A DELPHI STUDY OF THE FUTURE AGRICULTURAL WATER RESOURCE NEEDS IN OKLAHOMA

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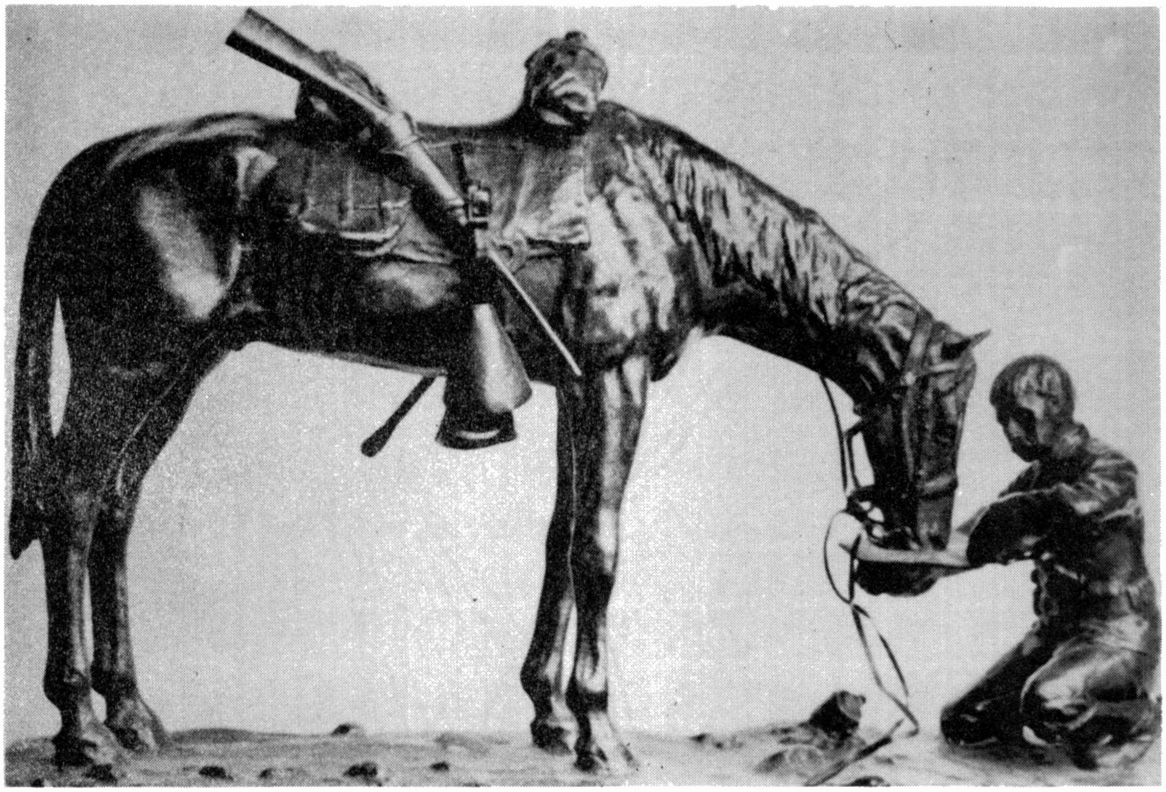

THE LAST DROP

(bronze 1900 by Charles Schreyvogle)

Source: James D. Horan. The Life and Art of Charles Schreyvogle. New York: Crown Publishers Inc., 1969, p. 39.

CHAPTER I

INTRODUCTION

Water, one of the most abundant chemical compounds on earth and perhaps the rarest chemical compound in the universe, is basic to the survival of man. Without the proper quantity and quality of water, mankind cannot exist in his physical form.

Continued population growth, and related agricultural and industrial growth, places an ever-increasing demand on the available water resources. Although water is a renewable resource, its availability at any given place or point in time is finite. If the demand for water is greater than the supply, serious problems can and do develop.

Proper water resource management has become more and more important as population growth continues. Projections of water resource demand are an important dimension in the overall water management scheme. A lack of adequate projections can lead to serious shortages, as is the situation today with the energy supply dilemma. Timely and accurate projections can avert the need for crisis management emanating from poor planning.

Concern over an adequate supply of quality water has spread to many parts of the United States, not just in the arid western states. According to Wollman and Bonem (1971), their comprehensive study suggests

> . . . it [concern over adequate fresh water supplies], will become more intense and spread still more rapidly as population--especially urban population--and industrial activities

> continue to grow. . . . In view of this the need for well-grounded projections of future supplies and requirements is as great for water as for any other of the country's major natural resources or resource commodities (p. 3).

Oklahoma is experiencing a period of tremendous growth and change. A publication by the Oklahoma Water Resources Board (1975, p. x) indicated "Oklahomans today are at the crossroads." One of the limiting factors that will determine the character of future growth patterns in Oklahoma is the water resources that will be available to facilitate that growth. It appears that additional resources and information are necessary for responsible decision making. The Oklahoma Water Resources Board (1975, p. x) stated "Oklahoma does not have enough water in the right places to meet present or foreseeable needs."

Oklahoma occupies a rather unique position with respect to its ecological and environmental profile. Being a transition zone, both geographically and climatically, its ecosystems are particularly unique. This unique combination demands that quality policy decisions can only be made when accurate and appropriate data and projections are used to weigh the variables. The problem is that information being used to influence important decision making may be inappropriate (Campbell, 1977).

According to the Sunday Oklahoman (October 1, 1978),

> Experts predict this Ogallala aquifer will dry up in some areas in just three years; in other areas it may last 20 years. This week, Secretary of Commerce, Juanita M. Kreps approved a $6 million study of the Ogallala aquifer . . . (p. 28).

The Ogallala aquifer is one of the major sources of ground water in western Oklahoma. In one particular area near Guymon, the water level in the aquifer, which averages only 300 feet thick, dropped 75 feet in only 20 years (Oklahoma Water Resources Board, 1976).

Recharge of the Ogallala aquifer is minimal. According to the Oklahoma Water Resources Board (1976, p. 12), ". . . pumpage from wells exceeds recharge. Only 1.5 percent of the annual rainfall, or one-fourth inch, reaches the water table." Seventy-five feet of water in the water table represents a 3,600 year period of natural recharge. The reported drop in the water table of 75 feet in 20 years is 180 times the natural recharge rate for the same 20 year period. "Ground water in the Ogallala formation is being mined" (Oklahoma Water Resources Board, 1976, p. 12).

In other areas of Oklahoma ground water seems to be plentiful. A major ground water source, Antlers Sand, which is located in south-eastern Oklahoma, has been estimated by the United States Geological Survey to hold even more water than that part of the Ogallala formation found in western Oklahoma. It was estimated that Antlers Sand contains about 73,700,000 acre/feet of water with an estimated availability of 40 percent recoverable, or 29,500,000 acre/feet of available water. The Ogallala formation which is estimated to hold 70,000,000 acre/feet of water has an estimated recovery rate of about 50 percent or 35,000,000 acre/feet of available water.

The Antlers Sand is found in an area of the state that receives an average annual precipitation of 36 to 50 inches. The Ogallala formation, however, lies in a region of the state that receives only 16 to 22 inches of annual precipitation.

The diversity of available water resources within the boundaries of Oklahoma is tremendous.

Statement of the Problem

The problem was that agricultural endeavors in Oklahoma are marked by an exceedingly uncertain and perilous future. This is due partly to the diversity of available water resources within the boundaries of Oklahoma, the unstable energy supply, and the small profit margins.

The question, "What lies ahead?", has always been a difficult, if not impossible, question to answer. The people of Oklahoma, the farmers and ranchers, the planners, the educators, and legislators must attempt to gain a measure of insight into what the future holds so they can better accomplish their roles in our culture.

Purpose and Significance of the Study

The major purpose of this study was to gather and examine data to determine what the agricultural community (the group most directly affected by water resources) predict relative to the present and future agricultural patterns and water resources in Oklahoma.

It may be argued that one of the many missions of public schools is to increase the knowledge and/or awareness level of students on issues and concerns as they affect the society in which the student will be living in the future. Because our educational systems often function as preparatory agencies, this preparatory function is a reality which educators deal with in curricular matters. What is done with students in schools often reflects what educators believe about the future.

One of the curricular considerations for Oklahoma schools involves determining how the state's environment is changing. Children who are now in our elementary schools will be living as adults in the twenty-first century. In the future both personal life-styles and society may be very different than today. Concern for the future suggests we provide curricula for living in tomorrow's world as well as today's.

Information gathered and examined in this study can be of value in planning for alternatives. Although this study dealt with agricultural water resources and future needs, the author believes the curricular implications are far-reaching. Farming, ranching, food transportation, agricultural marketing, agricultural engineering, food services, health-related fields, to name a few, depend largely on economical agricultural water resources.

If future agricultural water needs far outweigh future supplies, the school curricula should change to better prepare and inform students to deal with water-related concerns. If the agricultural/economic base of Oklahoma is going to change radically, schools should be prepared to incorporate into the curriculum more environmental science and environmental awareness programs. These programs should stress water resource concerns so students may effect rational environmental impact in the future.

