**

Representative Sloan moved to pass **HB 2060** favorably and place on the Consent Calendar. Representative Lloyd seconded. Motion carried.

**Action on HB 2095:**

Representative McClure moved to strike the new language on Lines 15 and 16, ~~is found by the commission to have intentionally violated,~~ and insert with the original language, *shall violate,* in **HB 2095**. Representative Freeborn seconded. Motion carried.

Representative Lawrence moved to pass **HB 2095** favorably, as amended. Representative Sloan seconded. Motion carried.

**Action on HB 2100:**

Representative Sloan moved to change **HB 2100**, on Page 4, line 25 to read ~~statute book~~ *Kansas Register*. Representative Lawrence seconded the motion. Motion carried.

Representative Sloan made a motion to include on Page 3, line 33, *including such protection of confidentiality as requested by the telecommunications public utility, and the utility's suppliers and customers, for contracts entered into by them.* Representative Myers seconded. Motion carried.

Representative McKinney moved to adopt an amendment to **HB 2100** by inserting on Page 1, lines 25-27, and Page 4, lines 19-21, . . . *including such protection of confidentiality as requested by the electric public utility, and the utility's supplier and customers, for contracts entered into by them, as the commission deems reasonable and appropriate.* Representative Alldritt seconded. Motion carried.

Representative Sloan made a motion that **HB 2100** be passed favorably, as amended. Representative Lawrence seconded. Motion carried.

**Action on HB 2060:**

Representative Freeborn made a motion to reconsider the previous action on **HB 2060**, and amend Line 10, inserting. . . *and public utilities under the jurisdiction of the state corporation commission.* . Representative Sloan seconded. Motion carried.

Representative Sloan moved to pass **HB 2060** as amended. Representative Myers seconded. Motion carried.

There being no further business to come before the Committee, the meeting adjourned at 4:30 p.m.

The next meeting is scheduled for January 31, 1995.

# HOUSE ENERGY AND NATURAL RESOURCES COMMITTEE GUEST LIST

**DATE: January 30, 1995**

NAME	REPRESENTING
Lee Ross	DWR-KS D.A.
J. C. Long	UtiliCorp
ED SCHAUB	WESTERN RESOURCES
TREVA POTTER	MIDWEST ENERGY
Whitney Damron	Pete McCall Associates
Tom Bruno	Allent Assoc
Dirk Durant	Ks Sierra Club - Ks Natural Resources Council
Naomi Durant	Sierra Club + KNRC
PHILIP HURLEY	PATRICK J. HURLEY & CO.
Michelle Peterson	Ks Gov. Insultino
Steve Hunt	Ks. Water Office
Chris Alwood	Ks Water Office
Jeff Ross	STUNT
Larry Daggett + Susan Daggett	Ks Sierra Club
Greg Bryant	Ks Sierra Club and J
Bianca Storlazzi	Wolf River Environmental Soc.
Peter Dymnicki	KIOGA
Jack Stone	P-H East
Frank Allen	SWBT
Denny Koch	SWBT

Larry Ross  
 & Michelle Huffmann  
 Ann Hill  
 Alpine Hunter  
 Bill Craven

Ks. SIERRA CLUB  
 Ks Sierra Club  
 KNRC  
 KNRC  
 KNRC-SIERRA

**Testimony of  
Stephen A. Hurst  
Director, Kansas Water Office  
Before the  
House Energy and Natural Resources Committee  
Regarding House Bill No. 2040 on Weather Modification  
January 30, 1995**

Thank you Mr. Chairman, I am Stephen A. Hurst, Director of the Kansas Water Office.

I am here today to testify in support of House Bill 2040 which would amend the language of the current Weather Modification Act. The current act provides for weather modification activities "for profit" or purely for "research." The amended language is basically clean up, and would provide for an "operational," "not for profit" program, which more accurately represents the current state licensed program.

I would like to give you a brief background and history of the Western Kansas Weather Modification Program. Weather modification involves the use of aircraft to seed cloud formations with particles of silver iodide or dry ice in an attempt to either enhance precipitation or suppress hail formation. Weather modification activities began in Western Kansas in 1972 and several cloud seeding operations were conducted from 1972 through 1978. The centerpiece of weather modification activities in Kansas is represented by the Western Kansas Weather Modification Program that has operated from 1975 to the present time under the leadership of the Western Kansas Groundwater Management District No. 1. The Western Kansas Weather Modification Program has been solely locally funded with financial support typically ranging between \$150,000 and \$250,000 per year. State support for the Program has been limited to the annual issuance of a permit to operate the Program by the Kansas Water Office.

In late 1993 and early 1994, Keith Lebbin and Wayne Bossert, Managers of Western Kansas Groundwater Management District No. 1 and Northwest Kansas Groundwater Management District No. 4, respectively, called upon the Kansas Water Office to evaluate the effectiveness of this Program in order to increase the likelihood that state support might be provided to enhance and/or enlarge the Program. The Kansas Water Office proceeded to prepare a new subsection of the State Water Plan entitled "The State Role in Weather Modification" and was directed by the Kansas Water Authority to proceed with an evaluation of the Program. It was indicated in this new subsection that state support for the Program would be dependent upon a favorable outcome to the evaluation.

The Western Kansas Weather Modification Program has been evaluated on several previous occasions by various entities. However, the previous evaluation methodology and/or results have been viewed as somewhat inconclusive by the Kansas Water Office. The recently completed evaluation of this Program, by the Kansas Water Office, differed from previous evaluations of the Program in the following three significant areas: 1) the general methodology to be used for

conducting the Kansas Water Office evaluation was distributed to the three Western Kansas Groundwater Management District Managers and was endorsed by the Managers and the Kansas Water Office, 2) the target area (counties receiving cloud seeding) consisted of the six counties who had participated in the Program for every year that was included in the evaluation time period and 3) the control area did not include any counties that received cloud seeding during any portion of the evaluation time period.

The precipitation component of the Kansas Water Office evaluation of the Program showed that precipitation declined by 0.25 inches in the target area from the pre-cloud seeding time period of 1941 to 1970 to the cloud seeding time period of 1979-1993. This amount of change in rainfall is well within normal precipitation variation and was determined to be of no practical economic significance. It should also be noted that in 1993 only seven percent of all flights were for the sole purpose of rainfall enhancement. The importance of seeding for hail suppression has always been the major thrust of the Program due to funding limitations and the amount of loss that can occur with a severe hail storm.

In contrast to the precipitation component, the Kansas Water Office evaluation of the hail suppression component of the Program was very positive. The estimated percentage decrease in hail damage to crops in the target area was 27 percent, and resulted in an estimated benefit of approximately \$60,000,000 to the six county target area for the 1979-1993 time period or \$4,000,000 per year, after the expenses to operate the Program have been deducted. These figures are based on reduced hail damage to crops and do not include any estimate of the savings due to reduction in hail damage to dwellings, personal property, wildlife or other natural resources.

Hail losses within the state can be both variable and staggering. In 1993, the State of Kansas sustained \$43,418,000 of insured crop-hail damage, its greatest dollar loss of insured crops due to hail damage since 1948. Since not all farmers insure their crops for hail damage, the total dollar loss for crop-hail damage was, of course, much greater than \$43,418,000 in 1993. Although 1993 was also the worst year for crop-hail damage to the Western Kansas Weather Modification Program target area counties, it should be noted that the insured crop-hail damage loss for Sheridan County, a control area county, was \$4,542,000 in 1993, which exceeded the total crop-hail damage loss for all six target area counties.

From the outset the original designers of the Western Kansas Weather Modification Program knew the Program could never eliminate all crop-hail damage and they never claimed to be able to do so. Originally, the Program was designed around the best use of the available funding, a concept that has allowed it to expand or contract each year depending on the number of participating counties. Despite Program funding limitations, the Kansas Water Office has concluded that the dollar value of the crop-hail damage reduction, to date, has been very significant. As a result of the recently completed evaluation, the Kansas Water Office and Kansas Water Authority have requested adequate funding in Fiscal Year 1996 to match Western Kansas county participation in hail suppression weather modification activities at \$10,000 per participating county. The Governor has recommended \$190,000 for this purpose.

As you can see, the current program has evolved into a not for profit, operational program, and House Bill 2040 would simply adjust the statutory language to allow for this type of operation. I do have a request for two technical amendments from Keith Lebbin, Manager of Western Kansas Groundwater Management District No. 1. On page 3, line 41 and on page 4, line 4, the word "year" should be replaced with "seasons" as the National Weather Modification Association requires experience based on growing seasons, which may not equate with years.

Again, the Kansas Water Office supports the passage of House Bill 2040.

