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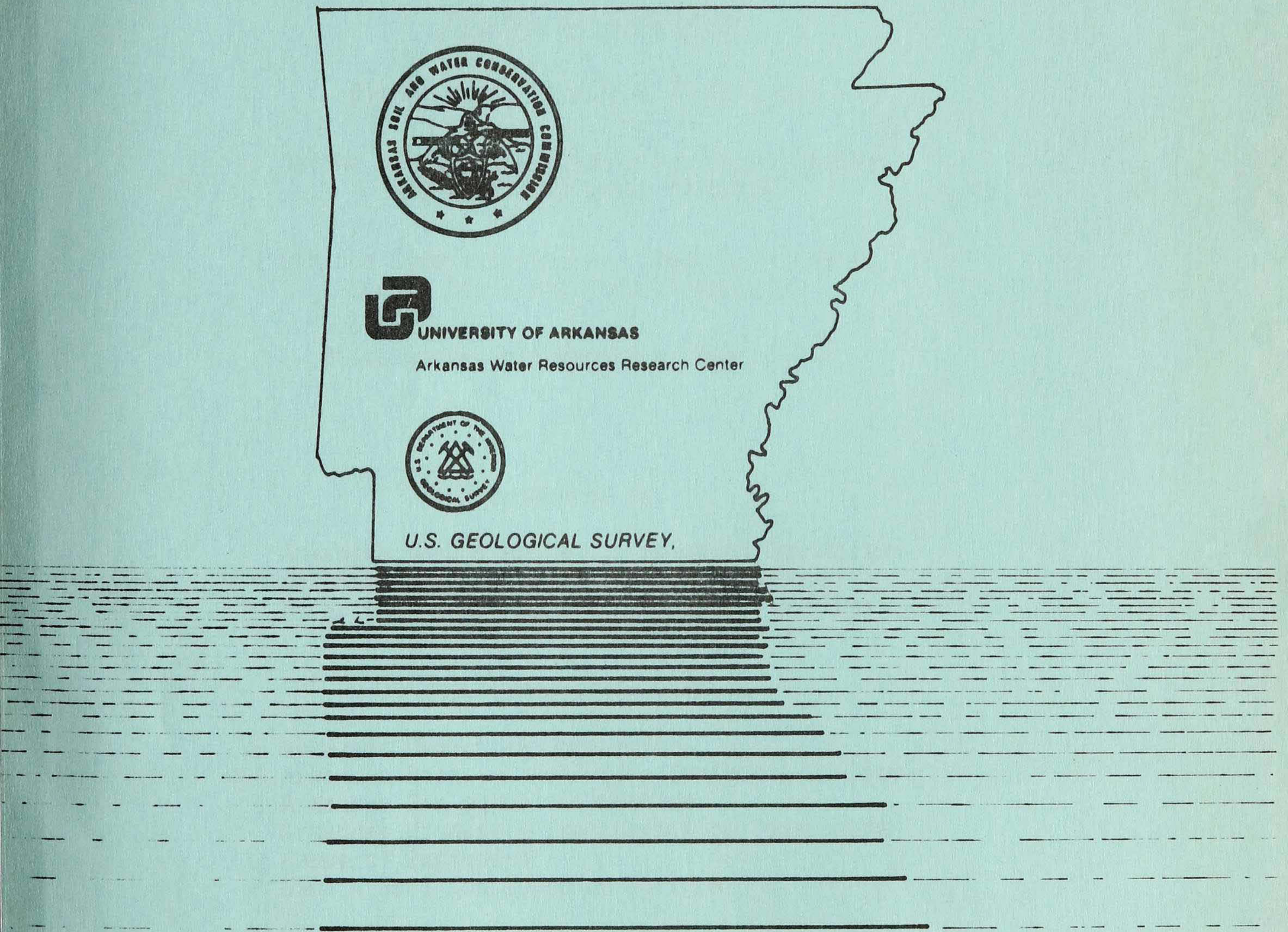
Proceedings of the First Arkansas Water Conference

Randy Young
Arkansas Soil and Water Conservation Commission

Alice T. Gamache
University of Arkansas, Fayetteville

PROCEEDINGS
OF THE
FIRST ARKANSAS WATER CONFERENCE

DECEMBER 1985



SPONSORED BY:

ARKANSAS SOIL AND WATER CONSERVATION COMMISSION

ARKANSAS WATER RESOURCES RESEARCH CENTER

U. S. GEOLOGICAL SURVEY, ARKANSAS DISTRICT

ARKANSAS WATER CONFERENCE

December 3-4, 1985

Ferndale 4-H Center
One Four-H Way
Little Rock (Ferndale), Arkansas

Purpose of Conference

Discuss Water Problems in Arkansas

Define Resources Available for Understanding and Resolving Water Problems

Enhance Communication and Cooperation Among Local, State and Federal Agencies

Disseminate Information to the Public

Sponsored By:

Arkansas Soil & Water Conservation Commission
Arkansas Water Resources Research Center
U. S. Geological Survey, Arkansas District

In Cooperation With:

Arkansas Department of Health
Arkansas Dept. of Pollution Control & Ecology
Arkansas Geological Commission
Arkansas Highway & Transportation Department
Corps of Engineers
USDA - Soil Conservation Service

PROGRAM

Tuesday, December 3, 1985

8:40	Welcome & Introduction	Mr. Randy Young, Director Arkansas Soil & Water Conservation Commission
8:50	Facing Our Water Problems	Governor's Representative
9:00	Overview of Problems - Present and Future	Mr. Randy Young
9:15	Special Announcements	Mr. Charles Bryant

CRITICAL SURFACE WATER PROBLEMS

Chairman: Mr. Don Potter
Arkansas State Highway & Transportation Dept.

9:30	Streamflow Deficiencies	Mr. Earl Smith Arkansas Soil & Water Conservation Commission
9:55	Water Quality	Dr. Phyllis Garnett, Director Arkansas Dept. of Pollution Control & Ecology
10:15	Public Water Supply Problems	Mr. Bruno Kirsch Arkansas Dept. of Health
10:40	Flooding	Mr. Charles Venable Arkansas State Highway & Transportation Dept.
11:05	Refreshments	

CRITICAL GROUNDWATER PROBLEMS

Chairman: Mr. O. A. Wise
Arkansas Geological Commission

11:25	Deficiencies - Low Yields and Water Level Declines	Mr. William V. Bush Arkansas Geological Commission
11:40	Contamination and Poor Natural Quality	Dr. Ralph Desmarais Arkansas Dept. of Pollution Control & Ecology
12:05	Lunch Break	
12:55	Potential Problems from Hazardous Wastes	Mr. Mark Witherspoon Arkansas Dept. of Pollution Control & Ecology

Tuesday, December 3, 1985

WATER DATA AVAILABILITY AND ACCESSIBILITY
Chairman: Mr. Chuck Bennett
Arkansas Dept. of Pollution Control & Ecology

1:15	Surface Water Quantity	Mr. Terry Lamb U.S. Geological Survey
1:30	Surface Water Quality	Mr. Charles T. Bryant U.S. Geological Survey
1:45	Groundwater Quantity	Mr. A. H. Ludwig U.S. Geological Survey
2:15	Groundwater Quality	Mr. Ed E. Morris U.S. Geological Survey
2:35	Break	

WATER DATA NEEDS
Chairman: Mr. Jon Sweeney
Arkansas Soil & Water Conservation Commission

2:50	Groundwater Quality Monitoring	Mr.Timothy Spruill U.S. Geological Survey
3:15	Expanded Stream-gaging Network	Mr. Braxtel Neely, Jr. U.S. Geological Survey
3:30	Hazardous Waste Site Monitoring	Mr. Jim Rigg Arkansas Dept. of Pollution Control & Ecology
3:50	Agricultural Non-point Pollutants	Mr. Ray Linder Soil Conservation Service
4:10	Research Needs	Dr. Leslie E. Mack, Director Arkansas Water Resources Research Center
4:30	Adjourn	

Wednesday, December 4, 1985

SOLUTION TO WATER PROBLEMS
Chairman: Mr. Gene Washburn
Corps of Engineers, Little Rock District

8:40	Overview of Existing Legal Issues	Mr. John F. Gibson Attorney, Arkansas Soil & Water Conservation Commission
9:00	Current and Future Legal Solutions to Water Problems	Mr. J. W. Looney Dean, Univ. of Ark. School of Law
9:35	Water Resources Management	Mr. David Burrough Corps of Engineers, Little Rock District
10:05	Water Resources Management	Mr. Fred Hoffman Corps of Engineers, Memphis District
10:25	Water Resources Management	Mr. James B. Kazel Corps of Engineers, Vicksburg District
10:45	Refreshments	
11:10	Real Time Data	Mr. William Shope, Jr. U.S. Geological Survey
11:30	Significance of the State Water Plan	Mr. Earl Smith Arkansas Soil & Water Conservation Commission
11:50	Water Management Models	Dr. Richard Peralta Dept. of Agricultural Engr. Univ. of Arkansas, Fay.
12:10	Lunch Break	

PANEL DISCUSSION

Chairman: Mr. Harold Seifert
Arkansas Department of Health

1:00 P.M.