Rational environmental decisions leave succeeding generations with choices. Irrational decisions do not. For example, if the water resources in the Oklahoma Panhandle are depleted to the point that farming is no longer economical in the Panhandle, then students within the Panhandle can no longer choose to be farmers there. Limiting the choices for future generations is not an educational goal of our schools.

Assumptions of the Study

To complete this study, the following assumptions were made:

1. County extension directors, district and area conservationists,

leaders and staff members of committees and study groups dealing with water resources are knowledgeable and concerned with water resources and will respond honestly on a Delphi Study.

2. The Delphi Technique is useful for assessing present problems and concerns and in predicting future needs.

3. The design of the research instrument will yield data reflecting a measure of consensus on present and future water resource needs.

Limitations of the Study

For reasons of cost and data management, the participants receiving the research instrument were limited to county extension directors, district and area conservationists, and other selected individuals, totaling 194 in all.

The research instrument was limited in size and scope in an effort to maximize response rate.

Definition of Terms

For the purpose of this study, the following definitions were used:

Acre/Foot--The amount of water required to cover one acre at a depth of one foot (43,560 cubic feet, 325,815 gallons).

Delphi Technique--A questionnaire format consisting of two or more rounds of questioning that endeavors to focus on consensus of opinion concerning future events.

The literature contains few criteria for the construction of a Delphi research instrument; however, the Delphi Technique used in this study exhibits the following characteristics:

1. The format was a paper and pencil questionnaire administered by mail.
2. The questionnaire items were generated by the principal investigator and by the participants.
3. The questionnaires were accompanied by a set of instructions.
4. Each item on the second-round questionnaire was accompanied by some form of statistical feedback.
5. Individual responses were kept anonymous for all iterations.
6. Iterations with feedback continued until consensus reached a point of diminishing returns as determined by the principal investigator.
7. Participants did not meet or discuss issues face to face and were geographically remote from one another.

Environmental Education--Education of the public at all levels that includes, but is not limited to elementary science or outdoor education classes, secondary environment or life science, environmental education workshops or programs at the undergraduate and graduate level, seminars on environmental education.

Statistical Feedback--Information supplied by the participants that gave ordinal or percentage data concerning a previous round of questioning.

Water Resources--For the purpose of this study, all forms of water sources were considered resources, which include: precipitation, stream flow, natural and man-made impoundments, aquifer holdings, alluvium and terrace deposits, agricultural runoff, and municipal wastewater.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Although the topic under investigation in this study was directed toward gathering information relevant to the future agricultural water resources, a review of literature dealing with Delphi investigations was also deemed necessary. The initial portion of the literature review dealt with water resources and Oklahoma water resources in particular. The latter portion of the literature review was directed toward examination of the Delphi Technique in forecasting the future.

Water Resources--An Overview

"The beast of the field shall honour me, the dragons and the owls; because I give waters in the wilderness, and rivers in the desert, to give drink to my people, my chosen" (Isaiah, 43:20).

Almost all of the water in the world is saltwater, an estimated 1.3 billion km^3 of the world's water is salty. That compares to an estimated 40 million km^3 of fresh water. Man uses only two-tenths of one percent (0.2 percent) of the world's total water supply but is encountering problems in relation to adequate supply (Van Dam, 1978). Van Dam (1978) suggested that we have a major challenge concerning water resources.

In man's recent past, our use for water has been growing exponentially. Miller (1975) suggested that we were on a "J" curve of increasing per capita and net use (Figure 1). His projections indicated that the demand for water by the year 2000 would be near our total usable supply of water in the United States.

Agricultural Use of Water Resources

The primary use for water worldwide and in the United States, and particularly in Oklahoma, is agricultural (Van Dam, 1977; Wollman and Bonem, 1971). "Irrigated acres, which today is the largest single user of water, gross and net, is projected to grow . . ." (Wollman and Bonem, 1971, p. 43). "The major use in the United States today, whether measured by intake or by loss to the atmosphere is irrigation" (Wollman and Bonem, 1971, p. 43). In northwestern Oklahoma, municipal and industrial use of water was estimated to total 57,000 acre/feet of water, while irrigation use was estimated to be 1,546,200 acre/feet annually by the year 2030 (Oklahoma Water Resources Board, 1975). "In the western United States, still upwards of 90 percent of all water use is for irrigation purposes" (Ruttan, 1965, p. 2). "The bulk of the groundwater depletion in arid lands has been for agriculture" (Bowden, 1977, p. 131).

Agriculture and water resources go hand-in-hand, a knowledge of agriculture is incomplete without a working knowledge of water resources.

> If there were an endless supply of water and concentrated fuels, the activity on the High Plains would also be endless. But this food factory rests on storages of water, gas and oil, and these storages are running out. . . . By the 1980's water declines should make serious inroads in irrigated agriculture; thirty or forty years hence this commerce of pumped water should be over. The humans of the High Plains will be staring down tens of thousands of dry holes (Bowden, 1977, p. 102).

The study of plains agricultural history is the study of a history of water resources on the plains. "Plains agriculture became a search for

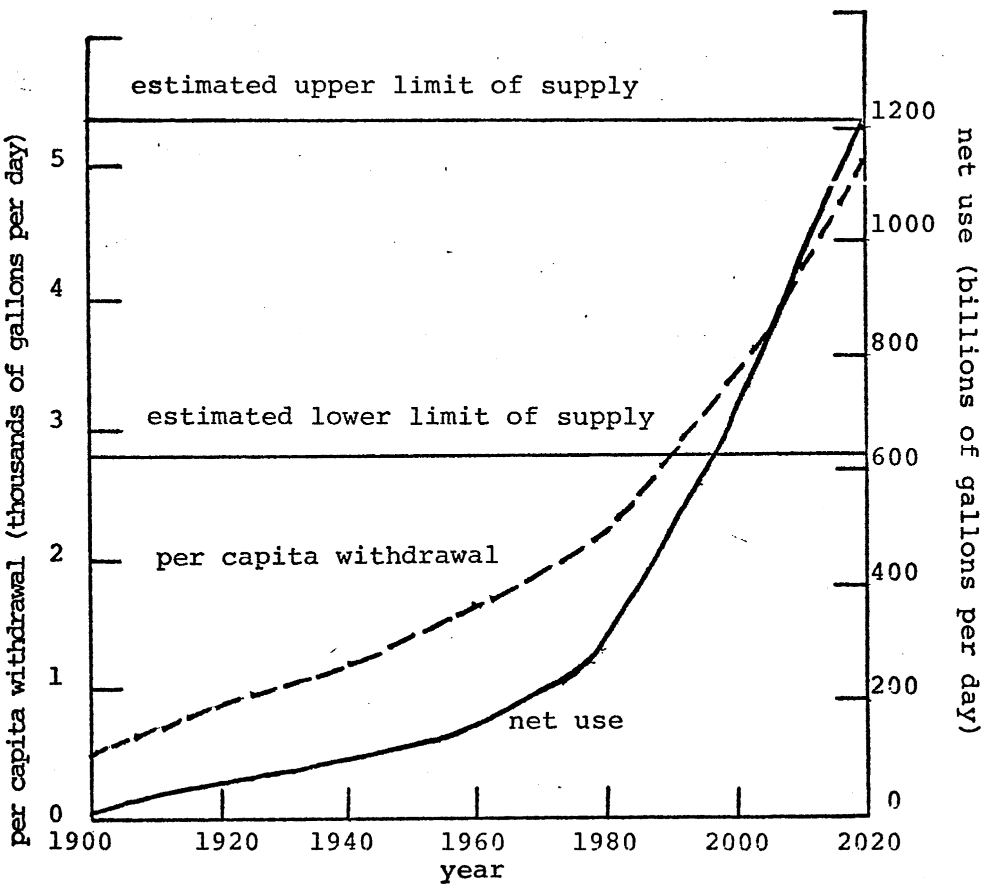

Figure 1. The "J" Curve of Increasing per Capita and Net Water Use in the United States

a way to escape weather. When words failed in this effort, interest increased in methods to pump underground water" (Sageser, 1967, p. 108).

People have known or speculated about underground aquifers, such as the Ogallala formation, for many years. What they did not understand was that the quantity of the water was finite. Black (1914) called the Ogallala an underground river that was one of the largest river systems in the United States. Hough (1897, p. 20) speculated that, "Without doubt these waters are connected with a great sheet of water which underlies all that region, and which sometime will be brought up by man to make the desert blossom."

Brockett (1882) suggested that the water supply in Arizona was sufficient to irrigate almost all the arable lands in Arizona. The men who thought that underground water came from underground rivers did not understand that a formation like the Ogallala is basically a large clay tub (Bowden, 1977).

Projected Demand for Irrigation

The projection of demand for irrigation land and water resources is a complicated process. Some of the factors which Ruttan (1965) used in his demand model are:

1. value of farm products,
2. number of irrigated acres,
3. current operating expenses,
4. marginal value product of irrigated land in cost per acre,
5. average annual cost of irrigated land in cost per acre,
6. time,
7. population,

8. per capita income,
9. a constant term for the production function,
10. a productivity coefficient for irrigated land,
11. a productivity coefficient for operating expenses,
12. income elasticity of demand for farm products,
13. a rate of change in regional share of national output in past period,
14. national total or a variable measure at the national level,
15. regional total or a variable measure at the regional level.