State of Kansas

# Kansas Water Plan

Management Section

## The Role of the State in Weather Modification

F.Y. 1996

Approved by the  
Kansas Water Authority  
July 1994

The Kansas Water Office  
109 SW Ninth Street  
Topeka, KS 66612-1249  
913-296-3185

An Equal Opportunity Employer

Introduction . . . . .	2
Concepts . . . . .	2
Policy Issues, Options, Recommendations and Objectives . . . . .	4
Summary of Policy Recommendations . . . . .	4
Policy Objectives . . . . .	5
Plan Implementation . . . . .	5
Legislative Action . . . . .	5
Administrative Action . . . . .	5
Financial Requirements . . . . .	6
Time Schedule . . . . .	6
Evaluation . . . . .	6
References . . . . .	6

# THE STATE ROLE IN WEATHER MODIFICATION

## Introduction

In 1974, the Kansas Legislature passed the Kansas Weather Modification Act (K.S.A. 82a-1401 *et seq.*) which established a process to issue weather modification permits in a manner which protects the public interest. The emphasis of the Act is the promotion of research to further available knowledge on weather modification research and the regulation of private weather modification activities to protect the health and economic welfare of Kansas citizens. The Act does not acknowledge the role of weather modification in water management, which is closer to the purpose of the ongoing operations by Groundwater Management District No. 1 than either research or profit.

The state has been involved in weather modification activities since the early 1970's. In the beginning, the state, in cooperation with the western groundwater management districts and the Bureau of Reclamation, conducted studies to examine the possibility of enhancing summer rainfall and suppressing damaging hail. By the early 1980's, the state limited itself to permitting weather modification activities but was not active in research or management. Since 1975, the main proponent of weather modification has been Groundwater Management District No. 1, which has conducted weather modification operations in eastern Colorado and southwest Kansas. There is growing interest for the state to provide technical and financial support for weather modification activities in western Kansas. This policy subsection examines the issue of the state's role in weather modification.

## Concepts

Weather modification in Kansas involves the introduction of silver iodide or dry ice particles or "condensation nuclei" into the convective clouds believed to potentially spawn thunderstorms. While the particles can be introduced from ground generators, most U.S. projects after 1960 have utilized aircraft. The majority of seeding in Kansas has been done by aircraft, either releasing particles into the updrafts at the base of the clouds or dropping flares or cartridges through the clouds from the top.

The presumption is that the seeded nuclei produce additional ice particles within the clouds which grow into snowflakes or small hail which melt as they fall to the ground. The melted ice particles would reach the ground as increased rainfall during the summer, when convective clouds are most prevalent from ground heating. The introduction of the seeded material also produced "competitive embryos" which tend to increase the number of frozen particles, albeit smaller in size within the cloud. These smaller particles have a lower probability of reaching the earth as hail, because of their tendency to melt in freefall.

Numerous evaluations have been conducted to examine the effectiveness of cloud seeding over the Great Plains in increasing rainfall and suppressing hail. Typically, daily, monthly and seasonal rainfall have been compared over time and between target areas which were subject to seeding versus control areas which had no seeding in the vicinity. This approach has been hampered by the difficulty in finding control areas not impacted by cloud seeding, spatial variability of weather patterns and the



lack of random selection of cloud systems to be seeded. The basic operation is to seed every potential storm cell to enhance the likelihood of results. Thus, there are few instances of leaving such cells alone to provide data on rain and hail events without seeding in the operational area.

Hail studies typically examine hail damage claims and hail insurance data, especially loss-cost ratios. Damaging hail is most extensive and frequent in the western Kansas counties and decreases as one moves eastward. Loss-cost ratios also decrease easterly. The ratio is the comparison of the monetary damage caused by hail to the total value of the crop.

The results from these studies have been mixed. Although some studies indicate a nine-ten percent increase in rainfall, there has been little statistical evidence that rainfall has definitely been increased because of the seeding operations. Most differences in rainfall fall within the range of normal variation of rainfall rates. There has been stronger evidence of hail suppression through lower loss-cost ratios within seeded areas and lower insurance rates offered to those farmers in counties which have supported weather modification activities. During the first half of 1994, the Kansas Water Office is conducting an evaluation on the Western Kansas Weather Modification Program, through a consensus approved methodology for the evaluation. Objectives will be to determine if the program has been effective in increasing precipitation or decreasing hail damage.

There has been considerable support for weather modification activities in western Kansas. Groundwater Management District No. 1 has operated a weather modification program since the "Muddy Road" project of the mid-1970's. The other two groundwater management districts overlying the Ogallala

aquifer (Nos. 3 and 4) have also expressed support for weather modification. The Ogallala Task Force, in 1993, issued recommendations supporting weather modification, particularly from the hail suppression aspect of the activity. Hail suppression prevents waste of water which has been pumped from the aquifer to raise a standing crop on the land. If that crop is damaged, its value disappears and the water used to raise the crop has been wasted. A key institutional restraint on weather modification activity in Kansas is the limited access to seed clouds over neighboring states, specifically Colorado. Current arrangements only allow overflights into Colorado within 10 miles of the border. This does not provide sufficient time for seeded storms to mature before reaching Kansas. Studies indicate that hail suppression benefits are greatest downwind of the seeding site. Therefore, the westernmost Kansas counties receive less benefit from weather modification activity since the seeded storm clouds are still in the formative stages over those counties. Nonetheless, a 30 percent reduction in hail damage has been reported in those counties.

Weather modification activities are also active in other states such as Texas, Oklahoma, and North Dakota. North Dakota reports that rainfall in the western portion of the state has increased and hail damage has been cut in half. The state cost-shares with counties on about a one:three ratio for weather modification activities with annual expenditures of about \$500,000. Oklahoma is similar to Kansas in that it only licenses such operations and does not conduct them nor financially aid them. Oklahoma weather modification has been chiefly financed from the private sector. Texas conducts a weather modification program with licensing, evaluation, and research support to the

Colorado River Municipal Water District. The District funds its weather modification activity through water sale revenues. A recent study of Texas operations, using new radar technology, indicated seeded storms lasted 36 percent longer and produced 130 percent more rainfall volume.

Given the interest in weather modification in the region of the state overlying the Ogallala Aquifer, this subsection examines the issue of the state's role in weather modification and the direction the state needs to take on the issue over the next decade.

## **Policy Issues, Options, Recommendations and Objectives**

There is one issue regarding weather modification from the state's perspective: the degree of state support for expanding or enhancing weather modification activities in western Kansas.

### **THE DEGREE OF STATE SUPPORT**

The state has traditionally supported weather modification activities but refrained from becoming financially linked to ongoing operational activities in western Kansas. Over the last two decades, Groundwater Management District No. 1 has taken the lead on coordination of technical, financial, and administrative support of weather modification. This includes interaction with Colorado. The state role has strictly been one of permit issuer, through the Kansas Water Office. Local government has been the driver for weather modification activities.

One option would be to continue the status quo position of the state, which minimizes state involvement and

commitment to weather modification. No state monies are dedicated to such activities and staff support is restricted to processing the appropriate permits. This option places weather modification as a low priority on the part of the state.

A second option would be for the state to develop a weather modification program of its own and undertake the operations of seeding storm clouds throughout western Kansas. Such an option would require large capital outlays by the state for aircraft, personnel, radar support, seeding materials, and administrative support. Any question of liability would be focused on the state.

The third, and recommended option, is for the state to develop a weather modification support program which will spur activities by local groups, particularly the groundwater management districts. Contingent upon favorable results from the current evaluation effort on hail suppression or precipitation enhancement, state money could be cost-shared with local support to expand weather modification activities. The local sponsors would operate the program, administer capital and operating expenditures and assume the risk of liability. The state would negotiate with neighboring states on the issue of overflights. Funding support to expand weather modification activities should be limited to ten years.

## **Summary of Policy Recommendations**

1. The Kansas Water Office should complete its evaluation of historic weather modification activities and determine the practical and economic significance of those activities in suppressing hail or increasing rainfall.

2. The Kansas Water Office should seek modification to the Weather Modification Act to recognize water management as a purpose for conducting weather modification.

3. If the evaluations show practically significant resource and economic benefits from weather modification, the Kansas Water Office should request funding to cost-share, on a 50-50 basis, with groundwater management districts to expand the weather modification activities over a ten-year period.

4. If the evaluation shows no practical significance, the Kansas Water Office will not request funds to help expand current weather modification activities.

5. The state will negotiate with neighboring states for overflights and assist local sponsors evaluate expanded weather modification activities.

## Policy Objectives

The preceding policies are intended to accomplish the following objectives for the counties that participate in weather modification activities:

1. A comparison of participating counties (i.e., those with cloud seeding activities) with nonparticipating counties (i.e., those that are not impacted by cloud seeding operations) will show that seasonal precipitation enhancement was of practical significance for the participating counties.

2. A comparison of participating counties with nonparticipating counties will show the suppression of hail damage to corn or wheat was of practical significance for the participating counties.

## Plan Implementation

### Legislative Action

K.S.A. 82a-1401, *et seq.*, should be modified to recognize water management activities as a reason for weather modification in addition to research and profit. If evaluation of weather modification proves positive, the statutes should be modified to allow for state cost-share funding with groundwater management districts for weather modification.

### Administrative Action

The Kansas Water Office should complete its evaluation of weather modification activities prior to September 1, 1994. If the results of that evaluation are positive, the Kansas Water Office should develop a weather modification support program which provides 50 percent cost-share funds to ground water management districts on a county participation basis. Matching funds of \$10,000 per participating county should be made available. Support should be limited to counties west of the line of counties between Phillips and Comanche counties. The groundwater management districts are encouraged to pool their activities and resources to take advantage of economies of scale for weather modification program expansion. Public water suppliers requesting weather modification support should subcontract with the groundwater management districts.