TECHNICAL PANEL TO RESPOND TO QUESTIONS FROM THE AUDIENCE

Dr. Phyllis Garnett, Bruno Kirsch, Bill Bush,
Dr. Les Mack, Randy Young, Dr. Richard Peralta

Summary by Session Chairman if Time Allows

2:30 P.M.

Refreshments

PANEL DISCUSSION

Chairman: Mr. Jerry Hill
Arkansas Department of Health

3:00 P.M.

PANEL TO DISCUSS FUNDING OF WATER RESOURCES INFORMATION GATHERING

Mr. Jack Gibson, State Senator
Mr. Knox Nelson, State Senator
Mr. Jody Mahoney, State Representative
Mr. Bobby Glover, State Representative
Mr. David Burrough, U.S. Corps of Engineers
Mr. Gene Gann, U.S. Geological Survey
Mr. Ken Kirkpatrick, U.S. Environmental Protection Agency

4:30 P.M.

Closing Remarks and Recommendations
Mr. Randy Young

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INTRODUCTION

Mr. Randy Young, Director
Arkansas Soil & Water Conservation Commission

Welcome to the Arkansas Water Conference. Is is indeed an honor for me to serve as Chairman on behalf of the conference sponsors which are: the United States Geological Survey, the Arkansas Water Resources Research Center at Fayetteville, and the Arkansas Soil and Water Conservation Commission.

The purpose of this Conference is to:

(1) Discuss Arkansas water problems and opportunities for addressing those problems. In the water resources management arena, Arkansas is truly the "Land of Opportunity" as our motto states.

(2) Serve as a public forum to stimulate thought and interest in Arkansas' water resources.

We encourage your active participation in the program and urge you to take full advantage of the question and answer periods. We need and welcome this type of dialogue and support on a sustained basis.

We hope you find the Conference interesting, informative and enjoyable. Thank you for joining us.

STATE OF ARKANSAS
BILL CLINTON
GOVERNOR

December 3, 1985

Greetings:

I would like to welcome you to the first Arkansas Water Conference.

Water is one of Arkansas' most important natural resources and there are many water related questions demanding answers. They are not purely technical questions, but rather subjective questions which must be discussed so that equitable compromises can be found.

I am pleased that this conference is taking place and the fact that a wide variety of agencies are participating is a hopeful indicator that the process of discovering equitable compromises will continue.

I'm sorry I cannot be with you today, but please know that I wish you a very successful, informative conference.

Sincerely,

Bill Clinton

BC:kf

Office of the Governor • State Capitol • Little Rock, Arkansas 72201 • 501-371-2345

S U M M A R Y

OVERVIEW OF SURFACE WATER AND GROUNDWATER PROBLEMS

Mr. Randy Young, Director
Arkansas Soil & Water Conservation Commission

As the competion for Arkansas' water resources intensifies, the problems with quantity and quality of surface and groundwater becomes more acute.

Surface water issues can be broadly grouped into quantity and quality problems. The most common quantity problem is streamflow deficiencies. The spatial and temporal distribution of streamflow and surface water demand have a negative correlation. Generally, low streamflow occurs during periods of highest demand. In the summer of 1985, flows in Bayou Bartholomew were insufficient to meet demand. The Commission was petitioned by water users in the basin to allocate the remaining streamflow using an equitable apportionment method. However, precipitation occurred shortly thereafter and streamflow increased sufficiently to meet demand. This is a typical example of surface water shortages during peak demand periods in the state.

Another area of concern is the need to establish minimum streamflows to protect fish and wildlife, maintain water quality, and satisfy other instream needs. Millions of gallons of water a day pass through this state on the way to the Gulf of Mexico. This water could be used in deficient basins if the variables outlined in Act 1051 of

1985 were defined and quantified. Guidelines must be established for interbasin transfer. Minimum streamflows must be determined for all instream uses. The quantity of streamflow available for development must be determined for future water resources planning activities.

Water quality problems focus on controlling non-point sources of pollution and water quality standards. Non-point sources of pollution are often times underestimated because by definition, the pollutants originate over an area, county or region of the state, and the severity of the problem stems from the additive effects of minor problems over large areas. The agricultural regions of Eastern Arkansas contribute tons and tons of topsoil to surface water streams and lakes. Conservation techniques must be developed and implemented that will maintain soil productivity while protecting water quality. The improper disposal techniques utilized in northwest and north central Arkansas for animal waste has caused excessive nitrate concentrations in streams.

Water quality standards are too rigid and unrealistic. Typically the least impaired or altered streams do not comply with these standards. Currently, the state is reviewing proposed activities for compliance with the water quality standards that are in place. The Arkansas Department of Pollution Control and Ecology has a study under way to consider naturally occurring seasonally and regionally variable water quality.

Priorities established in state statutes delineated public supplies as top priority in any disputes between competing uses. Development of Arkansas' water resources to sustain life and maintain health has priority over uses that provide economic gain. Providing suitable quality water for rural associations and municipal supply systems involves the selection of sources that will satisfy demand on a sustained basis. Cities along the Arkansas River Valley, such as Ft. Smith and Russellville, are currently in need of additional supplies and are involved in evaluating the options of: Impoundments on streams, Arkansas River water as a raw water source, tie into other supply systems, and selection of the best financial options available to construct the proper alternative. As economic development and the population increases, the demands on existing supply and treatment systems will place more and more cities in the position of making hard decisions on alternative sources. The decline in federal grants and the propensity of the current administration toward hard loans and money "up front", will make financing and implementation of appropriate management options difficult or impossible for the smaller rural water associations and municipalities in Arkansas.

Excessive surface water or "flooding" is a common springtime occurrence in Arkansas. The desire to develop floodplains by business, corporations and individuals effectively reduces storage for runoff from large storm events. Reduced storage causes higher than normal streamflows resulting in flooding. Development of a floodplain near an urban area increases the quantity of runoff and reduces the lag time due to coverage of the land by impervious materials.

Groundwater problems are similar to surface water problems in that they generally fall into the two categories of quantity and quality.

The State of Arkansas can be divided geologically into two provinces: The Delta and the Highlands. The Highland areas of the Ouachita Mountains and the Ozarks are underlaid by shales and sandstones. The fracture density and degree of deformation controls storage and transmissivity in the formations. These physical characteristics of the consolidated formations generally limit well yields to less than ten G.P.M. An exception to this rule are the deeper Gunter and Roubidoux formations that serve as municipal sources across the northern tier of counties in the State.

The Delta area is intensely farmed and much of it is irrigated. The demand by agriculture during June, July and August, when streamflow is lowest, has led to a dependence on groundwater reserves to supplement the inadequate surface water supplies. As a result, groundwater levels have declined in excess of sixty feet in the Alluvial Aquifer of Lonoke, Arkansas, Prairie, Cross, Poinsett and Craighead counties.

Municipal and self-supplied industrial withdrawals at Pine Bluff, El Dorado and Magnolia have lowered water levels 240, 320 and 260 feet respectively. Lower water levels are not inherently detrimental to groundwater supplies but potentially lead to aquifer compaction, reduced yields and quality degradation by the intrusion of salt water. Many isolated, small areas in the State are underlaid by portions of aquifers contaminated from naturally occurring mineral sources not associated with overdraft. Recent activities to protect our groundwater sources prior to contamination have concentrated on the potential effects of landfills, hazardous waste disposal, septic tank systems, surface impoundments for holding waste, underground storage tanks and injection of hazardous waste and salt water from oil and gas fields.

S U M M A R Y

STREAMFLOW DEFICIENCIES

Mr. Earl Smith
Arkansas Soil & Water Conservation Commission

The climate in Arkansas is classified as humid subtropical. This classification is characterized by dry, hot and humid summers caused by a lack of precipitation due to circulation around subtropical high pressure cells. Typical summer precipitation occurs as convectional heating type showers and occasional general rains as the result of cyclones or hurricanes in the Gulf of Mexico. Winters are mild and relatively wet. Winter precipitation occurs as a result of frontal clashes between Pacific or Canadian air masses and warm, moist air from the Gulf of Mexico. The different processes that result in the distribution of rainfall in Arkansas is further complicated by the orographic effects of the Ouachita and Ozark Highlands.

On an annual basis, precipitation averages 48 inches and varies from 42 inches in north central Arkansas to 54 inches in the Ouachita Mountains. Runoff in the state averages approximately 18 inches per year and ranges from 12 inches in the northwest corner of the State (Karst) to 24 inches in the Boston and Ouachita Mountains (Shale and Sandstone). Many factors influence the ratio of precipitation to runoff. Some common variables are: Land cover, slope, soil types, geology and evaporation rates. As these characteristics change from area to area within the state, runoff coefficients change accordingly.

While it is true that Arkansas has an abundance of water overall, the temporal and spatial distribution of surface water availability does not correlate with the patterns of surface water demand. Runoff is highest in the winter and early spring and lowest during the summer and early fall. Demand is lowest during the winter months and peaks during the months of June, July and August. Management options must focus on storage of high winter streamflow for use during the typically low streamflow-high demand periods of summer.