The Oklahoma Water Resources Board (1975) projected the demand for irrigation water in Oklahoma will be about 3.7 million acre/feet annually by 2020. This represents an increase of about 300 percent. Wollman and Bonem (1971) estimated that nationwide the demand for irrigation would increase by 40 to 60 percent by 2020. The demand for an increase of irrigation in Oklahoma will apparently be much greater than the projected increase in other parts of the country.

More efficient use of irrigation water is projected as demand increases and supply decreases (Wollman and Bonem, 1971). The Oklahoma Water Resources Board based its projected increases on a rate of 1.5 acre/feet per year of irrigation water in central Oklahoma and a rate of 2 acre/feet per year in western Oklahoma. The 1960 levels of usage listed by Wollman and Bonem (1971) were 1.8 acre/feet per year in the Lower Arkansas White Red River region (LAWR), of which eastern Oklahoma is a part, and 3.2 acre/feet per year in the Upper Arkansas White Red River region (UAWR), of which western Oklahoma is a part.

Wollman and Bonem (1971) estimated usage in 2020 of 1.5 acre/feet per year for LAWR and 2.2 acre/feet per year for UAWR. It appears that although the estimates for future irrigation water needs that were made by the Oklahoma Water Resources Board seem very high, in relation to Wollman and Bonem's estimates the acre/feet usage rate seem to be conservative or even low.

Cost of Irrigation Water

The amount of water required for irrigation is tremendous when compared to the value of the energy used to pump it from a deep well. A well pumping 1,000 gallons per minute has to run for 5.43 hours to pump one acre/foot of water. To pump one acre/foot of water on a 160 acre field, a well producing 1,000 gallons per minute, would have to pump continuously for 36.2 days running 24 hours a day.

According to Shipley (1978) the average cost of water in the Texas High Plains, pumped with an electric pump, was $23.78 per acre/foot in 1977. Considering the cost of irrigation water, the break-even prices for raising irrigated crops were: $3.64/bu for wheat, $3.05/cwt for grain sorghum, and $3.59/cwt for corn. Price quotations for November, 1977, were: $2.38/bu wheat, $3.25/cwt for sorghum, and $3.57/cwt for corn.

Goss (1978) expressed the view that irrigators have become alarmed at costs and noted it will affect food production in several ways through:

1. higher commodity prices,
2. a shift eastward in crop production from irrigated to dryland farming regions,
3. redistribution of farm income away from irrigated regions,
4. the impact on income and employment in rural communities.

Ed Kelly (1979), in an article dealing with irrigation and the cost of natural gas in the Oklahoma Panhandle, wrote:

> The situation is apparently so critical that the head of a group of area producers formed to fight curtailment and increased gas costs warns Guymon and other towns would virtually 'dry up' overnight if the wells stopped pumping (p. 1).

Kelly quoted Chet Nash, a Guymon implement dealer and spokesman for the High Plains Gas Consumer Group, and wrote, "Guymon is a city of 10,000 people, but if there's some law that cuts out our irrigation, I would say in 18 months the population would be down to 3,500" (p. 1). Kelly quoted Mabry Foreman, a farmer in the Panhandle, and wrote:

> I'm beginning to think that the water will last a lot longer than the money will . . . the price for interstate natural gas is approaching $2 per 1,000 cubic feet, a level that could, if it goes much higher, force some operators, particularly young producers, back to dryland farming (p. 2).

Interbasin Transfer of Water

Interbasin transfer of water is not new, it has been adopted in areas such as San Francisco, Los Angeles, New York City, and on a larger scale in Colorado and New Mexico (Fox, 1973). In all of the aforementioned areas the water is moved primarily by gravity downhill.

The legislature of Oklahoma is presently studying a plan which calls for the transport of water from southeastern Oklahoma to southwestern Oklahoma by means of a conveyance canal (Oklahoma Water Resources Board, 1976). This plan called for the water to be pumped uphill largely with electric pumps to the users in southwestern Oklahoma.

The proposed cost of water delivered to terminal reservoirs for municipal and industrial use will be about 27 cents per 1,000 gallons (Oklahoma Water Resources Board, 1975). According to Wollman and Bonem

(1971), the cost in 1971 would be from 5 cents to 20 cents per 1,000 gallons if the water was transported 163 miles and lifted 600 feet. The distance between Poteau, Oklahoma, in southeastern Oklahoma and Mangum in southwestern Oklahoma, is 328 miles. The difference in elevation is 1,120 feet. Using Wollman and Bonem's cost factor, transportation of water from Poteau to Mangum would be about 10 cents per 1,000 gallons and 40 cents per 1,000 gallons. The estimate of the Oklahoma Water Resources Board was similar to an estimate based on the cost factor computed using the figures given by Wollman and Bonem.

Using interbasin transfer, agricultural water cost, as estimated by the Oklahoma Water Resources Board, would be about $87 per acre/foot delivered to the farm. That would amount to a cost per acre of about $174 when using 2 acre/feet annually (Oklahoma Water Resources Board, 1975).

In 1951, landowners in Arizona agreed to pay $4.50 to $4.75 per acre/foot delivered to the farm (Carhart, 1951). In 1977, farmers were alarmed at a cost of $23.78 (Shipley, 1978).

Water is getting very expensive, ". . . the most expensive water is that obtained by interbasin transfers" (Wollman and Bonem, 1971, p. 210).

Interbasin transfer of water can also create ecological problems, as Miller (1975) suggested:

> Man continues to dream up large scale engineering schemes for diverting water from one area to another, usually for irrigation. Unfortunately, such projects sometimes generate even more expensive schemes to correct the problems created by the first project. . . . These projects successfully supplied water to fertile, dry land. But we are learning, as have past civilizations, that irrigation without adequate drainage is disastrous in the long run and destroys the land for crops. As it flows through the ground, water dissolves salts of sodium, calcium, magnesium and other substances. If these excess dissolved salts are not drained from a water basin as

> fast as they enter, the water can evaporate and allow salt to build up in the soil and ground water (p. 257).

The Delphi Technique

Forecasting techniques that rely on judgment and opinion depend on the imagination and technical adequacy of the forecasters. Nevertheless, forecasting the future seems to be a worthwhile enterprise despite the limitations imposed by relying on human judgment. The Delphi Technique was designed to produce consensus judgment in inexact fields. Forecasts based on careful judgment can provide coherent structures for testing alternative contemplated action and for anticipating other actions that may be needed or should be avoided.

When the Delphi Technique is used, there is a phenomenon at work which is not yet totally understood but is apparently usable. According to Dalkey (1967):

> Where response is a number (such as a date or amount), the most useful index has been the median of the individual estimates. During the process, opinions do converge; where answers can be checked against reality, it is found that the median response tends to move in the direction of the true answer (p. 8).
>
> In most cases, there is a pronounced convergence of opinion with iteration. . . . Where accuracy of response can be checked, it is shown to increase with iteration (p. 90).

Moore (1977) stated in a paper delivered at Kent State University:

> 'Project Delphi' was the name given to the Air Force-sponsored Rand Corporation study, starting in the early 1950's concerning the use of expert opinion. The objective of the original study was to 'obtain the most reliable consensus of opinion of a group of experts . . . by a series of intensive questionnaires interspersed with controlled opinion feedback' (p. 4).

Some of the applications for the Delphi Technique were identifying goals, arraying possible alternatives, and making future forecasts. Some specific applications of Delphi included exploring urban and regional planning options and exposing priorities of social goals (Moore, 1977).

Moore (1977, p. 3) suggested that the Delphi Technique should be used when "The problem does not lend itself to precise analytical techniques . . ." or when the problem is so broad or complex that face to face meetings of experts are not feasible.

The most successful use found for the Delphi Technique has been for forecasting and planning purposes (Brockhaus, 1977). Brockhaus (1977, p. 103) stated, "Since the inception of the Delphi method it has experienced increased application." Salancik (1971) wrote,

> The primary objective of a Delphi inquiry is to obtain a consensus of opinion from a group of respondents. The matter in which consensus is sought might typically be the time of occurrence of some potential future event (p. 65).

The construction of a Delphi Technique in technological forecasting is receiving ever increasing use; however, no hard and fast rules are laid down for any particular Delphi design (Turoff, 1970).

To point out some of the diversity in Delphi research design a few various guidelines are illustrated on the following pages. The diversity among the guidelines illustrates that there are few hard and fast rules for construction of a Delphi instrument. The guidelines are broken into four categories. These are:

1. Size of Respondent Groups,
2. Characteristics of Respondent Groups,
3. Number of Rounds,
4. Application and Uses.

Size of Respondent Groups

Forty environmental experts were polled by Dr. Smil in a Delphi study at the University of Manitoba in Winnipeg, Canada (Smil, 1974).

In 1958, Rand conducted a study with 150 university students (Dalkey, 1969).

Murry Turoff (1970, p. 153) stated, "A policy Delphi can be given to anywhere from ten to fifty people . . ."

It was indicated by Brockhaus (1977) that in the studies he investigated, two percent of the studies had five or fewer respondents while 40 percent had more than 40 respondents.