The state cost-share support should continue over ten years. The state should open discussion with Colorado over the issue of overflights in 1995 at the appropriate opportunity. If rainfall enhancement is a goal on the part of the ground water management districts, then those districts

should undertake appropriate programs to effectively utilize such increased rainfall by incorporating conservation practices on the land and scheduling irrigation in response to precipitation. Any questions of liability will be assumed by the groundwater management districts.

### **Financial Requirements**

Assuming full participation by all 39 counties in western Kansas for weather modification, the state commitment on cost-share would be \$390,000 annually. If the State Water Plan Fund is used, the Kansas Water Office will request the funds and seek their recommended expenditure from the Kansas Water Authority on a year-by-year basis.

### **Time Schedule**

The evaluation should be completed by September 1, 1994. Legislative changes should be done within the 1995 Legislative Session. Cost-share funds should be available in July 1995, if positive significant results come out of the evaluation.

### **Evaluation**

If state financial support of weather modification is obtained for Fiscal Year 1996, the Kansas Water Office will work with the groundwater management districts to monitor the benefits and impacts of weather modification. Techniques for storm volume scanning through the NEXRAD facilities in Goodland and Dodge City will be explored to assess rainfall and hail productions within seeded clouds. A follow-up evaluation of the expanded program will be taken after five years and reported to the Kansas Water Authority in the year 2001.

This evaluation will center on achievement of the two policy objectives stated in this subsection.

## **References**

1. *Evaluation of Operational Cloud Seeding in Western Kansas - Final Report*; A.S. Dennis, R.L. Feldy and R.M. Rasmussen; U.S. Bureau of Reclamation; Denver, Colorado; November 1987.
2. *Analysis of a Cloud Seeding Program in Southwestern Kansas - 1975-1990*; S.E. Hurt and W.F. Simpson; Emporia State University, 1992.
3. *An Exploratory Study of Crop-Hail Insurance Data for Evidence of Seeding Effects in North Dakota*; P.L. Smith, J.R. Miller and P.W. Mielke; South Dakota Institute of Atmospheric Sciences; June 1987.
4. *Effects of Cloud Seeding in West Texas: Additional Results and New Insights*; D. Rosenfeld and W.C. Woodley; Journal of Applied Meteorology. Vol. 32, No. 12, December 1993.

State of Kansas

# Kansas Water Plan

Management Section

## The Role of the State in Weather Modification

F.Y. 1996

Approved by the  
Kansas Water Authority  
July 1994

The Kansas Water Office  
109 SW Ninth Street  
Topeka, KS 66612-1249  
913-296-3185

An Equal Opportunity Employer

Introduction . . . . .	2
Concepts . . . . .	2
Policy Issues, Options, Recommendations and Objectives . . . . .	4
Summary of Policy Recommendations . . . . .	4
Policy Objectives . . . . .	5
Plan Implementation . . . . .	5
Legislative Action . . . . .	5
Administrative Action . . . . .	5
Financial Requirements . . . . .	6
Time Schedule . . . . .	6
Evaluation . . . . .	6
References . . . . .	6

# THE STATE ROLE IN WEATHER MODIFICATION

## Introduction

In 1974, the Kansas Legislature passed the Kansas Weather Modification Act (K.S.A. 82a-1401 *et seq.*) which established a process to issue weather modification permits in a manner which protects the public interest. The emphasis of the Act is the promotion of research to further available knowledge on weather modification research and the regulation of private weather modification activities to protect the health and economic welfare of Kansas citizens. The Act does not acknowledge the role of weather modification in water management, which is closer to the purpose of the ongoing operations by Groundwater Management District No. 1 than either research or profit.

The state has been involved in weather modification activities since the early 1970's. In the beginning, the state, in cooperation with the western groundwater management districts and the Bureau of Reclamation, conducted studies to examine the possibility of enhancing summer rainfall and suppressing damaging hail. By the early 1980's, the state limited itself to permitting weather modification activities but was not active in research or management. Since 1975, the main proponent of weather modification has been Groundwater Management District No. 1, which has conducted weather modification operations in eastern Colorado and southwest Kansas. There is growing interest for the state to provide technical and financial support for weather modification activities in western Kansas. This policy subsection examines the issue of the state's role in weather modification.

## Concepts

Weather modification in Kansas involves the introduction of silver iodide or dry ice particles or "condensation nuclei" into the convective clouds believed to potentially spawn thunderstorms. While the particles can be introduced from ground generators, most U.S. projects after 1960 have utilized aircraft. The majority of seeding in Kansas has been done by aircraft, either releasing particles into the updrafts at the base of the clouds or dropping flares or cartridges through the clouds from the top.

The presumption is that the seeded nuclei produce additional ice particles within the clouds which grow into snowflakes or small hail which melt as they fall to the ground. The melted ice particles would reach the ground as increased rainfall during the summer, when convective clouds are most prevalent from ground heating. The introduction of the seeded material also produced "competitive embryos" which tend to increase the number of frozen particles, albeit smaller in size within the cloud. These smaller particles have a lower probability of reaching the earth as hail, because of their tendency to melt in freefall.

Numerous evaluations have been conducted to examine the effectiveness of cloud seeding over the Great Plains in increasing rainfall and suppressing hail. Typically, daily, monthly and seasonal rainfall have been compared over time and between target areas which were subject to seeding versus control areas which had no seeding in the vicinity. This approach has been hampered by the difficulty in finding control areas not impacted by cloud seeding, spatial variability of weather patterns and the

lack of random selection of cloud systems to be seeded. The basic operation is to seed every potential storm cell to enhance the likelihood of results. Thus, there are few instances of leaving such cells alone to provide data on rain and hail events without seeding in the operational area.

Hail studies typically examine hail damage claims and hail insurance data, especially loss-cost ratios. Damaging hail is most extensive and frequent in the western Kansas counties and decreases as one moves eastward. Loss-cost ratios also decrease easterly. The ratio is the comparison of the monetary damage caused by hail to the total value of the crop.

The results from these studies have been mixed. Although some studies indicate a nine-ten percent increase in rainfall, there has been little statistical evidence that rainfall has definitely been increased because of the seeding operations. Most differences in rainfall fall within the range of normal variation of rainfall rates. There has been stronger evidence of hail suppression through lower loss-cost ratios within seeded areas and lower insurance rates offered to those farmers in counties which have supported weather modification activities. During the first half of 1994, the Kansas Water Office is conducting an evaluation on the Western Kansas Weather Modification Program, through a consensus approved methodology for the evaluation. Objectives will be to determine if the program has been effective in increasing precipitation or decreasing hail damage.

There has been considerable support for weather modification activities in western Kansas. Groundwater Management District No. 1 has operated a weather modification program since the "Muddy Road" project of the mid-1970's. The other two groundwater management districts overlying the Ogallala

aquifer (Nos. 3 and 4) have also expressed support for weather modification. The Ogallala Task Force, in 1993, issued recommendations supporting weather modification, particularly from the hail suppression aspect of the activity. Hail suppression prevents waste of water which has been pumped from the aquifer to raise a standing crop on the land. If that crop is damaged, its value disappears and the water used to raise the crop has been wasted. A key institutional restraint on weather modification activity in Kansas is the limited access to seed clouds over neighboring states, specifically Colorado. Current arrangements only allow overflights into Colorado within 10 miles of the border. This does not provide sufficient time for seeded storms to mature before reaching Kansas. Studies indicate that hail suppression benefits are greatest downwind of the seeding site. Therefore, the westernmost Kansas counties receive less benefit from weather modification activity since the seeded storm clouds are still in the formative stages over those counties. Nonetheless, a 30 percent reduction in hail damage has been reported in those counties.

Weather modification activities are also active in other states such as Texas, Oklahoma, and North Dakota. North Dakota reports that rainfall in the western portion of the state has increased and hail damage has been cut in half. The state cost-shares with counties on about a one:three ratio for weather modification activities with annual expenditures of about \$500,000. Oklahoma is similar to Kansas in that it only licenses such operations and does not conduct them nor financially aid them. Oklahoma weather modification has been chiefly financed from the private sector. Texas conducts a weather modification program with licensing, evaluation, and research support to the

Colorado River Municipal Water District. The District funds its weather modification activity through water sale revenues. A recent study of Texas operations, using new radar technology, indicated seeded storms lasted 36 percent longer and produced 130 percent more rainfall volume.

Given the interest in weather modification in the region of the state overlying the Ogallala Aquifer, this subsection examines the issue of the state's role in weather modification and the direction the state needs to take on the issue over the next decade.

## **Policy Issues, Options, Recommendations and Objectives**

There is one issue regarding weather modification from the state's perspective: the degree of state support for expanding or enhancing weather modification activities in western Kansas.