The standard for quantifying low streamflow is the lowest flow for a seven-day period in ten years. The seven-day, ten-year, low-flow (7Q10) for streams in Arkansas varies from zero to 100,000 - 150,000 C.F.S. for the Mississippi River. Most streams in the sandstone underlaid areas of the Boston Mountains, Arkoma Basin and the frontal zone of the Ouachita Mountains go to zero flow for the seven-day ten-year low-flow. Streamflow in the northern quarter of the State is sustained by springs from the underlying limestone and dolomites. Most of the delta streams go dry due to relatively rapid infiltration of runoff into surface clays, sand, silts and gravels and subsequent percolation down to the water table. Only the larger streams in eastern Arkansas, such as the Cache, St. Francis, Bayou Bartholomew and Saline Rivers, plus the larger regulated rivers such as the Ouachita, White and Arkansas Rivers, sustain substantial flow for the 7Q10.

Arkansas water law is based on the old English common law. The right to use water is incident to ownership of riparian land which is adjacent to surface water or overlying groundwater. Water disputes have generally been decided in the courts according to the reasonable use test which allows each owner to withdraw and use surface water while having due regard for the effect of that use upon other riparian owners. While the Commission has the authority to allocate during times of shortage and settle disputes among competing uses, many cases do not come to the attention of the Commission and are resolved by the proverbial "largest pump wins" philosophy. The result is that streams are pumped until the user can no longer maintain a water level sufficient to maintain suction by his pump. By that time, there is little streamflow left to allocate.

The total water used in 1981 statewide was 33 B.G.D. Eighty-four percent of this total was used for hydro and thermoelectric power and considered non-consumptive use. Sixteen percent, or 5.3 B.G.D., was considered consumptive use. Twenty percent of the total consumptive use was from surface water sources. Agriculture accounted for fifty-eight percent (618 MGD) of this total. Other uses were as follows: Self-supplied industry - 13.6 percent (145 MGD), public supplies - 13.4 percent (143 MGD), aquaculture - 11.2 percent

(120 MGD) and rural use was four percent of the total (41.6 MGD).

Act 1051 of 1985 was passed in an effort to establish a mechanism to determine the requirements of Arkansas water users and other purposes. The Act mandated that the Commission define and quantify many hydrologic variables. Some variables outlined in the Act were: Instream flow requirements for game and fish, navigation, maintenance of water quality, aquifer recharge and the establishment of minimum stream flows. The definition for minimum stream flows has been defined by the Commission as the lowest discharge that will satisfy the minimum instream flow requirement. Instream flow requirements are not additive for the purposes of navigation, fish and wildlife and water quality because the same flow can be used to satisfy all three of these non-consumptive uses. Therefore, the largest instream flow requirement will constitute the minimum stream flow. The quantity determined necessary for minimum stream flows will be reserved and protected for those uses within limits of climatological controls by ceasing all diversions beyond the established minimum.

Minimum stream flows have been proposed for Bayou Batholomew at the Jones, Louisiana gaging station (close to the AR-LA state line). Those requirements are as follows:

Non-consumptive Uses	Flow Requirements
1. Maintain water quality (7Q10)	44.0
2. Fish & wildlife (10% mean monthly for lowest month - August)	28.5
3. Navigation	Non-navigable
4. Interstate compacts (40% of wkly runoff - .4 x 80 CFS)	32.0
5. Minimum streamflow	44.0

As the competition for surface water intensifies and heavy reliance on groundwater reserves cause unacceptable water level declines, the management options affecting or supplementing streamflow are limited. Some viable options that could increase streamflows are as follows: Interbasin transfer and non-riparian use, off-stream storage, quantify minimum stream flows and the establishment of water management districts. These management options in accordance with a conjunctive use approach can provide ample water supplies to meet the water needs of Arkansans for decades to come.

SUMMARY

ESTABLISHMENT OF REALISTIC WATER QUALITY STANDARDS

Dr. Phyllis Garnett, Director
Arkansas Department of Pollution Control & Ecology

The basic goal of the Clean Water Act of 1972 was the achievement of a certain level of cleanliness in the waters of the nation which would provide for fishable-swimmable waters. Since 1972, millions of tax dollars have been spent in an effort to achieve this noble goal for the nation. In order to achieve what appeared to be a simple stated goal for water quality, values were established to be applicable nationwide. The falacy of these rigid standards is now evident in that there was a failure to recognize seasonally or regionally variable water quality. As a result, many of the most clean streams and lakes have naturally occurring water quality values that do not meet these standards.

The very framework of any state water quality regulatory agency is the standard by which it regulates and manages the State's resources. By necessity, the standards must be correct in order to do an efficient and effective job. The apparent disparity between the Water Quality Standards and actual water quality values led to the conclusion that a study should be undertaken to define water quality conditions in least-impaired streams within different physiographic regions of Arkansas. The overall objective is to develop and finally establish realistic water quality standards for the State of Arkansas and thus with a sound scientific basis, determine the level of cleanliness to which the waters of the State should be protected.

S U M M A R Y

PUBLIC WATER SUPPLY CONCERNS

Mr. Bruno Kirsch, Jr., P.E., Director
Div. of Engineering, Arkansas Dept. of Health

As many of you are aware, the Department of Health has the primary responsibility for the enforcement of our rules and regulations on public water systems and the administration of the Environmental Protection Agency's Safe Drinking Water Act. To that end I feel that there are three primary issues facing the drinking water program in our State. These are:

(1) The implementation of the new standards of the Safe Drinking Water Act.

(2) The analytical capacity of the Department of Health's laboratories to meet the new standards and to handle the ever increasing emergency situations affecting our water supplies.

(3) The potential use of the Arkansas River as a drinking water source.

The first of these issues is the proposed changes to the Safe Drinking Water Act (SDWA). Currently EPA is systematically reviewing the current standards and proposing new standards. At the same time Congress is reauthorizing the SDWA. The Senate and House of Representatives have passed their versions of the proposed changes to the Act. The Congress has been critical of EPA's apparent lack of concern in developing additional standards. Since 1974 EPA has only established one standard - trihelomethane. Nonetheless, our expanding analytical capabilities are detecting heretofore previously undiscovered minute concentrations of various toxic chemicals in individual and public water supplies across the nation. Some of these chemicals are suspected or known carcinogens. Others have not received sufficient assessment to document any public risk.

From the versions of the Act that I have reviewed, I feel Congress is mandating additional standards and is establishing definitive time tables for their development. Therefore, the standards that are being proposed by EPA are probably a compromise with Congress to meet the intent of the congressional legislation. Realistically, as new and more research continues into the area of toxic chemicals, I can only predict more standards being added to the Act.

The question remains "what are we going to find when we implement the new standards?" In this area I can only speak in generalities. I am aware that the states of Minnesota and Wisconsin have already monitored for the volatile organic compounds (primarily industrial solvents) which will be regulated with new standards. These states report that they have detected traces of these type of compounds in approximately 10% of their public water systems. Further, our laboratory personnel have reviewed our monitoring results for organic chemicals for the last year. It appears that approximately 20% of our samples have some type of unknown organic compound. Therefore, I can only assume that we will find some of these new compounds. However, whether they have any health consequences remains to be seen.

This leads me to the second and most pressing issue - the development of our analytical capabilities, especially in the organics laboratory, to provide the necessary laboratory support for our public water systems. Our program did anticipate the need for expanded laboratory capacity and requested additional funds during the last budget cycle. Unfortunately, the request was not approved and remains an unfunded priority of the agency. Thus, our water supply program and industry faces a growing dilemma. Historically, the public water systems have always relied on our laboratories to do their analytical work. Since our program does not anticipate any additional Federal funds and has been turned down for additional State funds, the public water systems face a real crisis in this area. It is my opinion that our laboratories should be expanded to increase their analytical capabilities. I am in the process of recommending various funding options. Hopefully, in the near future we will have this problem resolved.

The third, and most perplexing issue that the water supply program must address, is our long-standing policy against the use of the Arkansas River as a public water supply source. I have become acutely aware that this policy has little support among the environmental

The movement in our State for more environmental preservation is certainly justified and the preservation of the free flowing streams in the Ozark Plateau is a concern that our agency cannot discount. However, since it is our agency's responsibility to ensure the safety and acceptability of the public water supplies to our citizens, I certainly feel a comprehensive investigation needs to be undertaken to study the various aspects of this complex issue. Right now that opportunity exists through the Corps of Engineers. The Little Rock District Corps of Engineers has been authorized to do a study on just this issue. I firmly believe that all agencies should unite and insist that the study be completed.

For our part, my staff has been reviewing our position. Although we have not finalized our conclusions, there are the four general areas of concern. These are salt content, heavy metals, vulnerability and trace toxic organics.

Of these concerns, I feel that there is sufficient existing data on the salt concentration and heavy metals to warrant further investigation. The Arkansas Department of Pollution Control and Ecology's 1984 water quality report actually indicates that the salt concentration of the river is increasing. If this is actually the case, our agency must insist that a treatment process which removes salt is utilized before we can seriously consider the river as a drinking water source. The only viable treatment process for salt removal is reverse osmosis. The process is also capable of heavy metal removal. However, the treatment process is extremely expensive and has had operational difficulties. Therefore, it has not received widespread support by the water utilities of our nation.

All of us realize the vulnerability of the river. The Department's current policy is to require off-stream storage on all river sources. Thus, we would have to insist on at best two weeks to thirty days off-stream storage before the river could be considered. Further, we would require a routine monitoring program to ensure the safety and acceptability of the water to the customers.