"Although the exact distinction is not a clear cut matter, most practitioners would agree that a panel of 100 or more qualify as lsD [large scale Delphi] studies" (Huckfeldt, 1974, p. 75).

"There is a tremendous difference between a panel of 12 to 15 scientific experts . . . and panels of 100 on through 1,000 found in educational Delphi undertakings" (Judd, 1971, p. 181).

Characteristics of Respondent Groups

"Conventional Delphi is primarily concerned with experts, but may also use other subject groups who may be informed to a greater or lesser extent in the target areas of inquiry, but who do not qualify as experts (Sackman, 1975, p. 8).

College sophomores were used in an educational Delphi study dealing with social studies curriculum (Tyler, 1977).

Residents of a town were used as a respondent group to address community projects in a Delphi study in Stow, Ohio (Moore, 1977).

"The panelists represented federal, state, and local government agencies; industry; and concerned citizen groups" (Wedley, 1977, p. 74).

"It is preferable that the respondent group be composed of individuals at a fairly high level of responsibility" (Turoff, 1970, p. 156).

"The method is commonly selected to collect the opinions of experts and to bring back these opinions to convergence . . ." (Brockhaus, 1977, p. 110).

Number of Rounds

"The questionnaires are administered to the participants for two or more rounds . . ." (Sackman, 1975, p. 14).

"A policy Delphi requires at least four to five rounds as opposed to the two or three rounds that are usually sufficient for the technological type Delphi" (Turoff, 1970, p. 161).

"It was also learned that most Delphi studies in fact consist of 3 or fewer iterations versus the minimum of 4 iterations as suggested in the literature" (Brockhaus, 1977, p. 109).

Application and Uses

Exploring urban and regional planning options. Delineating the pros and cons associated with policy options and exposing priorities of personal values and social goals (Moore, 1977).

"The application objective of conventional Delphi may be the forecasting of specified events, long-term or short-term . . ." (Sackman, 1975, p. 8).

"Most policy planners are familiar with Delphi as a forecasting technique. Its more powerful use, however, is in non-forecasting applications--as a problem-solving aid" (Wedley, 1977, p. 70).

"To determine or develop a range of possible alternatives. To correlate informed judgments on a topic spanning a wide range of disciplines" (Turoff, 1971, p. 149).

". . . the Delphi method has been used primarily in applied research and has proven most successful when used for forecasting and planning purposes" (Brockhaus, 1977, p. 110).

Judd (1971) used the Delphi Technique to plan curriculum for higher education.

The author determined from a review of literature that the Delphi Technique can and does lend itself to a wide range of interpretations. This research was conducted, taking into consideration that the Delphi Technique allows the principal investigator a good deal of flexibility and opportunity for judgment in procedural matters.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

This study attempted to identify what problems, needs, and developments, related to water resources, will occur in the future, using the Delphi Technique to gather a consensus of opinions from selected individuals.

Description of the Population

It was determined that the population sampled in this study should be experts in, or be knowledgeable about, water resources and agriculture in Oklahoma. The population frame in this study was composed of county extension directors, area and state conservationists, leaders and staff members of committees, planning boards and study groups dealing with water resources, hydraulic engineers and geologists. All of the members of the population were employed within the state of Oklahoma at the time the study was accomplished. Individuals were identified from two personnel directories: one published by the United States Department of Agriculture Soil Conservation Service in December, 1978, and the other by the Oklahoma Cooperative Extension Service in February, 1978. A total of 194 individuals who met the aforementioned criteria were selected to receive the research instrument.

Collection of Data

The data was collected in a series of two rounds of questionnaires administered by mail. The first round of questionnaires was mailed to a population of 194 individuals who were given a 10-day period to answer and mail back the questionnaire to the principal investigator. The participants were supplied with a self-addressed stamped envelope with which to accomplish the mailback.

After a period of two consecutive working days elapsed without receiving any mailbacks, the data from the first round of questionnaires was analyzed and tabulated. The total time elapsed between the first mailout and data tabulation was 23 days.

After the data was analyzed and tabulated from the first round of questioning, a second round questionnaire was formulated using the information gathered in round one. Formulation of the second round questionnaire took eight days, at which time the second round of questionnaires was mailed to all individuals who had responded to the first round of questioning. The second round of questionnaires was mailed to a population totaling 128. The participants were given another 10-day period to answer and mail the questionnaire back. In the second round, the participants were again supplied with a self-addressed stamped envelope with which to accomplish the mailback.

The data from 107 returned questionnaires of the second round was analyzed and tabulated after two consecutive working days elapsed without receiving any mailbacks. The total time elapsed between the second mailout and data tabulation was 24 days.

Instrumentation

The research instrument for the first round of questioning was designed by the principal investigator and three other doctoral students and was approved by the principal investigator's doctoral committee. Before the instrument was sent to participants, administrators of the Soil Conservation Service and the Cooperative Extension Service were supplied with a copy of the instrument and were afforded an opportunity for input into the questionnaire. Neither the Soil Conservation Service nor the Cooperative Extension Service administrators suggested any changes in the instrument, but verbally gave permission to the principal investigator to allow the instrument to survey individuals in their respective organizations.

The first round questionnaire had a total of nine questions, and consisted of three pages, which included a cover letter with instructions. A copy of the first round questionnaire may be found in Appendix A.

The second round questionnaire was formulated using the data tabulated from the first round responses. The responses from the first round were organized for the second round questionnaire into seven items which incorporated all of the expressed opinions of the first round. Items No. 1 and No. 2 of the first round were incorporated into one item (No. 1) for the second round. The comments, as stated by the participants, for Item No. 7 of round one were extremely obtuse and diversified, and could not be logically grouped by the principal investigator. The broad interpretations and resultant diversity of responses for Item No. 7 of round one caused the principal investigator to determine that the question was not clearly understood by the participants and it was eliminated from round two.

The seven items in the second round questionnaire were essentially listings of opinions that were gathered in round one. The listings of gathered opinions were presented in the second round questionnaire in rank order with numerical notations indicating the total number of times each particular opinion was mentioned in round one responses. The second round questionnaire was designed so that the participants could indicate their opinions with only one or more checkmarks for each of the seven items.

In the design of the round two questionnaire, the principal investigator exercised a degree of interpretation of the opinions listed in round to facilitate data grouping. This was done primarily to prevent the round two questionnaire from becoming excessively voluminous. Interpretation of stated opinions was done carefully and kept to an absolute minimum.

The second round questionnaire consisted of a total of eight pages which included a cover letter with additional instructions. A copy of the second round correspondence may be found in Appendix B.

Data Analysis

Analysis of the data was accomplished by using the responses given in the first and second round questionnaires to generate listings, in rank order by number of times mentioned, of the opinions given by the participants. In addition, listings, in rank order by number of times mentioned, of short phrases that were chosen by the participants to clarify why each opinion was likely to be accurate.

In addition to analyzing the responses, the number of completed questionnaires that were mailed back for each round were grouped and counted. The state of Oklahoma was divided into five areas and completed questionnaires were counted from each of those areas to determine which area produced the greatest percentage of responses.

CHAPTER IV

ANALYSIS OF THE DATA

Introduction

The purpose of this chapter was to present the data collected in round one and round two of the questionnaires and to indicate the response rate for round one and round two questionnaires.

Demographic Analysis

For the purpose of this study a demographic analysis of the response rate for each round of questioning was done. A percentage was calculated to indicate the response rate for the total number of questionnaires sent out and percentages for response rates in each of five geographic areas that were identified.

Using a map of Oklahoma, the state was divided into four major areas and the Oklahoma City area. The division was done using Interstate 35 (I35) and Interstate 40 (I40) to divide the state into four relatively equal land areas and the Oklahoma City area, being in the center, was the fifth division.

Table I shows the percentage of responses for the round one questionnaire, both statewide and for each of the identified areas. Table II shows the percentage of response for round two, both statewide and for each of the five identified areas.

TABLE I

RESPONSE RATE FOR ROUND ONE QUESTIONNAIRE

Location	Number Sent Out	Number Returned	Percentage Returned
Oklahoma	194	128	65.9
Oklahoma City	3	2	66.6
Northwest	43	27	62.7
Northeast	59	43	72.8
Southwest	39	25	64.1
Southeast	50	31	62.0

TABLE II

RESPONSE RATE FOR ROUND TWO QUESTIONNAIRE

Location	Number Sent Out	Number Returned	Percentage Returned
Oklahoma	128	107	83.5
Oklahoma City	2	2	100.0
Northwest	27	24	88.8
Northeast	43	36	83.7
Southwest	25	20	80.0
Southeast	31	25	80.6

Round One Data

It should be noted that totals among the various items vary greatly because not all participants responded to all items of the round one questionnaire. It should also be noted that a degree of interpretation was exercised the the principal investigator to facilitate data grouping.

Question number one and question number two in the first round questionnaire were:

No. 1--What do you think will be the number one problem in the future regarding water resources?

No. 2--What do you think will be the number two problem in the future?