### **THE DEGREE OF STATE SUPPORT**

The state has traditionally supported weather modification activities but refrained from becoming financially linked to ongoing operational activities in western Kansas. Over the last two decades, Groundwater Management District No. 1 has taken the lead on coordination of technical, financial, and administrative support of weather modification. This includes interaction with Colorado. The state role has strictly been one of permit issuer, through the Kansas Water Office. Local government has been the driver for weather modification activities.

One option would be to continue the status quo position of the state, which minimizes state involvement and

commitment to weather modification. No state monies are dedicated to such activities and staff support is restricted to processing the appropriate permits. This option places weather modification as a low priority on the part of the state.

A second option would be for the state to develop a weather modification program of its own and undertake the operations of seeding storm clouds throughout western Kansas. Such an option would require large capital outlays by the state for aircraft, personnel, radar support, seeding materials, and administrative support. Any question of liability would be focused on the state.

The third, and recommended option, is for the state to develop a weather modification support program which will spur activities by local groups, particularly the groundwater management districts. Contingent upon favorable results from the current evaluation effort on hail suppression or precipitation enhancement, state money could be cost-shared with local support to expand weather modification activities. The local sponsors would operate the program, administer capital and operating expenditures and assume the risk of liability. The state would negotiate with neighboring states on the issue of overflights. Funding support to expand weather modification activities should be limited to ten years.

## **Summary of Policy Recommendations**

1. The Kansas Water Office should complete its evaluation of historic weather modification activities and determine the practical and economic significance of those activities in suppressing hail or increasing rainfall.



2. The Kansas Water Office should seek modification to the Weather Modification Act to recognize water management as a purpose for conducting weather modification.

3. If the evaluations show practically significant resource and economic benefits from weather modification, the Kansas Water Office should request funding to cost-share, on a 50-50 basis, with groundwater management districts to expand the weather modification activities over a ten-year period.

4. If the evaluation shows no practical significance, the Kansas Water Office will not request funds to help expand current weather modification activities.

5. The state will negotiate with neighboring states for overflights and assist local sponsors evaluate expanded weather modification activities.

## Policy Objectives

The preceding policies are intended to accomplish the following objectives for the counties that participate in weather modification activities:

1. A comparison of participating counties (i.e., those with cloud seeding activities) with nonparticipating counties (i.e., those that are not impacted by cloud seeding operations) will show that seasonal precipitation enhancement was of practical significance for the participating counties.

2. A comparison of participating counties with nonparticipating counties will show the suppression of hail damage to corn or wheat was of practical significance for the participating counties.

## Plan Implementation

### Legislative Action

K.S.A. 82a-1401, *et seq.*, should be modified to recognize water management activities as a reason for weather modification in addition to research and profit. If evaluation of weather modification proves positive, the statutes should be modified to allow for state cost-share funding with groundwater management districts for weather modification.

### Administrative Action

The Kansas Water Office should complete its evaluation of weather modification activities prior to September 1, 1994. If the results of that evaluation are positive, the Kansas Water Office should develop a weather modification support program which provides 50 percent cost-share funds to ground water management districts on a county participation basis. Matching funds of \$10,000 per participating county should be made available. Support should be limited to counties west of the line of counties between Phillips and Comanche counties. The groundwater management districts are encouraged to pool their activities and resources to take advantage of economies of scale for weather modification program expansion. Public water suppliers requesting weather modification support should subcontract with the groundwater management districts.

The state cost-share support should continue over ten years. The state should open discussion with Colorado over the issue of overflights in 1995 at the appropriate opportunity. If rainfall enhancement is a goal on the part of the ground water management districts, then those districts

should undertake appropriate programs to effectively utilize such increased rainfall by incorporating conservation practices on the land and scheduling irrigation in response to precipitation. Any questions of liability will be assumed by the groundwater management districts.

### **Financial Requirements**

Assuming full participation by all 39 counties in western Kansas for weather modification, the state commitment on cost-share would be \$390,000 annually. If the State Water Plan Fund is used, the Kansas Water Office will request the funds and seek their recommended expenditure from the Kansas Water Authority on a year-by-year basis.

### **Time Schedule**

The evaluation should be completed by September 1, 1994. Legislative changes should be done within the 1995 Legislative Session. Cost-share funds should be available in July 1995, if positive significant results come out of the evaluation.

### **Evaluation**

If state financial support of weather modification is obtained for Fiscal Year 1996, the Kansas Water Office will work with the groundwater management districts to monitor the benefits and impacts of weather modification. Techniques for storm volume scanning through the NEXRAD facilities in Goodland and Dodge City will be explored to assess rainfall and hail productions within seeded clouds. A follow-up evaluation of the expanded program will be taken after five years and reported to the Kansas Water Authority in the year 2001.

This evaluation will center on achievement of the two policy objectives stated in this subsection.

## **References**

1. *Evaluation of Operational Cloud Seeding in Western Kansas - Final Report*; A.S. Dennis, R.L. Feldy and R.M. Rasmussen; U.S. Bureau of Reclamation; Denver, Colorado; November 1987.
2. *Analysis of a Cloud Seeding Program in Southwestern Kansas - 1975-1990*; S.E. Hurt and W.F. Simpson; Emporia State University, 1992.
3. *An Exploratory Study of Crop-Hail Insurance Data for Evidence of Seeding Effects in North Dakota*; P.L. Smith, J.R. Miller and P.W. Mielke; South Dakota Institute of Atmospheric Sciences; June 1987.
4. *Effects of Cloud Seeding in West Texas: Additional Results and New Insights*; D. Rosenfeld and W.C. Woodley; Journal of Applied Meteorology. Vol. 32, No. 12, December 1993.

kwp/weatherm.od

## WESTERN KANSAS WEATHER MODIFICATION PROGRAM

- A. Overview of the Western Kansas Weather Modification Program and Related Kansas Water Office Actions
  
  
  
  
  
  
  
  
  
  
- B. Summary of the Weather Modification Program Evaluation
  
  
  
  
  
  
  
  
  
  
- C. Statistical Significance of Hail Suppression Data
  
  
  
  
  
  
  
  
  
  
- D. Crop Hail Damage Summaries (Includes County Tables)

## SUMMARY OF THE WEATHER MODIFICATION PROGRAM EVALUATION

Weather modification activities began in Western Kansas in 1972 and several cloud seeding operations were conducted from 1972 through 1978. The centerpiece of weather modification activities in Kansas is represented by the Western Kansas Weather Modification Program that has operated from 1975 to the present time under the leadership of the Western Kansas Groundwater Management District No. 1. The primary objective of the Program has been to reduce hail damage, although a significant effort has also been made to increase precipitation.

The Western Kansas Weather Modification Program has been solely locally funded with financial support typically ranging between \$150,000 and \$250,000 per year. State support for the Program has been limited to the annual issuance of a permit to operate the Program by the Kansas Water Office.

In late 1993 and early 1994, Keith Lebbin and Wayne Bossert, Managers of Western Kansas Groundwater Management District No. 1 and Northwest Kansas Groundwater Management District No. 4, respectively, called upon the Kansas Water Office to evaluate the effectiveness of this Program in order to increase the likelihood that state support might be provided to enhance and/or enlarge the Program. The Kansas Water Office proceeded to prepare a new subsection of the State Water Plan entitled "The State Role in Weather Modification" and was directed by the Kansas Water Authority to proceed with an evaluation of the Program. It was indicated in this new subsection that state support for the Program would be dependent upon a favorable outcome to the evaluation.

The Western Kansas Weather Modification Program has been evaluated on several previous occasions by various entities. However, the previous evaluation methodology and/or results have been viewed as somewhat inconclusive by the Kansas Water Office. The recently completed evaluation of this Program, by the Kansas Water Office, differed from previous evaluations of the Program in the following three significant areas: 1) the general methodology to be used for conducting the Kansas Water Office evaluation was distributed to the three Western Kansas Groundwater Management District Managers and was endorsed by the Managers and the Kansas Water Office, 2) the target area (counties receiving cloud seeding) consisted of the six counties who had participated in the Program for every year that was included in the evaluation time period and 3) the control area did not include any counties that received cloud seeding during any portion of the evaluation time period.

The precipitation component of the Kansas Water Office evaluation of the Program showed that precipitation declined by 0.25 inches in the target area from the pre-cloud seeding time period of 1941 to 1970 to the cloud seeding time period of 1979-1993. This amount of change in rainfall is well within normal precipitation variation and was determined to be of no practical economic significance. It should also be noted that in 1993 only 7 percent of all flights were for the sole purpose of rainfall enhancement. The importance of seeding for hail suppression has always been the major thrust of the Program due to funding limitations and the amount of loss that can occur with a severe hail storm.

In contrast, the Kansas Water Office evaluation of the hail suppression component of the Program was very positive. The estimated percentage decrease in hail damage to crops in the target area was 27 percent, and resulted in an estimated benefit of approximately \$60,000,000 to the six county target area for the 1979-1993 time period or \$4,000,000 per year, after the expenses to operate the Program have been deducted. These figures are based on reduced hail damage to crops and do not include any estimate of the savings due to reduction in hail damage to dwellings, personal property, wildlife or other natural resources.