Of all the concerns, the least amount of data is in the areas of trace toxic organics. Due to the new sophisticated equipment and techniques, we can analyze for these compounds at trace levels previously unknown just ten years ago. Right now, our analytical capabilities far exceed our ability to determine any biological/health significance. However, some epidemiological studies appear to indicate that if at all possible, we should not utilize water sources that receive numerous point and non-point sources as in the case of the Arkansas River. The Department acknowledges that other similar waterways are in use. These are some of the same waterways where studies were conducted. In addition, we found that Cincinnati, Ohio will become the first major city to install actuated carbon filters due to their concern over this issue. It appears that carbon filtration is a viable treatment alternative and it will need to be considered if we must use the River. I appreciate the opportunity to address this Conference and hope it becomes an annual forum to address our State's water issues.

S U M M A R Y

FLOOD PROTECTION OF ARKANSAS HIGHWAYS

Mr. Charles Venable
Arkansas State Highway & Transportation Department

The Arkansas State Highway & Transportation Department has over 16,000 miles of highways with approximately 6,600 bridges to maintain and upgrade. Therefore, it is obvious that surface water hydrology and hydraulics is very important to the Department. An example of this is the December, 1982 flood. Over $8,000,000 was expended for flood damage repair to our highways and bridges. It is very imperative that we continually upgrade our data collection and improve our technology through experience and research.

A major tool that the Department is using to continually improve itself in hydraulic related technology is our Hydraulics Section. The Section is professionally staffed by five engineers and three technicians. Since it is estimated that 15% of funds expended on highway projects is for construction and drainage structures, it is very important that we be apprised of the latest data collection, recent research and the changes in hydrologic and hydraulic technology for adequate cost-effective maintenance and design.

My purpose this afternoon is to inform you of our Hydraulics Section activities and view slides depicting flooding action upon our highways.

I. Flood Protection for Arkansas Highways:

Projects are designed and reviewed by the Section using the following design criteria:

(a) Primary and Interstate Highways

(1) 50-year flood

(2) Risks considered for the 100-year flood.

(b) Secondary Roads

(1) 25-year flood

(2) Risks considered for the 50-year flood.

(c) Urban Streets

(1) Federal Aid Projects - generally designed for 25-year flood unless community ordinance dictates otherwise.

(2) Non-Federal Aid Projects - 10-year flood.

(3) Storm Drains

(i) Interstate Projects - 50-year flood.

(ii) Other Federal Aid Projects - 10-Year flood

(iii) Non-Federal Aid Projects - 2-year flood

II. Floodplain Management Program:

The Hydraulics Section reviews each proposed highway project for floodplain compliance with local community ordinances as required by the National Flood Insurance Program administered through the Federal Emergency Management Agency.

When a project is located within a regulated floodplain or regulatory floodway, a detailed study is performed to verify that our hydraulic design is in compliance with the local regulation. Then, a variance and/or permit is obtained from the regulating City or County.

III. AHTD-USGS Programs:

The Arkansas Highway Department and U.S. Geological Survey are continually involved in cooperative efforts to improve hydraulic related effects upon our highways and bridges.

A research project is presently under way to develop a method to aid engineers in adequately predicting possible scour depths at bridge piers and abutments throughout the State. Stream crossings that have a history of scour problems are being studied in conjunction with this project.

The USGS is also involved in updating the "Floods in Arkansas, Magnitude and Frequency Characteristics through 1968" report for Arkansas. The objectives of this report are to present updated stream flood peak data and to revise regional equations and graphs which enable engineers to evaluate analytically the magnitude and frequency of floods in Arkansas on ungaged streams.

IV. AHTD Research Project on Small Streams (TRC-87):

The Hydraulics Section is involved in an ongoing research project at three stream crossings to measure rainfall and associated runoff. The subsequent data gathered at each site will be used to develop hydrographs for use in hydrologic studies with small drainage areas which will provide more efficient and economic design of bridges and culverts conveying runoff from small to intermediate drainage basins.

V. Drainage Manual:

In 1983 the Hydraulics Section published an updated drainage manual which is intended to be an operational handbook for the Department's use in hydrologic analysis and hydraulic design. The rapid development of technology in the fields of hydrology and hydraulics necessitates a continual updating of our procedures. A copy of the drainage manual is available from the Hydraulics Section.

VI. Historical High Water Information:

In February, 1983 the Arkansas State Highway & Transportation Department initiated a program to collect and store historical high water information. This is a perpetual high water data collection effort and is available for reference by all agencies. The information is used by the Department to design and maintain our highways and bridges. The value of all this effort and technology can be seen by recent flood events.

VII. Other Hydraulic Activities:

The Hydraulics Section represents the Department on: The AASHTO Task Force on Hydrology and Hydraulics which is writing highway drainage guidelines for the nation's hydraulic design engineers, the Transportation Research Board on Hydrology, Hydraulics and Water Quality, and the Advisory Committee that developed a master drainage plan for Little Rock.

VIII. The Effects of the September, 1978 Flood Upon Ark. Highways:

The flood of September, 1978 was caused by intense rainfall for a duration of six hours on the morning of the 13th. This flood was the most catastrophic on record in the Fourche Creek and Rock Creek Basins. Transportation was severely disrupted as many cars were swept away by the current and many roads were closed, including I-30 and I-430.

The storm had a recurrence interval of greater than 100-years. More than $900,000 was expended for flood repairs to our highways and bridges.

IX. The Effects of the December, 1982 Flood Upon Ark. Highways:

On December 2, 1982 a storm system moved into Arkansas producing tornadoes, severe thunderstorms and intense rainfall.

(slides were shown at this point)

Abnormally high discharges and stages were reported at various locations across the State. In most cases, discharges exceeded the 100-year recurrence interval. Rainfall amounts ranged from 8-15 inches in a 72-hour period. Many highways and bridges were overtopped causing severe roadway and bridge damage. Several highways were closed due to high water and roadway damage and bridge failure. More than $8,000,000 was spent on flood damage repair.

Summation:

It is obvious there is a need for continued stream gagings and data collection with a possible expansion. Additional funds are needed for upgrading flood prone highways and bridges.

S U M M A R Y

DEFICIENCIES: LOW YIELDS AND WATER LEVEL DECLINES

William V. Bush
Arkansas Geological Commission

Low yields and water level declines are major groundwater problems confronting Arkansas. Increased use and demand for water in all parts of the State has made a solution to these problems a critical necessity. The first step toward a solution is to identify the problem areas. Groundwater records provide the data necessary to delineate these areas. This data was recently reviewed and the information was published in USGS Water Resources Investigation Report 85-4010, "Groundwater Problems in Arkansas".

The amount of groundwater available in any section of the State is controlled primarily by the geologic characteristics of the bedrock or sediments. In Arkansas the geologic framework is divisible into two major physiographic provinces: the Interior Highlands in the northwest and the Gulf Coastal Plain in the southeast. The groundwater conditions differ greatly in these provinces from place to place, as do the problems.

In the Interior Highlands, which include the Ouachita Mountains, Arkansas River Valley and the Ozark Mountains, the bedrock consists primarily of sandstone, shale, limestone, dolomite and novaculite. The groundwater typically occurs in fractures and joints in the sandstones, shales and novaculite, and in solution cavities in the limestones and dolomites. However, along the Arkansas River Valley and along some other major streams, groundwater is present in the alluvial deposits.

Low yields, less than 10 gpm, are a common problem in major areas of the Interior Highlands. Many of the low yield wells are shallow, less than 200 feet deep, and yields over 25 gpm are rather uncommon.

In contrast, some areas in the Interior Highlands do yield quantities of groundwater. The alluvial deposits which overlie the consolidated rocks along the Arkansas River Valley produce up to 750 gpm and are usually less than 80 feet thick. In the Ozark Mountains the major aquifers, the Roubidoux Formation and the Gunter Member of the Gasconade Formation, may yield up to 500 gpm. They are a source of water for many Municipal Water Association systems. Depths of these units range from 500 to 3,500 feet. The major recharge area for these aquifers is in southern Missouri.

The Gulf Coastal Plain covers the southeastern portion of Arkansas and consists primarily of alternating sequences of unconsolidated sand, silt, clay and gravel of Quaternary, Tertiary and Cretaceous age. Six major aquifer systems supply most of the groundwater in the Coastal Plain. Water level declines are very evident in two of these systems in several areas. In the Sparta Sand of the Claiborne Group water levels have declined in Columbia, Union, Arkansas and Jefferson Counties where withdrawals for irrigation, municipal and industrial uses have far exceeded the recharge of the aquifer. Examples of declining water levels are 100 feet in Arkansas County, 240 feet in Jefferson County, 260 feet in Columbia County and more than 320 feet in Union County.

Two major areas of water level decline in the Quaternary aquifer system occur in eastern Arkansas. Water levels in an area west of Crowley's Ridge in Craighead, Poinsett and Cross Counties and another area in Prairie, Lonoke and Arkansas Counties have dropped as much as 60 feet. The cause of these declines is directly attributed to irrigation withdrawals that exceed recharge of the aquifer. The average decline is approximately 0.75 foot per year but records indicate that it has declined as much as 8 feet in one particularly dry year.

Low yields are characteristic in some of the aquifers in southwest Arkansas. They include the Carrizo Sand, Wilcox Group and Midway Group which are comprised predominantly of clay, fine sand and silt.