In the analysis of the first round questionnaire, question number one and number two were combined. Every problem identified by the participants was given a value of one point each time it was mentioned as either the number one or number two problem of the future. The probable causes for each problem were listed and given a value of one point each time they were mentioned. Table III shows the responses for question No. 1 and No. 2 of round one. The numerical notations adjacent to each item indicates the total points accumulated for that item.

Question number three in the first round was:

No. 3--What human or technological developments are needed to prevent a critical water problem from developing in the future?

Opinions were categorized into a list of 25 needs. The list of needs relevant to question No. 3 may be found in Table IV. Opinions are presented in rank order by number of times mentioned, with numerical notations to indicate the total number of times each opinion was mentioned.

Question number four in the first round was:

No. 4--When do you foresee a "critical" period in relation to water resources?

TABLE III

RESPONSES FOR QUESTION NO. 1 AND NO. 2 OF ROUND ONE

Problems Identified	SUPPLY 71	POLLUTION 60	DISTRIBUTION 50	COST 40	POLITICAL CONTROLS 8	WASTE WATER MANAGEMENT 8	WASTEFUL USE 2	WATER DRAIN SYSTEMS 1
Probable Causes For Problems	increased demand 22	erosion 27	cost of transporting 13	cost of energy 18	red tape 3	distribution of waste water 1	poor management 2	inadequate drainage systems 1
	aquifer depletion 8	industrial wastes 8	uneven availability 10	structure costs 8	well spacing 1	cost of treatment 1		
	increased population 4	agri-chemicals 5	obsolete rural sys. 4	equip. and pumping costs 6	limit transfer of water 1	population increase 1		
	inadequate impoundments 2	inadequate law enforcement 4	location of population 3	management costs 3	acq. land for impoundments 1	industrial waste increase 1		
	saltwater intrusion 2	population increase 4		transportation costs 3				
	industrial growth 1	saltwater intrusion 3		low farm profits 1				
	water rights 1	intensified reuse 1						
	poor planning 1							

TABLE IV

RESPONSES FOR QUESTION NO. 3 OF ROUND ONE

Rank Order Listing of Opinions	
23	economical east to west transfer system
12	more conservation of available resources
11	more public awareness of the water resources problem
7	NONE (no needs in technological or human development)
7	more long-range planning
7	additional water impoundments
7	increased enforcement of pollution control laws
7	more public relations efforts between east and west
6	more education in water conservation measures
6	equitable water rights laws
5	development of more economical energy sources
4	better water management practices
4	development of aquifer recharge techniques
4	development of large-scale distribution techniques
3	stronger erosion control programs
2	development of small-scale desalination techniques
2	more education in pollution control
2	development of more drought resistant strains
1	small-scale alcohol distilling technology
1	more cost-share programs for structure development
1	increased dryland farming
1	point source pollution reduction
1	development of techniques to increase aquifer recovery rates
1	more rural water districts
1	more research in agricultural water management

In the item analysis of No. 4, 10 time-frames and a category for "no estimate" were identified. Table V shows the item analysis for question No. 4 of round one. It should be noted that the total number indicated for the "number of times chosen" is higher than the total responses returned for round one. This was due to the fact that when an estimate was made by a respondent that was for a period of more than a five-year span, that response was tallied in more than one time-frame.

TABLE V

RESPONSES FOR QUESTION NO. 4 OF ROUND ONE

Time Frame	Number of Times Chosen
0 years or now	13
1-5 years	13
6-10 years	19
11-15 years	17
16-20 years	24
21-25 years	19
26-30 years	5
31-35 years	1
Over 35 years	8
Never	4
No estimate	8

Question number five in round one was:

No. 5--Do you predict an increase or decrease in irrigation? Do you predict an increase or decrease in "dry land" farming? Why?

In the analysis of question No. 5 the three questions were talled as one item. Therefore, the totals do not add up to the total responses received. Some participants did not respond to the question and others responded to only one of the questions. The total tallies and the reasons given may be found in Table VI.

TABLE VI

RESPONSES FOR QUESTION NO. 5 OF ROUND ONE

Irrigation			Dry Land Farming		
will increase	remain static	will decrease	will increase	remain static	will decrease
74	8	44	56	9	43

Reasons:

29 energy costs
19 increased demand for food and fiber
16 cost of production demands fewer gambles
16 equipment costs
13 aquifer depletion
8 loss of land to rural development
6 high land costs
5 marginal land is being cleared
4 low farm prices
4 more intensive management
4 more pasture will be grazed not farmed
3 poor quality water for irrigation
2 better dry land varieties will be used
2 no more irrigation land is available
2 productionof dry land crops is not economical
2 trickle and sprinkler systems using present range
1 salt levels on land now becoming toxic
1 more specialty crops like vegetables

Question number six in round one was:

No. 6--Do you predict a change in the character of farming in Oklahoma because of water resources?

In the item analysis of question No. 6, the statements made by the participants were categorized into 16 short comments. The 16 comments, with numerical notations to indicate the number of times mentioned, may be found in Table VII.

TABLE VII

RESPONSES FOR QUESTION NO. 6 OF ROUND ONE

A Synopsis of Comments Made by Participants	
28	no significant changes
24	better crop varieties
18	farms will be larger
12	very little change
12	different crops
8	farms will be smaller
8	more intensive farm management
6	better tillage methods
6	more vegetable crops
3	fewer farms
3	more pasture
2	production of economical yields rather than maximum yields
2	urban sprawl reducing available water supplies
1	more oil seed production
1	more alfalfa
1	better fertilizers

Question number seven in round one was:

No. 7--Do you believe the development of future energy sources will be playing an important part in water resources development?

The responses to question No. 7, as stated by the participants, were vague and diversified and could not be logically grouped by the principal investigator. The broad interpretation and resultant diversity of responses caused the principal investigator to determine that the question was not clearly understood by the participants, and it was eliminated from round two.

Question number eight in round one was:

No. 8--Will education in relation to water resources become more or less important? Why?

Consensus was reached on this item in the first round: 122 participants said it would be more important, two participants said it would be less important. In the item analysis for the second part of question No. 8 "Why?", the reasons given were categorized into seven items. The analysis may be found in Table VIII.

Question number nine in round one was:

No. 9--In the space below please feel free to make any comment you desire on the future water resources in Oklahoma.

In the item analysis of question No. 9, the comments that were received were categorized into six statements that were most often mentioned in one form or another by the participants. A synopsis of the comments may be found in Table IX.

Round Two Data

The participants were asked to further define and focus the opinions given in round one by responding, with checkmarks, on the second round questionnaire (the second round correspondence may be found in Appendix

TABLE VIII

RESPONSES FOR QUESTION NO. 8 OF ROUND ONE

	Type of Education that Will Be Important
90	more public awareness of conservation
11	education in irrigation management
6	education dealing with the economics of water
5	public school education in water conservation
5	more irrigation research
4	more education in water laws
1	more technical education

TABLE IX

RESPONSES FOR QUESTION NO. 9 OF ROUND ONE

A Synopsis of Comments Most Often Made
The general public needs to become aware of the problems in many areas of water resources which include: pollution control, supply, economic value of water, conservation techniques.
The east-west interbasin transfer plan should be implemented.
The east-west interbasin transfer plan should not be implemented because of many problems which include: insufficient planning, a lack of economic inpact studies, the eastern part of Oklahoma may need the water in the future, structure cost.
We need more environmental education activities in our public schools, both elementary and secondary, to educate our children about water resources.
More large water impoundments are needed and should be built to meet future demands for water.
More small water impoundments are needed and should be built to meet future demands for water.

B). One hundred and seven second round questionnaires were filled out by the participants and returned. The 107 returned questionnaires represented a return rate of 83.5 percent for the second round.

The tallies for each of the seven items in round two were totaled and are herein presented. The totals for six of the seven items were equal to, or a multiple of, the number of returned questionnaires. The total responses tallied for item No. 4 in the second round is greater than the number of returned questionnaires. This is true because a number of participants made two checkmarks where only one was wanted. The principal investigator had no logical way to determine which checkmark of two was more indicative of a participant's opinion; therefore, all checkmarks were counted. This resulted in the data being slightly weighted for item No. 4. However, the principal investigator was able to identify a definite tendency in item No. 4 despite the slightly weighted data.

Item No. 1 of the second round asked the participants to respond to a listing of problems and reasons that was generated by the first round questionnaire. The participants were again asked to indicate what they thought would be the number one problem, and reason for the problem, regarding water resources in the future in light of the first round responses.

Table X shows the responses for item No. 1 of round two. The numerical notations adjacent to each item indicate the total number of times that problem or reason was chosen in round two. An indication of the degree of shift between round one and round two for this item can be made by comparing Table III to Table X.

TABLE X

RESPONSES FOR ITEM NO. 1 OF ROUND TWO

Problems Identified	SUPPLY 73	POLLUTION 18	DISTRIBUTION 10	COST 5	WASTEFUL USE 1			
Probable Causes For Problems	increased demand 62	erosion 14	cost of transporting 6	cost of energy 3	poor management 1			
	aquifer depletion 5	industrial wastes 3	uneven availability 4	equip. and pumping cost 1				
	increased population 2	inadequate law enforcement 1		transportation costs 1				
	inadequate impoundments 2							
	industrial growth 1							
	water rights 1							

Item No. 2 of the second round asked the participants to indicate what they believed would be the three most needed human or technological developments regarding future water resources in Oklahoma. They chose from a rank ordered listing of 25 items generated in round one. Table XI lists, in rank order, the choices made by the participants. The numerical notations indicate the number of times chosen as one of the top three needs, the total number of choices made was 3 x 107, or 321. To compare choices between round one and round two, Table XI can be compared to Table IV.