Hail losses within the state can be both variable and staggering. In 1993, the State of Kansas sustained \$43,418,000 of insured crop-hail damage, its greatest dollar loss of insured crops due to hail damage since 1948. Since not all farmers insure their crops for hail damage, the total dollar loss for crop-hail damage was, of course, much greater than \$43,418,000 in 1993. Although 1993 was also the worst year for crop-hail damage to the Western Kansas Weather Modification Program target area counties, it should be noted that the insured crop-hail damage loss for Sheridan County, a control area county, was \$4,542,000 in 1993, which exceeded the total crop-hail damage loss for all six target area counties.

From the outset the original designers of the Western Kansas Weather Modification Program knew the Program could never eliminate all crop-hail damage and they never claimed to be able to do so. Originally, the Program was designed around the best use of the available funding, a concept that has allowed it to expand or contract each year depending on the number of participating counties. Despite Program funding limitations, the Kansas Water Office has concluded that the dollar value of the crop-hail damage reduction, to date, has been very significant.

As a result of this recently completed evaluation, the Kansas Water Office plans to request adequate funding in Fiscal Year 1996 to match Western Kansas county participation in hail suppression weather modification activities at \$10,000 per participating county.

STATE OF KANSAS



Joan Finney, Governor

KANSAS WATER OFFICE  
Stephen A. Hurst  
Director

Suite 300  
109 SW Ninth  
Topeka, Kansas 66612-1249

913-296-3185  
FAX 913-296-0878

MEMORANDUM

Date: November 16, 1994  
To: Kansas Water Authority  
From: *D. Eklund* Darrel L. Eklund, Ph.D., Kansas Water Office  
Subject: Statistical Significance of Hail Suppression Data

At our Kansas Water Authority meeting in Liberal on November 2, 1994 questions were raised about the validity or reliability of the hail suppression data that were used to evaluate the Western Kansas Weather Modification Program and some concern was expressed that no statistical tests were conducted, hence, perhaps the positive results were just due to chance. Although my Ph.D. just happens to be in statistics, it is my usual approach to try to present data analyses to subject matter experts, such as yourself, in a manner as simple and straight forward as I can. It has been my impression, based on personal experience, that not everyone shares my excitement and enthusiasm for conducting statistical tests. Also, I know that the practical significance of many data analysis efforts are of equal, if not more importance than statistical significance. Hence, I had not suggested to my peer review committee or the Kansas Water Authority that a formal statistical analyses should be conducted.

Although, I assured Kansas Water Authority members that I believed the data results were of statistical significance, as well as practical significance, Daljit Jawa and I have taken the time to conduct two statistical tests and attached the results for your review. One statistical test was performed using data from the 1948 to 1970 time period and the other for the 1979 to 1993 time period. For the 1948 to 1970 time period, the results clearly establish that no relationship existed between the study area chosen and the loss cost ratios, prior to cloud seeding since the chi-square value is only 0.16 (See Analysis 1). However, for the 1979 to 1993 time period the chi-square value of 5.38 is statistically significant (See Analysis 2). This indicates for the 1979 to 1993 time period, during which cloud seeding occurred in the target area, that a statistically significant relationship does exist between the study areas and the resulting loss cost ratio. Hence, the results of the evaluation of the Western Kansas Weather Modification Program demonstrate both the statistical and practical economic significance of the Program.

Now that the effectiveness of the Hail Suppression Program has been thoroughly examined and documented, for the 1979-1993 time period, it is appropriate to determine an estimate of the Program's current impact on hail suppression. A key factor in the effectiveness of a hail suppression program is believed to be the liquid seeding agent formulation. The current formulation used by the Western Kansas Weather Modification Program has been the same since 1987. Hence, analyzing the hail suppression data for the 1987-1993 time period should provide a better estimate of the current effectiveness of the Hail Suppression Program. Using only actual crop-hail damage data for the 1987-1993 time period, the best current estimate of crop-hail damage reduction is 49 percent, which is a very significant improvement over the estimated 27 percent crop-hail damage reduction for the entire 1979-1993 time period.

MEMORANDUM  
November 16, 1994  
Page Two

It is usually much easier to make decisions on the basis of hindsight. If the Weather Modification Subsection of the State Water Plan were being written today, I would not recommend that cloud seeding support be restricted to **only** 39 counties in Western Kansas and would not recommend that participation in the Program be subject to annual endorsement at the local level. There is strong evidence that a well funded Program would be of enormous economic benefit to farmers and property owners and is worthy of support in a more stable and comprehensive manner at the state level.

I am a strong supporter of the Kansas Rural Water Associations efforts to stop wastage of water via their Leak Detection Program, which received a very positive evaluation from the Kansas Water Office some time ago. However, I believe that the amount of Kansas water wasted due to crops being destroyed by hail is far in excess of the amount of water saved from wastage by the very excellent Kansas Rural Water Association Leak Detection Program. The Ogallala Aquifer is essentially a nonrenewable water resource and is of immense economic importance to Western Kansas and the entire State. The basic water policy question is this. Is it in our best interests as stewards of the Ogallala Aquifer in Kansas to save an estimated 49 percent of the water that is currently wasted by crop hail damage by funding from whatever source, a cloud seeding program that has a 37 to 1 cost benefit ratio?

DLE:kf

cc: Basin Advisory Committee Chairpersons  
Wayne Bossert, Northwest Kansas GMD No. 4  
Steve Frost, Southwest Kansas GMD No. 3  
Stephen A. Hurst, Kansas Water Office  
Keith Lebbin , Western Kansas GMD No. 1  
Tom Stiles, Kansas Water Office

## ANALYSIS 1 (Pre-Cloud Seeding Time Period)

- 1) Null hypothesis: For the pre-cloud seeding time period (1948-1970) there is no relationship between the study areas (control and target) and the hail suppression loss cost ratio.  
  
Alternative hypothesis: For the pre-cloud seeding time period (1948-1970) there is a relationship between the study areas (control and target) and the hail suppression loss cost ratio.
- 2) Choose  $\alpha = 0.05$  as our level of significance.
- 3) Choose a chi-square test of independence as our test criterion to determine if the null hypothesis is true. Reject the null hypothesis if the computed value of chi-square is greater than or equal to 3.84. A chi-square value of 3.84 or larger would occur only five times out of 100 if the null hypothesis is true.
- 4) Compute the value of chi-square.

Table of Observed Values (1948-1970)

Study Area	Loss Cost Ratio		Row Total
	Less than 10	10 or more	
Target	101	37	138
Control	131	53	184
Column Total	232	90	322

Table of Expected Values (1948-1970)

Study Area	Loss Cost Ratio	
	Less than 10	10 or more
Target	$(138 \times 232)/322 = 99.43$	$(138 \times 90)/322 = 38.57$
Control	$(184 \times 232)/322 = 132.57$	$(184 \times 90)/322 = 51.43$

$$\text{Chi-square} = \frac{(101 - 99.43)^2}{99.43} + \frac{(37 - 38.57)^2}{38.57} + \frac{(131 - 132.57)^2}{132.57} + \frac{(53 - 51.43)^2}{51.43} = 0.16$$

- 5) Since chi-square = 0.16 is less than 3.84 we conclude that we can not reject the null hypothesis on the basis of this data. The very small value of chi-square is strong evidence that there was no relationship between the study areas and the loss cost ratio during the pre-cloud seeding time period. Hence, if a statistically significant relationship is found to exist during the cloud seeding time period it is reasonable to assume that it is a result of the cloud seeding activities.



## ANALYSIS 2 (Cloud Seeding Time Period)

- 1) Null hypothesis: For the cloud seeding time period (1979-1993) there is no relationship between the study areas (control and target) and the hail suppression loss cost ratio.  
  
Alternative hypothesis: For the cloud seeding time period (1979-1993) there is a relationship between the study areas (control and target) and the hail suppression loss cost ratio.
- 2) Choose  $\alpha = 0.05$  as our level of significance.
- 3) Choose a chi-square test of independence as our test criterion to determine if the null hypothesis is true. Reject the null hypothesis if the computed value of chi-square is greater than or equal to 3.84. A chi-square value of 3.84 or larger would occur only five times out of 100 if the null hypothesis is true.
- 4) Compute the value of chi-square.