In summary, the Interior Highlands have widespread areas of low yields that restrict uses requiring large volumes of groundwater. In contrast, there is an abundance of groundwater throughout most of the Gulf Coastal Plain but heavy withdrawals for irrigation, municipal and industrial uses have created alarming local water level declines in two of the major aquifers. Furthermore, water quality problems have been created by the decline in water levels in some areas. As groundwater use increases and as withdrawals continue to exceed recharge, water level declines will increasingly affect the water quantity and quality and adversely influence the development of groundwater dependent economies in the Gulf Coastal Plain.

S U M M A R Y

GROUNDWATER CONTAMINATION PROBLEMS

Dr. Ralph Desmarais
Arkansas Department of Pollution Control & Ecology

(Illustrative slides were shown)

Arkansas is in the process of developing a strategy for the protection of its groundwater against contamination. The development of that strategy involved the examination of the sources and occurence of groundwater contamination. Some sources are simple, such as, waste spilled or dumped close to the water table that leaches contamination into the groundwater. Other sources are more complex, harder to identify and react with the groundwater in ways that are difficult to predict. The four major sources of contamination in Arkansas are: (1) contamination from human and animal wastes, (2) from municipal, industrial and oil field wastes, (3) salt water intrusion, (4) mineral extraction activities.

In addition, any of man's activities that interfere with the natural recharge process can contribute to contamination by reducing the available fresh water and enhancing the amount of available contaminated runoff - urbanization, road construction and agricultural activities are the major examples.

Groundwater contamination is far more difficult to clean or contain than surface contamination. Most state protection strategies focus on prevention activities involving zoning requirements, aquifer protection programs, siting regulations, etc., on the grounds that it is far easier and less costly to prevent the contamination than to clean it up.

Over 700,000 tons of hazardous waste were generated in Arkansas in 1984, the vast majority of which was injected under ground in south Arkansas. Underground injection may be described as the purposeful contamination of unusable salt water formations far below the upper fresh water sources of drinking water. The remaining 200,000 or so tons were either treated on site, stored or shipped to a recycling or treatment center. Those generators that treat or dispose of their waste on site are subject to groundwater monitoring regulations under the Resource Conservation & Recovery Act. There are 17 such sites in Arkansas. These sites have been mapped and those parameters that revealed contamination in quantities above the standards established under the Safe Drinking Water Act have been published in the USGS Water Resources Investigation Report 85-4010, "Groundwater Problems in Arkansas".

Arkansas has 269 abandoned coal mines and 186 abandoned metal mines. Arkansas Tech at Russellville is currently conducting a study of the quality of the water that has flooded such mines which will give us a better understanding of the effects of mineral extraction on groundwater. The process of acid mine drainage is well understood. Correcting it is far more difficult.

The extent to which agricultural practices have affected Arkansas' groundwater is unknown. The main areas of concern are wastes from animal droppings, fertilizer applications and pesticide use. EPA is in the process of conducting a nationwide investigation of pesticide contamination of groundwater. Unfortunately, Arkansas was not included in this study. Nitrates have been a major problem for domestic well users in northwest Arkansas with wells located along fracture traces in Karst areas.

A number of contaminated sites associated with the wood processing industry have turned up in the state. The chemical pentachlorophenol found in the groundwater at these sites is used with creosote in the treatment of wood and is considered toxic. It is on the EPA Priority Pollutant list.

In terms of volume, the state's largest producer of waste is the oil industry which generates large quantities of salt water with every barrel of oil produced. Many spills have been documented by the Department both above and below the ground. The most famous of these is in Miller County which was the subject of an EPA study on the costs of cleaning up such spills. The determination at the time was that the spill was too expensive to clean up. Some 7,000 disposal pits associated with the oil and gas industry were identified by the Surface Impoundment Assessment. The exact impact of these pits on groundwater is unknown but the report rates them as the most serious of the types of impoundments it addresses in terms of potential threat to the groundwater.

The underground injection of salt water in the oil fields has reduced some of the problems related to these pits as their use has been limited to back up and temporary storage. But underground injection has introduced some problems by increasing hydrostatic pressure in some of the lower formations and, thereby, increases the potential for the upward migration of salt water through cracks, faults and abandoned wells.

Given the large number of sources of contamination, we are fortunate that our drinking water is as good as it is. Partly, the good quality of our drinking water can be explained by the location of supply wells deep enough to avoid much of the surface contamination. However, some cities that have gone to deeper wells are now experiencing problems stemming from overdraft and salt water intrusion. Unfortunately, we have had little experience in analyzing safe yields for our major aquifers. USGS and the University of Arkansas are currently beginning to develop management models which will give us a better grip on these problems. Safe yields combined with adequate protection of our groundwater supplies are necessary to ensure good water for generations to come.

S U M M A R Y

POTENTIAL PROBLEMS FROM HAZARDOUS WASTES

Mr. Mark Witherspoon
Arkansas Department of Pollution Control & Ecology

The most obvious, as well as the most critical, problem with hazardous waste land disposal is the potential introduction of waste material into underground sources of drinking water. Site specific examples of groundwater contamination due to past disposal practices are available in Arkansas and common in this country as a whole. Pre-arranged deterrents to potential groundwater contamination problems in the form of proper facility hydrogeologic siting, advanced engineering design, and regulatory requirements have advanced exponentially over the last few years. However, the final indicator of the presence of groundwater contamination at a specific facility depends on the ability of a set of monitoring wells to provide a true representative sample of potentially effected groundwater.

The problem with sampling for groundwater quality is that current laboratory detection capabilities exceed the ability of most monitoring systems to produce an unbiased representative sample of groundwater quality. For example, a waste component reported in quantities as low as a part per billion, could easily be the result of contaminants introduced during well construction, or sample retrieval.

Of course, the result of these potential problems is the fact that groundwater contamination may be indicated where it is actually not present - or more significantly, groundwater contamination may not be indicated were it is indeed occurring.

S U M M A R Y

SURFACE WATER QUANTITY

Mr. Terrance Lamb
U.S. Geological Survey

The collection of surface water data is a major activity of The Water Resources Division of the Geological Survey. These data are collected in cooperation with State and local governments and other Federal agencies. In 1985 the Survey operated approximately 8,000 daily-discharge stations through the nation, some with records that extend back to the beginning of the century.

The program of surface water investigations by the Survey in Arkansas has grown through the years as Federal and State interest in water resources has increased. The Arkansas office of the Survey began collecting surface water data as part of a statewide water resources program, with the establishment of 8 gaging stations in 1927. Prior to this time discharge records were primarily to evaluate the hydroelectric power potential of the streams. The program expanded to 16 gaging stations by 1930 and then declined during the early years of the depression as State cooperation was reduced. Disastrous floods in the mid-1930's and the resulting emphasis on flood control brought out the great need for basic streamflow data in the State. During the last half decade, much of the Survey's present program of streamflow stations was established in cooperation with

State agencies and the U.S. Army Corps of Engineers. The war effort during the 1940's curtailed expansion of the program but during the period 1950-1970, there was a gradual increase in the program. By 1970 the Survey was operating 76 daily-discharge surface water stations in Arkansas.

Based on our evaluation of the Arkansas District surface water program in consultation with cooperating agencies, 20 daily-discharge stations were discontinued at the end of the 1970 water year. Of these, 9 stations were converted to partial record stations at the request of cooperators. The partial record station operation consists of a stage record and occasional discharge measurements in order to maintain the high end of the rating curve or, in some cases, a complete rating curve. Annual peaks only are published for the partial record stations.

During the period 1971 through 1978 a few daily-discharge stations were either dropped or converted to partial record stations. Beginning in the 1979 water year, the Survey took over operation of 8 additional daily-discharge stations at the request of the Little Rock District Corps of Engineers. By the 1982 water year, most of these additional stations had been converted to partial record stations due to re-evaluation of data needs, both by the Corps and the Survey.

Surface water quantity or stage information is now available for 252 sites in Arkansas. Of these, 48 are USGS operated daily-discharge stations, 19 are operated by other agencies and 23 are discontinued daily-discharge stations formerly operated by the USGS. The remaining sites have either peak-stage record, a stage-discharge relationship available, or both.

Information from these stations is used (1) to define current hydrologic conditions, sources, sinks and fluxes of water through regulated or unregulated hydrologic systems, (2) in developing regionally transferable information about the relationship between basin characteristics and streamflow, (3) for the verification or enforcement of existing compacts, court decrees, or water laws, (4) for the planning and design of projects such as dams, levels, navigation systems, water supplies, roads, bridges, irrigation canals, and waste treatment facilities, (5) in making operation decisions in the daily operation of reservoirs, hydro-power generation, or diversions, (6) for flood forecasting, (7) for computing loads for water quality monitoring, and (8) for other uses such as recreational needs.

The Survey collects streamflow information by the methods described in USGS Water Supply Paper 2175.

S U M M A R Y

SURFACE WATER QUALITY

Mr. Charles T. Bryant
U. S. Geological Survey

Collection of surface water quality data in Arkansas was begun on a continual basis in October, 1945 when 6 daily sampling stations were established by the U.S. Geological Survey in cooperation with the University of Arkansas. The 6 stations were located on the St. Francis River at Marked Tree, the White River at Beaver and at Batesville, the Black River at Black Rock, and the Arkansas River at Van Buren and at Little Rock. Samples collected from these stations were analyzed for specific conductance, pH, silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids, and hardness.