Item No. 3 of the second round asked the participants to identify a time-frame in which they foresaw a "critical" period in relation to water resources. Ten time-frames ranging from zero years to never, plus a "no estimate" frame were identified in the first round. Participants were asked to chose only one time-frame in round two. A comparison between round one and round two can be made by comparing Table XII to Table V. Table XII shows the responses for item No. 3 of round two.

Item No. 4 of the second round asked the participants to predict, in light of the round one data, whether an increase or a decrease would occur in the amount of irrigation and dryland farming in Oklahoma. During the analysis of the data it was found that a number of participants made two responses where only one was desired. All responses were recorded which resulted in the data being weighted. In the first part of item No. 4, 158 responses were recorded from 107 questionnaires, which indicates that 51 participants had two responses or checkmarks counted. A comparison can be made between the first round and the second round responses on this item by comparing Table XIII to Table VI.

TABLE XI

RESPONSES FOR ITEM NO. 2 OF ROUND TWO

Rank Order Listing of Choices	
58	more conservation of available resources
56	economical east to west transfer system
49	more public awareness of the water resources problem
22	development of more economical energy sources
20	additional water impoundments
20	more education in water conservation measures
20	better water management practices
15	more public relations between east and west
15	more long-range planning
12	increased enforcement of pollution control laws
12	stronger erosion control programs
6	equitable water rights laws
3	more research in agricultural water management
3	development of aquifer recharge techniques
3	development of large-scale desalination techniques
2	more cost-share programs for structure development
1	development of small-scale desalination techniques
1	more education in pollution control
1	small-scale alcohol distilling technology
1	development of techniques to increase aquifer recovery rates
1	NONE (no needs in technological or human developments)

TABLE XII

RESPONSES FOR ITEM NO. 3 OF ROUND TWO

Time Frame	Number of Times Chosen
0 years or now	1
1-5 years	16
6-10 years	28
11-15 years	13
16-20 years	28
21-25 years	13
26-30 years	1
31-35 years	1
Over 35 years	3
Never	0
No estimate	3

The responses for item No. 4 of the second round can be found in Table XIII.

TABLE XIII

RESPONSES FOR ITEM NO. 4 OF ROUND TWO

Irrigation			Dry Land Farming		
will increase	remain static	will decrease	will increase	remain static	will decrease
56	8	29	44	8	13

Reasons:

42	increased demand for food and fiber
37	energy costs
10	aquifer depletion
6	cost of production demands fewer gambles
3	high land costs
3	more intensive management
2	loss of land to rural development
1	marginal land is being cleared
1	low farm prices
1	better dry land varieties will be used
1	more speciality crops like vegetables

Item No. 5 of the second round asked the participants to predict what changes in the character of farming in Oklahoma would occur, in light of the data from round one. Each participant was asked to choose three comments from a list of 16 which was generated in round one. The total responses equaled 3 x 107, or 321 choices tallied. A comparison between round one and round two data for this item can be made by comparing Table XIV to Table VII. The results for item No. 5 of round two can be found in Table XIV.

TABLE XIV

RESPONSES FOR ITEM NO. 5 OF ROUND TWO

Comments Chosen by Participants	
74	more intensive farm management
73	better crop varieties
59	farms will be larger
24	better tillage methods
22	production of economical yields rather than maximum yields
21	no significant changes
20	different crops
8	more vegetable crops
6	more pasture
5	fewer farms
2	farms will be smaller
1	urban sprawling reducing available water supplies

Item No. 6 of the second round asked the participants to choose what type of education and what level of education would be most important relative to water resources. Consensus for the first part of a similar question was reached after the first round of questioning. The second round further investigated the responses, and the results can be found in Table XV. Numerical notations indicate the number of times each type was chosen as most important; the total number of choices equals 107.

Item No. 7 in the second round asked the participants to respond to a list of comments that was generated by the first round questionnaire. Participants were asked to respond by indicating with a checkmark whether they agree, disagree, or are uncertain relative to each of six comments.

The responses for item No. 7 of round two can be found in Table XVI. Numerical notations indicate the number of times each of the three response choices was checked. Each comment received a total of 107 checkmarks.

TABLE XV

RESPONSES FOR ITEM NO. 6 OF ROUND TWO

Type of Education that Will Be Important	
Areas	
71	more public awareness of conservation
16	public school education in water conservation
13	education dealing with the economics of water
4	education in irrigation management
2	more irrigation research
1	more technical education
Levels	
50	adult education
37	secondary education
20	elementary education

TABLE XVI

RESPONSES FOR ITEM NO. 7 OF ROUND TWO

Agree	Disagree	Uncertain	
106	1	0	The general public needs to become more aware of the problems in many areas of water resources would include: pollution control, supply, economic value of water, conservation techniques.
43	33	31	The east-west interbasin transfer plan should be implemented.
37	46	24	The east-west interbasin transfer plan should not be implemented because of many problems which include: insufficient planning, a lack of economic impact studies, the eastern part of Oklahoma may need the water in the future, structure cost.
102	3	2	We need more environmental education activities in our public schools, both elementary and secondary, to educate our children about water resources.
52	28	27	More large water impoundments are needed and should be built to meet future demand for water.
85	8	14	More small water impoundments are needed and should be built to meet future demand for water.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

After administering two rounds of the Delphi research instrument, it was determined that several predictions could be made relative to the future of agricultural water resources in Oklahoma. Although it seemed desirable to gain additional clarity relative to a few items, the risk of further participant attrition was avoided by limiting the study to only two rounds.

Clarity of responses was generally good; however, some interpretation of responses was necessary. The principal investigator decided that succinct instructions would increase the response rate and would more than counteract the resultant misinterpretations of questions. Even though instructions were succinct, the second round questionnaire, including a cover letter, was eight pages long. Eight pages were thought to be near the maximum level which participants would be expected to respond to when a high rate of return is ancticipated.

A response rate of 65.9 percent was achieved for the first round questionnaire and a response rate of 83.5 percent was achieved for the second round questionnaire. The high response rate achieved tended to indicate that the topic under investigation was important to the wide range of experts participating in the study.

Conclusions

The conclusions reached in this study are presented in this section as a listing of six predictions and four general comments. The predictions and comments were based on the data gathered in the two rounds of questionnaires, inasmuch as they determined consensus.

Prediction Number One: Oklahoma will experience two major problems relative to agricultural water resources. The number one problem will be a short supply due mainly to increased demand and aquifer depletion. The second major problem will be water pollution due mainly to soil erosion and industrial wastes.

Prediction Number Two: Oklahoma will need to develop the following: an economical, equitable and efficient water source and distribution system, the implementation of a program that will maximize all available water resources, a delivery system that will increase the public awareness of the water resource problems.

Prediction Number Three: Oklahoma will experience a critical period in relation to water resources within 20 years and possibly within 10 years.

Prediction Number Four: Oklahoma will experience an increase in both irrigated and dryland acreage being farmed due mainly to the increased demand for food and fiber.

Prediction Number Five: Oklahoma will experience an increase in the size of the average farm where intensive farm management will be necessary. These larger farms will utilize better crop varieties, use better tillage methods and produce economical rather than maximum yields.

Prediction Number Six: Public awareness and education relative to water resources will become very important at all levels, which includes adult, secondary, and elementary education programs.

Comment Number One: The general public needs to become more aware of the problems in many areas of water resources.

Comment Number Two: We need more environmental education activities in our public schools at the elementary and secondary level.

Comment Number Three: More water impoundments, both large and small, are needed and should be built.

Comment Number Four: The east-west transfer system is very controversial; however, opinions which favor its construction are slightly more evident than opinions which oppose its construction. Many people have not yet formed a definite opinion on the subject.

Recommendations

As a result of the findings of this study, the following recommendations were made:

1. More water impoundments should be built in Oklahoma.
2. Public schools should incorporate into the curriculum vigorous environmental education programs which emphasize water resources.
3. A statewide delivery system should be developed which will enable the general public to become more aware of the problems relative to water resources.

Recommendations for Further Research

It is recommended that a similar study be done which samples a nonexpert population to include farmers and urban dwellers.

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APPENDIXES

APPENDIX A

CORRESPONDENCE NUMBER ONE

Oklahoma State University
NATURAL RESOURCE AND
ENVIRONMENTAL EDUCATION CENTER

Stillwater, Oklahoma 74074
Poultry Science Bldg. 212A
(405) 624-7015

May 29, 1979

Dear Participant:

In an effort to gather a consensus of expert opinion on the future agricultural water resources of Oklahoma, the Natural Resources and Environmental Education Center at Oklahoma State University is facilitating this study. We have chosen the Delphi Technique, developed by the Rand Corporation, to conduct this study. As you may already know, the Delphi Technique is designed to produce consensus judgment in inexact fields. The information gathered in this study will help us with the development of curriculum materials in water resources in the field of environmental education.