Table of Observed Values (1979-1993)

Study Area	Loss Cost Ratio		Row Total
	Less than 10	10 or More	
Target	84	6	90
Control	99	21	120
Column Total	183	27	210

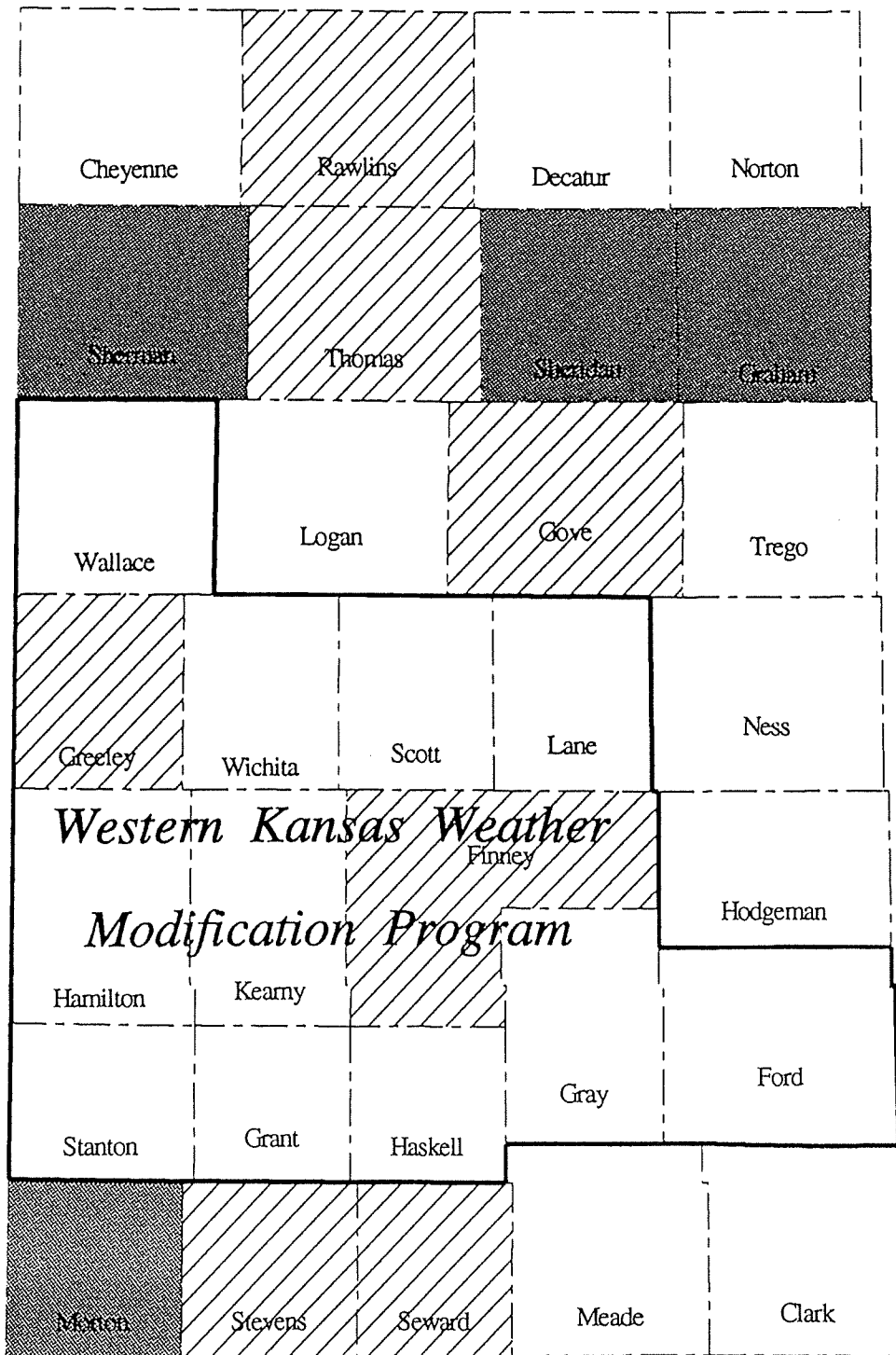
Table of Expected Values (1979-1993)


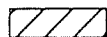

Study Area	Loss Cost Ratio	
	Less than 10	10 or More
Target	$(90 \times 183)/210 = 78.43$	$(90 \times 27)/210 = 11.57$
Control	$(120 \times 183)/210 = 104.57$	$(120 \times 27)/210 = 15.43$

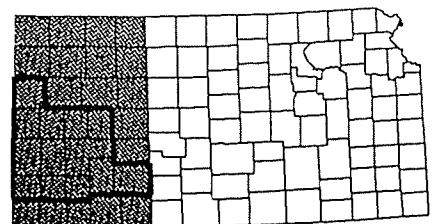
$$\text{Chi-square} = \frac{(84 - 78.43)^2}{78.43} + \frac{(6 - 11.57)^2}{11.57} + \frac{(99 - 104.57)^2}{104.57} + \frac{(21 - 15.43)^2}{15.43} = 5.38$$

- 5) Since chi-square = 5.38 is greater than 3.84 we conclude that we can reject the null hypothesis. Hence, a statistically significant relationship does exist between the study areas and the lost cost ratios during the cloud seeding period. A review of the tables show that there were fewer high loss cost values observed in the target area than would have been expected (6 compared to 11.57) if the null hypothesis were true. Hence, the Western Kansas Weather Modification Program has been effective in suppressing crop hail damage in the target area.

# Average Crop Hail Damage per Harvested Acre By County, Western Kansas, 1992 – 1993



-  \$0.01 – \$15.00 per harvested acre
-  \$15.01 – \$25.00 per harvested acre
-  \$25.01 – \$46.00 per harvested acre



Location Map

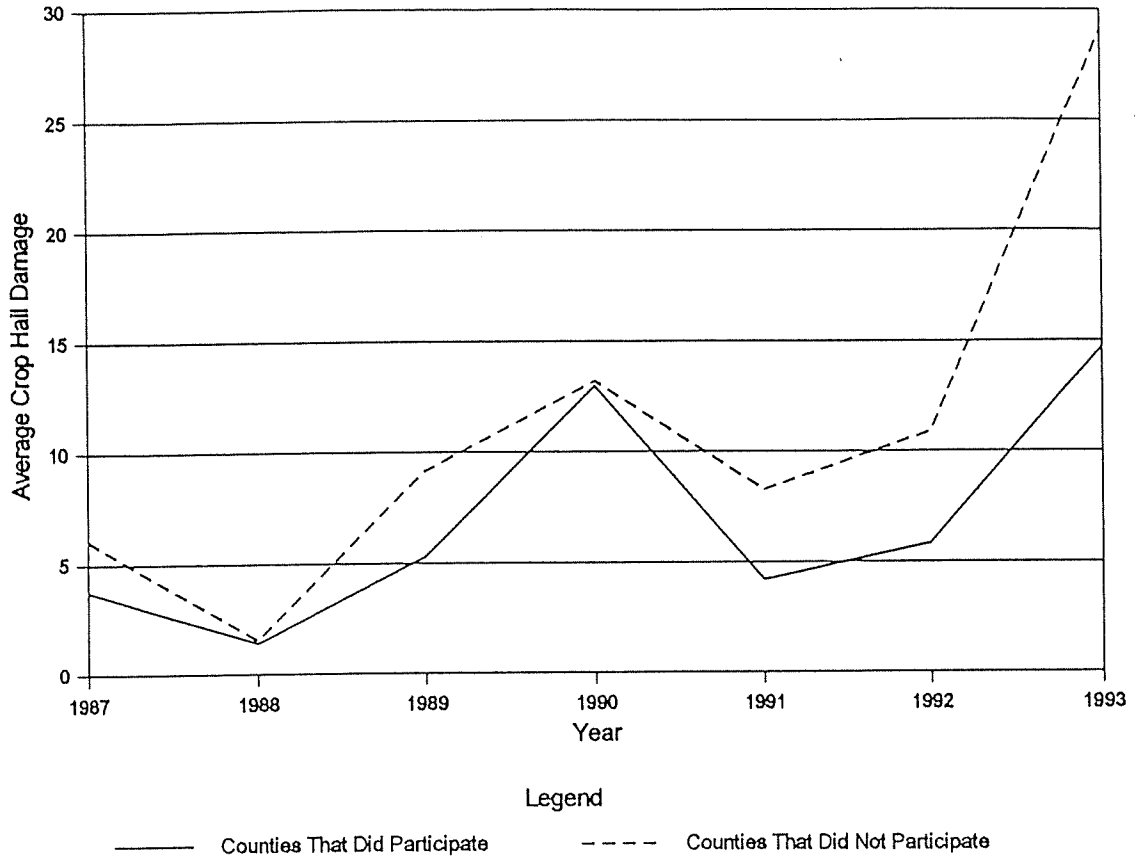
1-24  
+18

**AVERAGE CROP HAIL DAMAGE PER HARVESTED ACRE BY WEATHER  
MODIFICATION PARTICIPATION STATUS  
WESTERN KANSAS,<sup>a/</sup> 1987-1993**

Year	Counties That Participated In Weather Modification Program	Counties That Did Not Participate In Weather Modification Program
1987	\$3.76	\$6.06
1988	1.41	1.54
1989	5.31	9.20
1990	12.97	13.23
1991	4.21	8.28
1992	5.84	10.91
1993	14.69	29.09
Average	\$6.88	\$11.19

<sup>a/</sup> Includes all Kansas counties that are located west of Highway 283.