In 1956 the U.S. Geological Survey and the Arkansas Geological Commission became cooperators for water quality data collection. In the years following several stations were added to the network and several constituents were added to the analytical schedule. The additional constituents included nutrients, suspended sediment, turbidity, color, dissolved oxygen, chemical and biochemical oxygen demand, boron, detergents, bacteria and tritium. In 1968 there was a significant increase in constituents added to the analytical schedule. Included were the following minor elements; aluminum, barium, beryllium, boron, cadmium, chromium, cobalt, copper, gallium, germanium, lead, lithium, molybdenum, nickel, rubidium, silver, strontium, tin, titanium, vanadium, zinc, and zirconium.

The pesticides aldrin, DDD, DDE, DDT, dieldrin, endrin, heptachlor, heptachlor epoxide, and lindane were also added in 1968. By 1973 pesticide analyses also included chlordane, toxaphene, parathion, methyl parathion, and diazinon.

The radiochemical constituents uranium, radium, gross alpha and gross beta were also added to the analytical schedule in 1968.

In 1985 the U.S. Geological Survey was operating 120 surface water quality stations. Analytical schedules generally included common constituents (inorganics), nutrients and trace metals.

In 1968 the Arkansas Pollution Control Commission (now the Arkansas Department of Pollution Control & Ecology) established a surface water quality network consisting of 60 stations. The analytical schedule for these stations included temperature, iron, manganese, calcium, magnesium, sulfate, chloride, nitrate, phosphate, residue on evaporation, hardness, calcium carbonate, total alkalinity, conductivity, pH, color, turbidity, BOD, dissolved oxygen and bacteria. Additional constituents added by 1974 included the trace metals arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc, and the pesticides aldrin, DDD, DDE, DDT, heptachlor, heptachlor epoxide, methoxychlor, methyl parathion, and toxaphene.

In 1985 the Arkansas Department of Pollution Control & Ecology operated a monitoring network of 110 stations. The analytical schedule generally included the constituents shown in the previous paragraph but with fewer pesticides.

A large data base on water quality exists for major reservoirs in Arkansas. In the 1960's the Little Rock District Corps of Engineers began measuring on a regular schedule dissolved oxygen, temperature and specific conductance in vertical profiles in Beaver, Table Rock, Bull Shoals and Norfork Lakes. In 1974 the U.S. Geological Survey began operating lake stations for the Corps. The network now consists of 87 stations on 15 lakes in the White, Arkansas and Red River basins.

All surface water quality data collected by the U.S. Geological Survey are published in annual data reports and are stored in the USGS data storage and retrieval system known as WATSTORE. These data are retrievable from WATSTORE as tables, graphs, statistics and plots. All surface water quality data stored in WATSTORE are also stored in STORET, the data storage and retrieval system operated by the U. S. Environmental Protection Agency.

Surface water quality data collected by the Arkansas Department of Pollution Control & Ecology are stored in STORET. These data are also stored in WATSTORE for publication in the annual "Water Data Report for Arkansas". Data from both WATSTORE and STORET are available to the public.

Additional surface water quality data have been collected by Universities and other State and Federal agencies. Universities collecting surface water quality data include the University of Arkansas at Fayetteville, at Monticello and at Little Rock, Arkansas Tech University, and Ouachita Baptist University. Other State agencies collecting data include the Game and Fish Commission and the Arkansas Department of Health. Other Federal agencies collecting data are the Memphis and Vicksburg Districts of the Corp of Engineers, and the Soil Conservation Service.

Much of the data collected by the various agencies are stored in STORET and are available to the public.

S U M M A R Y

GROUNDWATER QUANTITY

Mr. A. H. Ludwig
U.S. Geological Survey

Groundwater plays a major role in satisfying the water supply needs in Arkansas. In 1981 groundwater sources provided 81%, 4,300 million gallons per day, of the State's water for irrigation, public and rural supplies and industrial uses. The largest withdrawal of groundwater is for irrigation, mostly in the eastern part of the State. Nearly all municipal and industrial supplies in the southeastern half of the State are obtained from groundwater sources. One-half of the population of the State depends on groundwater as a source of drinking water.

The occurrence of groundwater is associated closely with rock type. Groundwater is abundant in the southeastern part of the State which is underlaid by highly productive, thick, alluvial deposits and by gently dipping unconsolidated and semiconsolidated sediments. Groundwater is less abundant in the northwestern half of the State which is underlaid by generally low yielding consolidated rocks consisting of limestone, dolomite, sandstone and shale.

The availability of groundwater data is closely associated with the areas of greatest groundwater potential. Most data is from wells in the Coastal Plain sediments where groundwater is the predominant source of supply. The data, primarily water use and water levels, are collected as part of county or areal studies conducted by Survey personnel in connection with cooperative programs with the Arkansas Geological Commission, the Corps of Engineers or the Arkansas Soil and Water Conservation Commission.

Groundwater data are also being collected by other State and Federal agencies. Soil Conservation Service personnel in the 27 counties in eastern Arkansas are collecting data on pumping plant efficiency, irrigation application rates and specific capacity in addition to providing water level measurements for the Geological Survey's analysis of the alluvial aquifer. The Soil and Water Conservation Commission is currently collecting and storing groundwater use data voluntarily submitted by water users in the State. Soil and Water is also assisting the Geological Survey in collecting withdrawal data from industrial users as part of the Survey's water use program. The Arkansas Department of Health receives withdrawal data from each of the municipal and rural water systems in the State.

Data collected by Survey and other Federal and State agencies are being processed for placement into one of the appropriate automated data systems, either in the Survey's computer, or the State agencies own system. Currently there are more than 10,000 well entries in the Survey's Groundwater Site Inventory (GWSI) data base. These include, in part, information on well construction, yield, water levels, and geologic source unit. Water use data from 1980 through 1984 are located in the National Water Use Data System (NWUDS) Data Base. In the future, water use data will be collected and stored on a site-specific basis and will reside in the State-level Water Use Data Base (SWUDS). The data in any of the systems is retrievable in a variety of forms, including tables or plots, to meet the specific requirements of the users.

S U M M A R Y

AVAILABILITY AND ACCESSIBILITY OF GROUNDWATER QUALITY DATA

Mr. E. E. Morris
U.S. Geological Survey

An inventory was made of all sources of groundwater quality data within the State of Arkansas. A questionnaire was mailed to State and Federal agencies and Universities who have collected groundwater quality data. The responses are given in Table 1. The Table represents the predominance of available data within the State of Arkansas. The data will be used to assess the condition of groundwater in the State, and to guide future detailed studies.

TABLE 1

GROUNDWATER QUALITY DATA AVAILABILITY FOR ARKANSAS

Collecting Agency	Number of Wells	[1]Type of Analyses: Inorganics	Organics	Trace Metals	Radio-chemical	Type of Data Storage: Paper Copies	Com-puter	Is Data Available to Public: Yes	No
Ark. Mining Institute (Ark. Tech University)	19	X		X		X		X	
Ark. Dept. of Pollution Control & Ecology	39	X	X	X		X	X	X	
Dept. of Energy (Natl. Uranium Res. Evaluation Program)	[2]200	X	X	X	X	X	X	X	
University of Arkansas Soil Lab.	3,538	X		X		X		X	
U.S. Geolo-gical Survey	3,415	X	X	X	X	X	X	X	
Ark.Dept.Health	854	X	X	X	X	X	X	X	

[1] Not all types of indicated analyses are performed on each well water sample.

[2] Estimated.

S U M M A R Y

GROUNDWATER QUALITY MONITORING

Mr. T. B. Spruill
U.S. Geological Survey

State and Federal water management agencies are continually faced with questions concerning the adequacy of the quality of groundwater supplies for various uses. Public agencies also must often determine whether groundwater in a particular area has been or will be contaminated by some land-use practice to permit appropriate regulatory action. Groundwater quality monitoring networks, if carefully designed, can provide the necessary data for effective decision making.

Groundwater quality monitoring is conducted at three different levels. Point monitoring is defined as monitoring chemical quality changes through time or vertical space in a single well. Local monitoring is defined as monitoring of chemical quality changes in several wells (a well network) in an area of less then ten square miles. Regional monitoring is monitoring of chemical quality changes in several wells located in areas of more than ten square miles. State agencies, which are responsible for regulating and protecting public water supplies over a large area, can effectively provide data to answer questions concerning baseline groundwater quality information and questions about possibly deteriorating groundwater quality using regional monitoring networks.

Data from regional groundwater quality monitoring networks can be used to describe chemical quality characteristics of water from supply wells in each of the identified groundwater regions for any selected year for which data are available. The mean or median of regional concentrations of a selected chemical constituent can be used as an estimate of typical characteristics in each area. Estimates of the percentage of wells which do not meet use standards in selected areas can also be derived from the network. The regulatory agency can control the known amount of precision of these estimates by altering sample size - this flexibility allows changes to be made in the network as the needs of the particular agency change.

Groundwater quality data from regional groundwater quality monitoring networks can be used to test hypothese about groundwater contamination in localized areas. To demonstrate this use, chloride data from wells in the Burrton area in Kansas compared with chloride data from wells in the Kansas network in that groundwater region indicate significantly larger concentrations in the Burrton area. In comparing nitrate data from wells in north central Kansas to wells in the Kansas network, there were no significant differences in concentrations.