We need your cooperation and opinions to achieve the goals of this study. This survey has been cleared through administrators of the Soil Conservation Service and the Cooperative Extension Service.

Through a series of two or more rounds of questionnaires, your opinion will be solicited and an effort will be made to gain a measure of consensus on what emerge as central themes.

In (this) the first round, it is desirable to allow total freedom concerning the directions of possible topics of concern. This round is directed toward accumulating a wide range of opinions of water-related issues and identifying the issues that occur most frequently. In the second and succeeding round(s), you will be given a listing of issues and statistical feedback and will be asked to give further opinion on rank of importance and/or likelihood of occurrence. A shift toward consensus is highly probable, but not essential to the study.

All responses on questionnaires are confidential and will be known only by the Principal Investigator and staff. Only anonymous listings and statistical feedback will be given to you. The same is true for the final report. Anonymity is a critical and integral part of this technique. Individual responses will be destroyed after the final report is prepared. Your return address is attached to the return envelope only because there will be succeeding rounds, and because there will be a geographical component in this study.

There will be no effort made to match individuals with responses except for mailback purposes and demographic considerations. You will be given an opportunity to receive a copy of the final report if you so desire.

Round one should, if at all possible, be mailed back by June 8 . If because of your busy schedule, this is not possible please mail back at your earliest possible convenience.

Yours truly,

Ron Miller

Ron Miller

DELPHI STUDY ROUND ONE

NOTE: Examples given should not limit topics of consideration but are given for clarification only. Please be specific in giving an opinion. i.e. If you say supply will be a problem, will it be because of aquifer depletion or saltwater intrusion or increased demand or climatic change. etc. If you say cost ... tell why, i.e. energy supply or increased depth of wells or equipment costs, etc.

1. What do you think will be the number one problem in the future regarding water resources? i.e.; supply, distribution, pollution, cost, controls, waste water management, erosion, etc.

____

____

2. What do you think will be the number two problem in the future?

____

____

3. What human or technological developments are needed to prevent a critical water problem from developing in Oklahoma in the future? If NONE will be needed write "NONE"

____

____

4. When do you foresee a "critical" period in relation to water resources?

Never or ______________
year/years

5. Do you predict an increase or decrease in irrigation? __________

Do you predict an increase or decrease in "dry land" farming? ______

Why? ______________________________

____

6. Do you predict a change in the character of farming in Oklahoma because of water resources? i.e., different crops, drouth resistant strains, smaller farms, etc.

Why? ______________________________

____

7. Do you believe the development of future energy sources will be playing an important part in water resources development?

   Why? ______________________________

   ____

8. Will education in relation to water resources become more or less important?

   Why? ______________________________

   ____

9. In the space below please feel free to make any comment you desire on the future water resources in Oklahoma.

   ____

   ____

   ____

   ____

   ____

   ____

APPENDIX B

CORRESPONDENCE NUMBER TWO

Oklahoma State University
NATURAL RESOURCE AND
ENVIRONMENTAL EDUCATION CENTER

Stillwater, Oklahoma 74074
Poultry Science Bldg.212A
(405) 624-7015

June 26, 1979

Dear Participant:

Thank you very much for responding to the first round of our water resources Delphi instrument. The responses that were received from you exceeded our greatest expectations. Of the 194 questionnaires that were sent out by us 123 were returned with valued comments.

Your informed responses indicated to us that you used your valuable time to respond honestly and diligently to the questionnaire. Please indulge a further request of your time and talent to help us focus more clearly on the collective opinions.

The following item analysis of each of the nine items was an honest attempt on our part to incorporate all of the expressed opinions. Totals among the various items vary greatly because not all participants responded to all items.

The "comments" section in the first round was so widely used (to our delight) that a comprehensive listing would be almost impossible. However, an effort was made to use the information in the "comments" section to define some parameters to which you could respond in this round.

In the item analysis of round one a degree of interpretation of the comments was exercised by the Principal Investigator, to facilitate data grouping. Interpretation was done carefully and kept to an absolute minimum.

As you well know, most water related issues are very interrelated i.e. it is difficult to separate SUPPLY from ECONOMICS, or DEMAND FOR WATER from COMMODITY PRICES et cetera. When responding to each item in this round, as much as possible, consider each item or area on its own merits.

Round two should be mailed back by July 6. If because of your busy schedule, this is not possible, please mail back at your earliest convenience.

Yours truly,

Ron Miller

Ron Miller

DELPHI STUDY ROUND TWO

1. For this round items one and two of the first round were combined.
   The questions were:
   What do you think will be the number one problem in the future regarding water resources?
   What do you think will be the number two problem in the future?

The results of round one are listed below. Each time a particular problem was mentioned as either the No.1 or No.2 problem it was given one point. Future problems mentioned are listed in rank order by the number of points accumulated. The number to the left indicates the total points accumulated for that issue. In the column to the right are listings of the probable causes given for the likelihood of the problem. They also are listed in rank order with totals given for accumulated points.

Please make two checks in this section. One in the space provided next to what you believe will be the No.1 problem in the future, and one next to the primary reason for that problem.

MAKE A TOTAL OF ONLY TWO (2) CHECKS IN THIS SECTION.

	71 SUPPLY		22 increased demand		2 saltwater intrusion
			8 aquifer depletion		1 industrial growth
			4 increased population		1 water rights
			2 inadequate impoundments		1 poor planning
	60 POLLUTION		27 erosion		4 population increase
			8 industrial wastes		3 saltwater intrusion
			5 agrichemicals		1 intensified reuse
			4 inadequate law enforcement		
	50 DISTRIBUTION		13 cost of transporting water		4 obsolete rural systems
			10 uneven availability		3 location of population
	40 COST		18 cost of energy		3 management costs
			8 structure costs		3 transportation costs
			6 equipment and pumping costs		1 low farm profits

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	8 POLITICAL CONTROLS		3 red tape		1 limit transfer of water
			1 well spacing		1 acquiring land for impoundments
	8 WASTE WATER MANAGEMENT		1 distribution of waste water		1 population increase
			1 cost of treatment		1 industrial waste increase
	2 WASTEFUL USE		2 poor water management		
	1 WATER DRAINAGE SYSTEMS		1 inadequate drainage systems		

2. Item No.3 in the first round was:
What human or technological developments are needed to prevent a critical water problem from developing in Oklahoma in the future?

In the analysis of item No.3 the comments were categorized into twenty-five needs each need listed below received at least one vote in the first round. They are listed below in rank order **with the total number of times mentioned next to the item.**

Please place a check in the space provided next to the top three **items that you feel will be most needed in the future.**

MAKE A TOTAL OF ONLY THREE (3) CHECKS IN THIS SECTION.

- [ ] 23 economical east to west transfer system
- [ ] 12 more conservation of available resources
- [ ] 11 more public awareness of the water resources problems
- [ ] 7 NONE (no needs in technological or human developments)
- [ ] 7 more long-range planning
- [ ] 7 additional water impoundments
- [ ] 7 increased enforcement of pollution control laws
- [ ] 7 more public relations efforts between east and west
- [ ] 6 more education in water conservation measures
- [ ] 6 equitable water rights laws
- [ ] 5 development of more economical energy sources

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	4	better water management practices
	4	development of aquifer recharge techniques
	4	development of large-scale desalination techniques
	3	stronger erosion control programs
	2	development of small-scale desalination techniques
	2	more education in pollution control
	2	development of more drought resistant strains
	1	small-scale alcohol distilling technology
	1	more cost-share programs for structure development
	1	increased dryland farming
	1	point source pollution reduction
	1	development of techniques to increase aquifer recovery rates
	1	more rural water districts
	1	more research in agricultural water management

3. Item 4 in the first round was:
When do you foresee a "critical" period in relation to water resources?

In the item analysis of No.4, eleven time frames were identified and are listed below. The total number of votes tallied for each time frame is given above each time frame.

Please make a check mark above the time frame which best describes when you foresee a "critical" period in relation to water resources.

MAKE A TOTAL OF ONLY ONE (1) CHECK IN THIS SECTION.

13 0 years or now	13 1-5 years	19 6-10 years	17 11-15 years	24 16-20 years	19 21-25 years

5 26-30 years	1 31-35 years	8 over 35 years	4 never	8 no estimate	

4. **Item** No.5 in round one was:
   Do you predict an increase or decrease in irrigation?
   Do you predict an increase or decrease in "dry land" farming?
   Why?

The item analysis of item No.5 is found below. Again the **numerical** notation found in each category is the total tally **for each** category taken from round one.

Place a check mark, in the space provided, over the category **that best** describes what you believe will take place in the **future.** Below the chart is a listing, in rank order, of the **reasons** given in the first round for the choices made. Place **a check** in the space provided next to the reason that best **describes** why you made the previous choice.

MAKE A TOTAL OF ONLY TWO (2) CHECKS IN THIS SECTION.