**AVERAGE CROP HAIL DAMAGE (DOLLARS) PER HARVESTED ACRE  
BY WEATHER MODIFICATION PARTICIPATION STATUS<sup>a/</sup>  
WESTERN KANSAS, 1987-1993**



<sup>a/</sup> Includes all Kansas counties that are located west of Highway 283.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>  
CHEYENNE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	184,800	\$50,655	\$0.20
1988	174,240	\$12,599	\$0.00
1989	195,150	\$1,717,366	\$8.73
1990	210,140	\$340,341	\$1.55
1991	194,000	\$2,158,697	\$11.06
1992	162,400	\$327,461	\$1.95
1993	215,570	\$1,136,963	\$5.20
Average	190,900	\$820,583	\$4.10

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**CLARK COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	87,790	\$73,885	\$0.77
1988	87,370	\$0	-\$0.07
1989	62,800	\$16,311	\$0.19
1990	104,700	\$20,843	\$0.13
1991	69,500	\$19,789	\$0.21
1992	69,200	\$80,676	\$1.10
1993	107,200	\$829,734	\$7.67
Average	84,080	\$148,748	\$1.43

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**COMANCHE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	102,900	\$26,336	\$0.52
1988	96,220	\$8,069	\$0.01
1989	88,000	\$110,496	\$1.19
1990	112,000	\$19,778	\$0.11
1991	97,500	\$31,003	\$0.25
1992	109,200	\$629,343	\$5.69
1993	115,800	\$880,688	\$7.54
Average	103,089	\$243,673	\$2.19

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**DECATUR COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	197,600	\$455,093	\$2.23
1988	195,340	\$142,911	\$0.66
1989	185,760	\$235,187	\$1.20
1990	203,400	\$744,952	\$3.59
1991	197,900	\$43,828	\$0.15
1992	215,900	\$485,698	\$2.18
1993	208,400	\$2,195,602	\$10.47
Average	200,614	\$614,753	\$2.93

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.



**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**EDWARDS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	197,150	\$248,297	\$1.19
1988	197,520	\$0	-\$0.07
1989	164,800	\$35,510	\$0.15
1990	214,450	\$0	-\$0.07
1991	205,000	\$181,839	\$0.82
1992	196,550	\$138,351	\$0.63
1993	223,370	\$88,298	\$0.33
Average	197,398	\$115,382	\$0.43

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**ELLIS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	158,200	\$909,794	\$5.68
1988	131,020	\$0	-\$0.07
1989	88,700	\$193,798	\$2.11
1990	155,850	\$514,475	\$3.23
1991	145,250	\$104,529	\$0.65
1992	141,260	\$23,323	\$0.10
1993	168,810	\$520,164	\$3.01
Average	141,299	\$323,726	\$2.10

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
FINNEY COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	345,850	\$2,263,795	\$6.55
1988	310,200	\$328,627	\$1.06
1989	356,350	\$1,985,425	\$5.57
1990	379,500	\$2,817,635	\$7.42
1991	372,850	\$1,545,745	\$4.15
1992	424,250	\$2,771,527	\$6.53
1993	391,800	\$11,414,739	\$29.13
Average	368,686	\$3,303,927	\$8.63

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
FORD COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	316,550	\$663,302	\$2.10
1988	282,250	\$1,514	\$0.01
1989	261,850	\$485,885	\$1.86
1990	298,050	\$1,027,362	\$3.45
1991	290,350	\$210,450	\$0.72
1992	281,100	\$1,097,843	\$3.91
1993	325,650	\$877,797	\$2.70
Average	293,686	\$623,450	\$2.12

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**GOVE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	192,150	\$851,785	\$4.36
1988	180,330	\$82,482	\$0.39
1989	210,600	\$127,609	\$0.54
1990	205,950	\$2,099,469	\$10.12
1991	207,000	\$537,104	\$2.52
1992	190,300	\$845,049	\$4.37
1993	219,470	\$2,730,765	\$12.37
Average	200,829	\$1,039,180	\$4.95

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**GRAHAM COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	170,240	\$146,735	\$0.79
1988	145,810	\$23,832	\$0.09
1989	152,970	\$514,130	\$3.29
1990	154,410	\$943,045	\$6.04
1991	172,350	\$230,155	\$1.27
1992	183,000	\$115,645	\$0.56
1993	134,600	\$4,405,754	\$32.66
Average	159,054	\$911,328	\$6.39

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
GRANT COUNTY, 1987-1989, 1991-1993<sup>b/</sup>**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	196,970	\$534,041	\$2.71
1988	175,260	\$94,464	\$0.54
1989	184,550	\$1,166,771	\$6.32
1991	191,100	\$846,661	\$4.43
1992	201,800	\$176,504	\$0.87
1993	220,900	\$1,124,770	\$5.09
Average	195,097	\$657,202	\$3.33

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

b/ Grant County did not participate in the Western Kansas Weather Modification Program in 1990.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
GRAY COUNTY, 1990-1993<sup>b/</sup>**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1990	311,330	\$2,474,348	\$7.95
1991	309,850	\$3,156,361	\$10.19
1992	317,300	\$2,884,275	\$9.09
1993	350,000	\$1,603,036	\$4.58
Average	322,120	\$2,529,505	\$7.95

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

b/ Gray County did not participate in the Western Kansas Weather Modification Program during the time period from 1987-1989.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.



**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
GREELEY COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	184,200	\$94,023	\$0.51
1988	185,950	\$2,950	\$0.02
1989	199,650	\$1,349,593	\$6.76
1990	216,350	\$1,570,665	\$7.26
1991	191,200	\$2,048	\$0.01
1992	195,760	\$1,084,763	\$5.54
1993	204,570	\$7,577,097	\$37.04
Average	196,811	\$1,668,734	\$8.16

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**ESTIMATED OR POTENTIAL NET SAVINGS DUE TO  
REDUCED CROP HAIL DAMAGE  
HAMILTON COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Net Savings	Net Savings Per Harvested Acre
1987	195,700	\$423,502 <sup>a/</sup>	\$2.09
1988	179,300	\$1,014 <sup>a/</sup>	-\$0.06
1989	178,150	\$264,054 <sup>a/</sup>	\$1.41
1990	165,050	\$3,200,169 <sup>a/</sup>	\$19.32
1991	176,000	\$935,625 <sup>a/</sup>	\$5.25
1992	176,620	\$552,567 <sup>b/</sup>	\$3.13
1993	183,960	\$4,196,767 <sup>b/</sup>	\$22.81
Average	179,254	\$1,367,671	\$7.71

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1991, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program was seven cents per harvested acre per year.

b/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs were provided by the Western Kansas Weather Modification Program for 1992 and 1993 and were estimated at seven cents per harvested acre per year for 1987-1991.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
HASKELL COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	219,900	\$1,141,450	\$5.19
1988	209,540	\$114,638	\$0.55
1989	239,650	\$4,866,012	\$20.30
1990	248,770	\$766,569	\$3.08
1991	251,900	\$2,020,859	\$8.02
1992	269,450	\$655,570	\$2.43
1993	256,400	\$1,913,949	\$7.46
Average	242,230	\$1,639,864	\$6.72

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**HODGEMAN COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	172,600	\$145,078	\$0.77
1988	150,830	\$4,338	-\$0.04
1989	123,900	\$22,982	\$0.12
1990	167,350	\$107,626	\$0.57
1991	155,750	\$189,219	\$1.14
1992	160,000	\$530,001	\$3.24
1993	173,290	\$642,138	\$3.64
Average	157,674	\$234,483	\$1.35

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
KEARNY COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	203,250	\$273,310	\$1.34
1988	191,710	\$126,859	\$0.66
1989	173,300	\$874,970	\$5.05
1990	198,050	\$788,760	\$3.98
1991	204,450	\$1,523,217	\$7.45
1992	201,150	\$843,493	\$4.19
1993	208,980	\$2,898,699	\$13.87
Average	197,270	\$1,047,044	\$5.22

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**KIOWA COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	151,500	\$78,448	\$0.45
1988	155,480	\$0	-\$0.07
1989	144,950	\$62,054	\$0.36
1990	182,330	\$1,306	-\$0.06
1991	194,400	\$19,765	\$0.03
1992	150,510	\$197,530	\$1.24
1993	171,300	\$107,921	\$0.56
Average	164,353	\$66,718	\$0.36

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
LANE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	169,020	\$442,311	\$2.62
1988	160,440	\$307,802	\$1.92
1989	158,750	\$421,965	\$2.66
1990	160,850	\$5,089,720	\$31.64
1991	163,150	\$157,953	\$0.97
1992	165,800	\$1,539,120	\$9.28
1993	183,220	\$714,914	\$3.90
Average	165,890	\$1,239,112	\$7.57

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**LOGAN COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	200,230	\$782,188	\$3.84
1988	173,810 *	\$362,106	\$2.01
1989	187,800	\$8,207	-\$0.03
1990	162,550	\$1,097,226	\$6.68
1991	186,550	\$2,083,661	\$11.10
1992	168,500	\$518,883	\$3.01
1993	204,360	\$1,256,463	\$6.08
Average	183,400	\$872,676	\$4.67

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.