Groundwater quality data from regional groundwater quality networks can also be used to evaluate annual or long-term changes in regional chemical quality due to possible land-use or climatic factors. Again, using Kansas network data as an example, application of a Spearman-Rho test for trend of nitrate concentrations in network wells located in northeastern Kansas sampled between 1978 and 1983, indicated no significant trend. Analysis of the same data using a non-parametric analysis of variance test indicated no significant differences in any single year for the same period.

S U M M A R Y

EXPANDED STREAM-GAGING NETWORK

Mr. Braxtel L. Neely, Jr.
U.S. Geological Survey

The stream-gaging network for Arkansas is designed to collect sufficient data throughout the State to satisfy immediate and future needs for water data. Stream-gaging networks must be continually evaluated to see if data are being collected where needed. The network should be modified when data are needed at new sites or when sufficient data have been collected. Other reasons for modifying a stream-gaging network are anticipated growths or declines in population and water use in some particular areas.

The primary ingredient for modifying a network is to keep abreast of the ongoing and planned activities in the State. Verbal contact with local and State officials is essential. These anticipated activities may generate new water needs which is an input to keeping the stream-gaging network current.

Data collected at streams is usually for one or two purposes; (1) an immediate need at a specific site and (2) general information that describes the area. Stream-gaging networks are usually designed to collect information that describes an area. Ideally, we need data at all points along a stream, but this is not feasible. The number of gages to be installed is an economics problem. The need for the data must be weighed against the cost for collecting the data. Most of the data needed at a site depends on long-term trends. Therefore, data needs must be anticipated far enough in advance so that data will be available when the need arises. These anticipated needs must be considered when modifying a stream-gaging network.

The type of data needed must be considered in designing the network. Average annual flow and flow duration data, for example, must be collected at continuous gaging stations. A continuous record of the flow is needed. Peak discharge data which is used in flood frequency analysis can be collected at crest-stage gages. These crest-stage gages record only the peak stage. Low flow sites usually do not require a physical gage except for a reference point where stages can be determined. Low flow data are collected by making about five discharge measurements per year. Some of the data have multiple purpose use. For example, peak discharges are collected at continuous gaging stations as well as crest-stage gages.

Rapidly growing water needs have generated a need for information about the quality of water. Our NASQAN stations are part of a national network on streams throughout the United States to show present water quality conditions and trends on selected streams. Arkansas has 13 NASQAN stations in this network. Similar data are collected on other streams throughout Arkansas. The quality of the water in the streams must be related to streamflow. Therefore, streamflow data must be available at all quality of water stations.

The stream-gaging network in Arkansas has changed many times since it was first designed. Changes in the network will continue to occur as water data needs change. Keeping abreast of ongoing and future activities in the State is essential to collecting the proper water data to support reasonable water management decisions.

S U M M A R Y

HAZARDOUS WASTE SITE MONITORING

Mr. Jim Rigg
Arkansas Department of Pollution Control & Ecology

Under the Resource Conservation and Recovery Act, CFR Subpart F, part 265.90, addresses groundwater monitoring at hazardous waste facilities. Under these regulations the owner/operator of a surface impoundment, landfill, or land treatment facility managing hazardous waste is required to implement a groundwater monitoring program capable of determining the facilities impact on water quality in the uppermost aquifer underlying the facility.

Determination of the effectiveness of groundwater monitoring systems requires an investigation into the subsurface conditions in the area of the waste management facility. The nature of groundwater system evaluation requires that subsurface data, including physical and hydrogeologic character of the underlying materials, as well as construction of the monitoring system components, be examined.

One of the purposes of the part 265 regulations was to prepare facilities for permitting. The Environmental Protection Agency assumed that data from detection and assessment monitoring under Part 265 would identify facilities that had contaminated groundwater. The data would serve as the foundation for developing the groundwater information required to be submitted with the facilities hazardous waste permit applications.

S U M M A R Y

WATER DATA NEEDS RELATING TO AGRICULTURAL NON-POINT SOURCES OF POLLUTION IN ARKANSAS

Mr. Donald Ray Linder
Soil Conservation Service

Row-cropped farmland and confined animal wastes are the two major non-point sources of agricultural pollutants in Arkansas. In 1982, average annual soil loss rates on cropland averaged 5 tons per acre, and 3,304,900 acres eroded at rates exceeding those necessary to protect the long-term productivity of the soil resource base (SCS 1982). This average cropland erosion rate is 50 to 100 times greater than that which occurs on forest land on similar soils. The results of these relationships on water quality is observed throughout eastern Arkansas where cropland often comprises 70 to 90 percent of smaller watersheds. Surface waters from such areas are typically highly turbid and nutrient-enriched, and pesticides are commonly detected in sediments and fish flesh (ADPC&E 1984).

During 1982, confined animal operations in a 22 county area of western and central Arkansas produced about 3,950,000 tons of fresh wastes (SCS unpublished data). Following storage and handling, these wastes contained 43,100 tons of nitrogen and 20,800 tons of phosphorus available for land application. The greatest concentrations of animals are located in Benton, Washington, Carroll and Hempstead counties where more than 2 tons of both nitrogen and phosphorus are produced per square mile of total surface area. Of particular concern are animal concentrations in portions of Benton, Washington, Carroll and Madison counties where carbonate rock terrain results in both ground and surface waters being extremely susceptible to pollution. Water quality data from this northwest corner of the State reveal elevated levels of nutrients and pathogenic bacteria indicators (ADPC&E 1984, Cox 1980, MacDonald et al 1975, Ogden 1979, Terry et al 1984, Wagner et al 1976).

Water data needs pertaining to non-point source agricultural pollution in Arkansas are summarized as follows:

(1) Continuation of long-term water quality monitoring data collection - Such data will continue to identify trends in agricultural pollutants. In addition, continual updating of analytical techniques and monitoring programs are necessary to provide early detection of impacts of newer agricultural chemicals on the aquatic environment.

(2) Establishing the validity of predictive models to local conditions within Arkansas - Water quality models such as the CREAMS model (ARS 1980) have been developed to predict impacts of various agricultural management systems on sediment, pesticide and nutrient transport. Irving and Associates (1985) found that results of the CREAMS model compared well to water quality sampling data collected in the Old Town Lake Watershed, Jackson County, Arkansas. Similar studies are needed in other physiographic regions of Arkansas to determine the applicability of such models to localized conditions.

Where needed, modifications of such models should be made to provide more accurate predictive capability of the impacts of agricultural activities on both surface water and groundwater.

(3) Formulating methodologies for relating water quality improvements into measurable increases in beneficial uses - Water quality models can be used to predict measurable changes in water quality parameters as a result of changes in agricultural management systems. However, methodologies are needed whereby changes in water quality parameters can be further used to measure specific levels of increases in recreational, municipal, industrial and agricultural uses. This capability will faciliate benefit-cost analyses as needed for water resource planning activities.

(4) Further research to determine animal waste activities that cause surface water and groundwater problems - Potential sources of excessive nutrient transport include high land application rates of manures, waste storage facilities, confined animal holding areas, manures applied to flood-prone lands, dead animal disposal and direct deposit of wastes by livestock wading in streams. More research is needed to establish the exact cause of elevated levels of nutrient transport. This is especially true where nitrate and bacterial levels exceed public health standards.

(5) Further research on nutrient levels and nutrient reactions of animal manures - Much of the data relied on to determine application rates of manures have been collected at different localities throughout the United States. Localized data on nutrient content

of certain types of animal wastes have been collected through the Soil Testing and Research Laboratory at the University of Arkansas at Fayetteville. However, inventories conducted by the SCS reveal numerous combinations of types of animal wastes, kinds of waste holding facilities and variable waste holding periods ranging from one day to one year. A comprehensive effort to establish localized nutrient levels for all situations needs to be undertaken. Such an effort will need to be constantly updated as management conditions such as feeding rations change. Also, localized research on nitrogen mineralization rates, volatilization losses and proportions of total nitrogen immediately available to plants needs to be conducted.

(6) Monitoring of water quality impacts of long-term application of phosphorus at rates exceeding plant requirements - At present, manure application rates are based on nitrogen requirements of the plant. This method often results in phosphorus being applied in amounts which are too great for plants to utilize. The long-term impacts of continual excessive application of phosphorus are not well established. Therefore, further research is needed.

(7) Studies to determine the water quality impacts of animal waste application on different soils - Soil depth, texture, natural fertility and slope vary tremendously among different groups of soils within the State. Research is needed to establish the limitations of each group of soils with respect to water quality impacts from animal waste application.

(8) Establishment of waste application rates which optimize tradeoffs between plant growth and water quality impacts - Most research about animal waste application has been based on the major objective of economically optimizing plant growth. This research has assumed that such optimum plant growth equates to minimize water quality impacts. Localized research within Arkansas is needed to better establish the optimum relationships among animal waste application rates, plant growth, economics and water quality impacts. Such research should be localized within regions of Arkansas to account for the many variations in soils, types of wastes and rainfall quantities and distributions.