74 will increase	8 remain static	44 will decrease	56 will increase	9 remain static	43 will decrease
IRRIGATION			DRY LAND FARMING		

- [ ] 29 energy costs
- [ ] 19 increased demand for food and fiber
- [ ] 16 cost of production demands fewer gambles
- [ ] 16 equipment costs
- [ ] 13 aquifer depletion
- [ ] 8 loss of land to rural development
- [ ] 6 high land costs
- [ ] 5 marginal land is being cleared
- [ ] 4 low farm prices
- [ ] 4 more intensive management
- [ ] 4 more pasture will be grazed not farmed
- [ ] 3 poor quality water for irrigation
- [ ] 2 better dryland varities will be used
- [ ] 2 no more irrigation land is available
- [ ] 2 production of dryland crops is not economical
- [ ] 2 trickle and sprinkler systems using present rangeland
- [ ] 1 salt levels on land now becoming toxic
- [ ] 1 more specialty crops like vegetables

5. Item No. 6 of round one was:
   Do you predict a change in the character of farming in Oklahoma because of water resources?

The item analysis categorized the statements into sixteen comments. They are listed below in rank order with a tally notation to the left of the item showing the total number of times a particular issue was mentioned.

Place a check mark next to the three comments you feel are most likely to happen in the future.

MAKE A TOTAL OF THREE (3) CHECK MARKS IN THIS SECTION.

- [ ] 28 no significant changes
- [ ] 24 better crop varities
- [ ] 18 farms will be larger
- [ ] 12 very little change
- [ ] 12 different crops
- [ ] 8 farms will be smaller
- [ ] 8 more intensive farm management
- [ ] 6 more vegetable crops
- [ ] 6 better tillage methods
- [ ] 3 fewer farms
- [ ] 3 more pasture
- [ ] 2 production of economical yields rather than maximum yields
- [ ] 2 urban sprawl reducing available water supplies
- [ ] 1 more oil seed produced
- [ ] 1 more alfalfa
- [ ] 1 better fertilizers

BECAUSE ITEM NO.7 OF THE FIRST ROUND WAS SO WIDELY INTERPRETED BY THE PARTICIPANTS, THE PRINCIPAL INVESTIGATOR DETERMINED THAT THE QUESTION WAS POORLY STATED, AND IT HAS BEEN ELIMINATED FROM THIS ROUND.

6. Item No.8 of the first round was:
Will education in relation to water resources become more or less important? Why?

Consensus was reached on this item in the first round.
122 participants said it would be <u>more</u> important.
2 participants said it would be <u>less</u> important.

Additional focus of consensus is desired in the areas of education that will be needed in the future. The item analysis is given below of the areas mentioned in round one.

Please make a check in the space provided next to the item that best describes the area of education that will be needed most.

Make another check mark next to the age group that will be most important.

MAKE A TOTAL OF TWO (2) CHECK MARKS IN THIS SECTION.

- [ ] 90 more public awareness of conservation
- [ ] 11 education in irrigation management
- [ ] 6 education dealing with the economics of water
- [ ] 5 public school education in water conservation
- [ ] 5 more irrigation research
- [ ] 4 more education in water laws
- [ ] 1 more technical education

adult education	secondary education	elementary education

7. Identifying and exploring all of the comments gathered in the first round would have been too time consuming for you, the participant, to consider responding to in this round. However, the comments were grouped into six "general" categories.

Please respond to each of the six "general" gategories by marking I agree, I disagree, or I am uncertain.

MAKE A TOTAL OF SIX (6) CHECK MARKS IN THIS SECTION

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agree	disagree	uncertain	
			The general public needs to become more aware of the problems in many areas of water resources which include;pollution control, supply, economic value of water, conservation techniques.
			The east - west interbasin transfer plan should be implemented.
			The east - west interbasin transfer plan should not be implemented because of many problems which include; insufficient planning, a lack of economic impact studies, the eastern part of Oklahoma may need the water in the future, structure cost.
			We need more environmental education activities in our public schools both elementary and secondary, to educate our children about water resources.
			More large water impoundments are needed and should be built to meet future demand for water.
			More small water impoundments are needed and should be built to meet future demand for water.

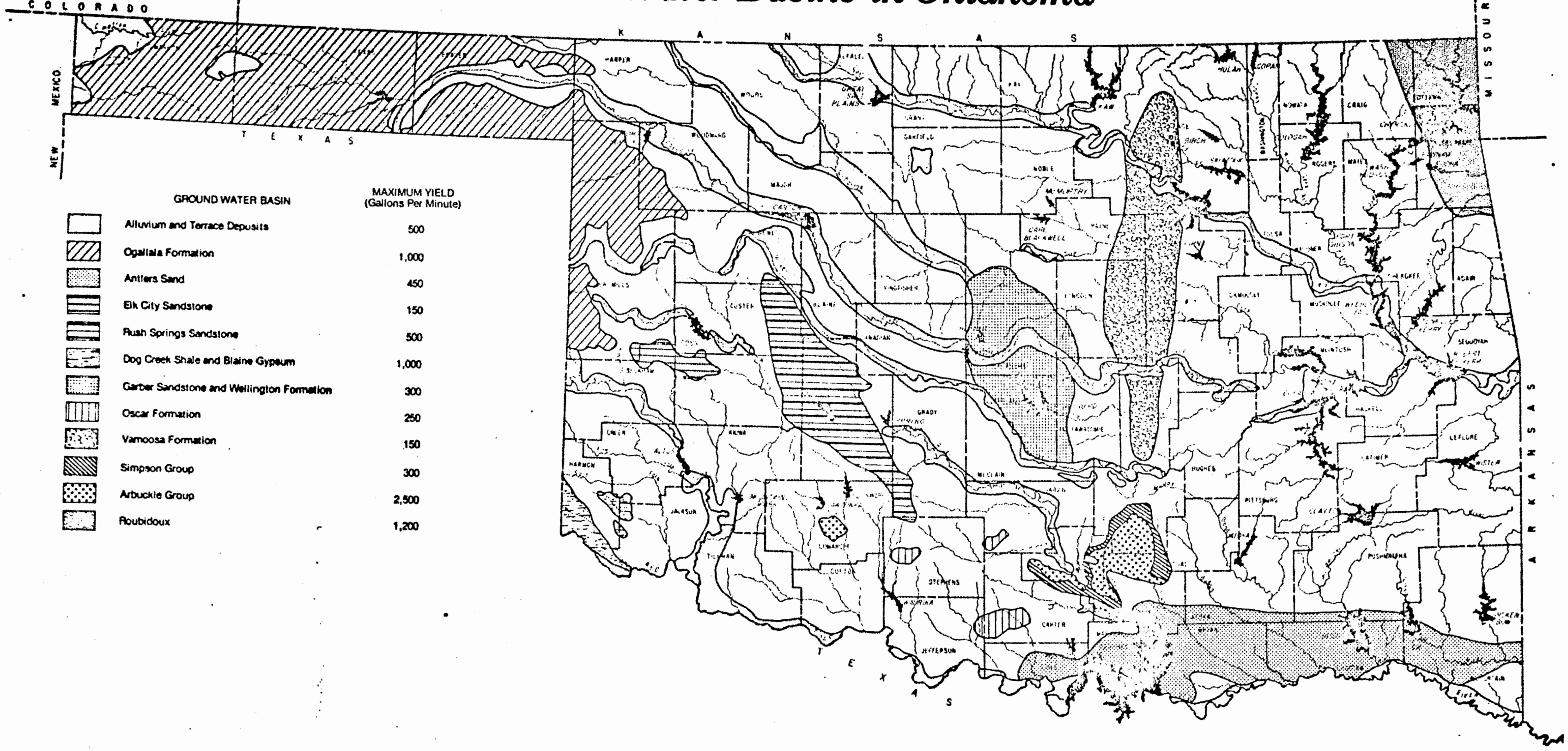
DO YOU WANT A COPY OF THE FINAL REPORT SENT TO YOU ________ OR __________

YES **NO**

APPENDIX C

MAP OF GROUND WATER BASINS IN OKLAHOMA

Ground Water Basins in Oklahoma



VITA

Ronald Miller

Candidate for the Degree of

Doctor of Education

Thesis: A DELPHI STUDY OF THE FUTURE AGRICULTURAL WATER RESOURCE NEEDS IN OKLAHOMA

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Long Branch, New Jersey, April 28, 1945, the son of Evart S. and Josephine Miller.

Education: Graduated from Keyport High School, Keyport, New Jersey, in June, 1962; received Bachelor of Science degree in Elementary Education from Oklahoma Panhandle State University, Goodwell, Oklahoma, in 1967; received Master of Education degree from Mansfield State College, Mansfield, Pennsylvania, in May, 1975; completed requirements for the Doctor of Education degree at Oklahoma State University in December, 1979.

Professional Experience: Rotary-wing aviator in the U.S. Army, 1966-1970; five years as public science teacher, grades five and six for the Southern Tioga School District, Mansfield, Pennsylvania, 1970-1976; Graduate Teaching Assistant (Science Education), Mansfield State College, Mansfield, Pennsylvania, 1974-1975; Graduate Research Assistant (Department of Curriculum and Instruction), Graduate Teaching Assistant (Science Methods and Environmental Education), Research and Development Specialist (Aerospace Education and Energy Awareness Education), Oklahoma State University, 1976-1979.