**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**MEADE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	203,290	\$107,417	\$0.46
1988	179,940	\$208,211	\$1.09
1989	186,900	\$151,691	\$0.74
1990	210,000	\$22,702	\$0.04
1991	203,100	\$100,279	\$0.42
1992	201,900	\$1,322,322	\$6.48
1993	211,500	\$274,048	\$1.23
Average	199,519	\$312,381	\$1.49

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**MORTON COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	170,570	\$734,567	\$4.24
1988	138,480	\$110,956	\$0.73
1989	134,200	\$390,112	\$2.84
1990	156,250	\$109,714	\$0.63
1991	166,050	\$240,913	\$1.38
1992	163,440	\$61,402	\$0.31
1993	143,200	\$3,943,211	\$27.47
Average	153,170	\$798,696	\$5.37

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>  
NESS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	193,270	\$268,750	\$1.32
1988	193,660	\$5,291	-\$0.04
1989	177,450	\$63,226	\$0.29
1990	207,750	\$1,899,630	\$9.07
1991	200,050	\$97,039	\$0.42
1992	199,600	\$95,659	\$0.41
1993	207,490	\$259,190	\$1.18
Average	197,039	\$384,112	\$1.81

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**NORTON COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	162,590	\$207,726	\$1.21
1988	159,110	\$32,740	\$0.14
1989	146,100	\$421,774	\$2.82
1990	192,550	\$559,961	\$2.84
1991	183,050	\$18,979	\$0.03
1992	204,750	\$273,638	\$1.27
1993	205,200	\$407,828	\$1.92
Average	179,050	\$274,664	\$1.46

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>  
PAWNEE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	249,300	\$594,607	\$2.32
1988	227,340	\$17,126	\$0.01
1989	176,550	\$70,265	\$0.33
1990	237,900	\$863,956	\$3.56
1991	231,850	\$53,996	\$0.16
1992	208,860	\$1,011,174	\$4.77
1993	248,010	\$1,680,060	\$6.70
Average	225,687	\$613,026	\$2.55

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>  
PHILLIPS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	162,200	\$537,842	\$3.25
1988	154,820	\$6,910	-\$0.03
1989	131,050	\$5,078	-\$0.03
1990	171,400	\$907,966	\$5.23
1991	169,500	\$647,159	\$3.75
1992	181,200	\$1,021,463	\$5.57
1993	178,140	\$1,933,609	\$10.78
Average	164,044	\$722,861	\$4.07

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**RAWLINS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	200,770	\$168,164	\$0.77
1988	182,820	\$16,660	\$0.02
1989	195,250	\$5,400,051	\$27.59
1990	231,150	\$244,677	\$0.99
1991	220,400	\$663,873	\$2.94
1992	202,150	\$227,614	\$1.06
1993	229,500	\$3,929,988	\$17.05
Average	208,863	\$1,521,575	\$7.20

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**ROOKS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	170,650	\$792,370	\$4.57
1988	158,270	\$21,572	\$0.07
1989	119,200	\$31,071	\$0.19
1990	146,350	\$798,783	\$5.39
1991	157,450	\$152,487	\$0.90
1992	158,240	\$251,407	\$1.52
1993	119,250	\$2,641,108	\$22.08
Average	147,059	\$669,828	\$4.96

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.



**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**RUSH COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	190,150	\$640,881	\$3.30
1988	172,810	\$0	-\$0.07
1989	112,550	\$258,051	\$2.22
1990	191,620	\$413,109	\$2.09
1991	191,250	\$198,749	\$0.97
1992	183,200	\$58,935	\$0.25
1993	191,190	\$116,632	\$0.54
Average	176,110	\$240,908	\$1.33

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
SCOTT COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	202,590	\$209,782	\$1.04
1988	182,800	\$259,399	\$1.42
1989	201,550	\$129,138	\$0.64
1990	226,700	\$4,983,976	\$21.98
1991	230,000	\$109,166	\$0.47
1992	219,970	\$2,250,542	\$10.23
1993	232,710	\$3,325,913	\$14.29
Average	213,760	\$1,609,702	\$7.15

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**SEWARD COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	157,740	\$133,959	\$0.78
1988	153,320	\$55,671	\$0.29
1989	155,200	\$607,683	\$3.85
1990	181,600	\$76,175	\$0.35
1991	197,900	\$3,241	-\$0.05
1992	179,750	\$2,440,582	\$13.51
1993	189,160	\$1,454,962	\$7.62
Average	173,524	\$681,753	\$3.76

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**SHERIDAN COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	212,200	\$991,085	\$4.60
1988	184,340	\$47,969	\$0.19
1989	206,870	\$60,719	\$0.22
1990	215,550	\$3,666,163	\$16.94
1991	234,350	\$271,569	\$1.09
1992	233,150	\$3,608,387	\$15.41
1993	220,090	\$6,466,938	\$29.31
Average	215,221	\$2,158,976	\$9.68

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>  
SHERMAN COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	259,000	\$505,344	\$1.88
1988	221,030	\$64,906	\$0.22
1989	253,680	\$1,502,854	\$5.85
1990	288,550	\$673,849	\$2.27
1991	275,500	\$3,666,754	\$13.24
1992	195,850	\$1,455,692	\$7.36
1993	305,360	\$6,780,987	\$22.14
Average	256,996	\$2,092,912	\$7.57

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED OR POTENTIAL NET SAVINGS DUE TO REDUCED  
CROP HAIL DAMAGE  
STANTON COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Net Savings	Net Savings Per Harvested Acre
1987	208,860	\$1,541,440 <sup>a/</sup>	\$7.31
1988	182,860	\$22,366 <sup>a/</sup>	\$0.05
1989	207,850	\$865,194 <sup>b/</sup>	\$4.16
1990	231,000	\$3,765,097 <sup>b/</sup>	\$16.30
1991	217,500	\$597,432 <sup>b/</sup>	\$2.75
1992	216,950	\$1,538,126 <sup>b/</sup>	\$7.09
1993	207,790	\$3,800,634 <sup>b/</sup>	\$18.29
Average	210,401	\$1,732,898	\$7.99

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county in 1987 and 1988, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

b/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs were provided by the Western Kansas Weather Modification Program for 1989-1993 and were estimated at seven cents per harvested acre per year for 1987 and 1988.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**STEVENS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	274,140	\$1,054,518	\$3.78
1988	225,640	\$483,130	\$2.07
1989	253,600	\$2,127,920	\$8.32
1990	261,300	\$433,793	\$1.59
1991	265,500	\$351,653	\$1.25
1992	262,090	\$625,890	\$2.32
1993	259,470	\$5,089,688	\$19.55
Average	257,391	\$1,452,370	\$5.55

<sup>a/</sup> Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**THOMAS COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	305,300	\$944,441	\$3.02
1988	282,510	\$207,963	\$0.67
1989	316,920	\$437,239	\$1.31
1990	350,050	\$3,549,113	\$10.07
1991	334,650	\$528,353	\$1.51
1992	228,700	\$1,247,443	\$5.38
1993	346,820	\$4,099,599	\$11.75
Average	309,279	\$1,573,450	\$4.82

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.



**POTENTIAL NET SAVINGS DUE TO REDUCED CROP HAIL DAMAGE <sup>a/</sup>**  
**TREGO COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Potential Net Savings	Potential Net Savings Per Harvested Acre
1987	145,410	\$76,407	\$0.46
1988	133,540	\$1,999	-\$0.06
1989	119,800	\$349,387	\$2.85
1990	141,950	\$356,999	\$2.44
1991	137,600	\$191,738	\$1.32
1992	136,520	\$75,082	\$0.48
1993	144,400	\$721,516	\$4.93
Average	137,031	\$253,304	\$1.77

a/ Potential net savings represent the estimated net savings that would have occurred if a Hail Suppression Program had been operational in the county from 1987-1993, if it had been equally successful as the Western Kansas Weather Modification Program during that same time period and if the cost of the program were seven cents per harvested acre per year.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs estimated at seven cents per harvested acre per year.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
WALLACE COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	160,180	\$1,061,273	\$6.63
1988	137,770	\$673,626	\$4.89
1989	175,200	\$46,016	\$0.26
1990	161,600	\$2,807,512	\$17.37
1991	155,800	\$977,180	\$6.27
1992	153,670	\$867,000	\$5.64
1993	178,020	\$2,047,725	\$11.50
Average	160,320	\$1,211,476	\$7.51

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.

**ESTIMATED NET SAVINGS<sup>a/</sup> OF WESTERN KANSAS WEATHER MODIFICATION  
PROGRAM DUE TO REDUCED CROP HAIL DAMAGE  
WICHITA COUNTY, 1987-1993**

Year	Estimated Harvested Acres	Estimated Net Savings	Estimated Net Savings Per Harvested Acre
1987	201,050	\$1,338,595	\$6.66
1988	169,800	\$234,093	\$1.38
1989	194,350	\$297,786	\$1.53
1990	210,900	\$3,294,899	\$15.62
1991	198,450	\$388,219	\$1.96
1992	193,780	\$715,411	\$3.69
1993	205,960	\$2,402,028	\$11.66
Average	196,327	\$1,238,719	\$6.07

a/ Estimated net savings represent the savings achieved after subtracting the County's portion of costs for the Western Kansas Weather Modification Program, from the estimated gross savings.

Source: Table was prepared by the Kansas Water Office (December, 1994) based on harvested acres published by KANSAS FARM FACTS, crop hail insurance data published by National Crop Insurance Services and Program costs provided by the Western Kansas Weather Modification Program.