S U M M A R Y

ARKANSAS WATER RESOURCES RESEARCH NEEDS

Dr. Leslie E. Mack
Arkansas Water Resources Research Center

As this conference has demonstrated, there are a wide range of missions, responsibilities and jurisdictions among the various Federal, State and local agencies concerned with water resources. The Fayetteville campus, as the primary land grant University in the State, is charged under the Water Resources Research Act of 1984 (P.L. 98-242) to conduct basic and applied research in all areas of water interests within the State. We are strongly encouraged to cooperate with any College or University within the State which shows an interest and competence to conduct research. Inherent with the program is the development of a cadre of water experts in various fields from their activities as principal investigators. As a built-in bonus, the research program for the past 21 years has helped to train several hundred students in Arkansas.

Research Needs - To discuss research needs alone without putting them in perspective may appear to the reader that the State has more water problems than solutions. That is not the case. We are blessed with abundant surface and groundwater supplies most of the time in most places, but we also have some problems. Some of these problems are getting worse and cannot be ignored. Other problems are in the making and can be prevented with understanding and action.

The Technical Advisory Committee for the Arkansas Water Resources Research Center is comprised of representatives of the water interested Federal and State agencies, academia and profit and non-profit organizations. This Committee has listed all of the significant water problems and research needs that it has identified. A newly revised list will be available early next year (1986). Thus, the Committee members determine what subjects need research and in what areas of the State they exist. The researchers then respond to the requests of the operational agencies. The Committee members rank the research proposals in the order of their importance.

Our research needs can be grouped into general areas of concern. They are: Ground Water, Surface Water, Water Quality, Data Bases, Water Resources Management, Economics and Law.

These research areas are similar to the basic foundation blocks for water mangement which include science and engineering, economics, law, administration, public awareness and environmental concerns.

More specifically, we are trying to emphasize research on our major problems. These include studies of alternative methods for conjunctive use of surface and ground water, propose management techniques for an aquifer that is being mined, such as the alluvial aquifer in the Grand Prairie, the effects and fate of salt in agricultural soils, scheduling of irrigation water, trace levels of pesticides in ground water, heavy metals in Beaver Reservoir tributaries, costs and benefits of soil erosion control, chemistry of Ozark Mountain springs, and institutional arrangements and financing alternatives for state and local water programs, just to name a few.

In the future, we will need more work on the following subjects: Effects of agricultural and forest practices on water resources; Dendrochronology to determine ancient streamflow records; Estimating surface and ground water pollution from land application of poultry and hog litter; Solutions to septic tank problems; Effects of flooding on water quality in Beaver Reservoir; Conjunctive use water management techniques; Analysis of water utility rates; Water quality variations in the Arkansas River; Water law; Institutional arrangements; Financing of water projects; Public awareness of water resources; Environmental effects from water resources projects; Ground water recharge, and possible rehabilitation of ground water reservoirs, for openers.

Summation - The Arkansas Water Resources Research Center serves as a research arm for the Federal and State agencies as well as private organizations. The Center also administers the Water Resources Research Act for all Colleges and Universities throughout the State.

Water resources research is a never-ending activity as the increase in population and technology also increases the competition for each clean water molecule.

Research is needed in all areas of water management including science and engineering, economics, law, administration, public awareness and environmental concerns.

SUMMARY

CURRENT LEGAL ISSUES IN ARKANSAS WATER MANAGEMENT

Mr. John Frank Gibson
Attorney, Arkansas Soil & Water Conservation Commission

Water law in Arkansas is basically governed by the reasonable use theory of the riparian rights doctrine. The owners of land bordering upon any river has a property right in the waters to the extent of the reasonable use thereof upon the lands riparian to the stream. The theory behind the doctrine requires the water which is drawn from the stream to be returned to the stream. Therefore, lands that are outside the watershed are not considered in Arkansas to be riparian to the stream. Therein lies the problem regarding inter-basin transfer of water from streams.

The riparian doctrine in Arkansas is clouded by the problems from transfers of ownership of riparian land away from the stream. When a person who owns, for example, 80 acres of land on the stream and conveys to another person 40 acres that is not bordered by the stream, that 40 acres does not carry with it the express reservation of riparian rights. Water rights in Arkansas under that doctrine are forever decreasing and we do not know the full extent of all riparian lands in the state without running an individual title search on each piece of land bordered by a stream.

The doctrine has been modified legislatively 3 times. Act 81 of 1957 modified tne law to permit the Arkansas Soil & Water Commission to make allocations among those lawfully taking water from streams during times of shortage. The priorities are: (1) to sustain life, (2) maintain health, and (3) preserve wealth. Also, any person who owns riparian land may get a permit to construct a dam to impound surplus waters on the stream. An impoundment created by that dam gives the owner thereof the exclusive right to withdraw waters in storage behind the dam.

The next modification or infringement upon the riparian rights doctrine came about in 1969 by Act 180. In that Act the Soil & Water Conservation Commission was given jurisdiction over the registration of water diversions from streams. Any person who withdraws water from streams is required under that Act to register their water diversion with the Commission on a form prescribed and provided by the Commission.

The last modification of our riparian rights doctrine was Act 1051 of 1985. By that legislation, the Legislature recognized that there was surplus waters in streams and it provides for interbasin transfer of those waters under the jurisdiction of the Soil & Water Conservation Commission. This Act has permitted that interbasin transfer of water which is limited to 25% of the excess waters defined in that Act to be waters above and beyond the riparian rights and instream flows, and projected uses in the basin. Rules and regulations are in the midst of being drafted to provide for the procedures. If there is any proposed interstate transfer of water, that proposal also has to go before the Soil & Water Conservation Commission for their approval. Under Act 1051 of 1985, we have not yet codified the area of controlling groundwater diversions. We are by that act able to obtain reporting of groundwater withdrawals.

On the general applicable law pertaining to groundwater, Arkansas is governed by the correlative use doctrine which states that any owner of land has a right to withdraw water flowing under the surface of his estate in any amount correlative to the rights of neighboring landowners to also do likewise.

It is also possible that a person who has created a prior and better use of the water might actually be recognized as having prior appropriation rights to that water and this would be recognized as a common law right of prior appropriation.

There is a statutory water right in Arkansas that is set up by the Interstate Compacts. Under the Arkansas River/Arkansas-Oklahoma Compact, which was signed in 1971, the State of Arkansas is obligated in certain areas to permit 40% of the yield in the watersheds in Arkansas to flow into the State of Oklahoma. Therefore, no water law or code in Arkansas can interfere with that obligation.

The other Compact is the Red River Compact between the states of Arkansas, Oklahoma, Louisiana and Texas, signed in 1979.

These obligations as set out in those Compacts further restrict the State's right to enact a water code that will prohibit these flows from going out of the State.

SUMMARY

CURRENT AND FUTURE SOLUTIONS TO WATER PROBLEMS

J. W. Looney
Dean, University of Arkansas School of Law

The easiest way to see the development of current law applicable to the resolution of water disputes is to consider examples of how conflicts might occur. Example 1: Two landowners have land adjoining a natural lake. One irrgates rice, one operates a marina. When a drought occurs, may the marina operator stop the rice producer from irrigating? Example 2: Two landowners own land adjoining the same stream. The upstream landowner dams the stream and takes water for irrigation purposes. Several years later the downstream owner decides that he would also like to irrigate and requests that the upstream owner reduce usage so that an adequate amount flows downstream. This would require the lowering of the upstream dam. Can this be required? Example 3: Landowner owns three parcels of land along a stream, only one of which actually touches the water. The second is adjacent to the first but does not adjoin the stream. The third parcel is close by but touches neither the stream nor either of the other parcels. If the landowner chooses to irrigate all three parcels, what is the result if a downstream owner complains? Example 4: Two landowners pump water from wells, one for irrigation, one for industry. May the industrial user be ordered to reduce pumping if that use affects the supply available to the farmer?

Under the riparian rights doctrine, as adopted and followed by the courts in Arkansas, each riparian landowner has a right to make reasonable use of water from an adjacent stream. The right to use water for strictly domestic purposes is superior to other uses of the water but all other lawful uses of water are equal. The right is limited by the concept of reasonableness. That is, each landowner must limit the amount and purposes for the use of the water to what is reasonable, giving due regard to the rights of other riparian landowners. Thus, in example 1, the rights of the irrigator and the marina operator are equal. When a drought occurs the use by one may be curtailed if it adversely affects the other.

Likewise, the rights of two riparian users are equal even though the use commences at different times. Thus, what is reasonable under a given set of circumstances can only be determined after the use has commenced. The right is unstable and always subject to modification by implementation of new uses by other riparians. Thus, in example 2, the second landowner has an equal right to use water from the same stream and is likely to be able to require the upstream owner to curtail his use in order to share a reasonable amount of the water.

A second generally accepted restriction under the riparian doctrine is that it limits the amount of water to land that is considered to be riparian - that is, land adjacent to the stream. Non-riparian uses can be enjoined if such uses interfere with lawful riparian uses.

Thus, in example 3, the landowner would be permitted to irrigate the land which is adjacent to the stream. He could be prevented from irrigating land that neither touches the stream nor is adjacent to his other property if this has an adverse affect on other landowners. It is uncertain whether he can be prevented from irrigating his second parcel - the one which touches the first but is not adjacent to the stream.

The concepts of the riparian doctrine have been used by courts to resolve disputes involving groundwater. The Arkansas Supreme Court specifically adopted the reasonable use doctrine for groundwater and indicated that not only will the reasonableness of groundwater use be judged by the quantity of water used but also by the reasonableness of the use on the overlying land. The Court indicated that where two or more persons own different tracts of land overlying a common source of groundwater, each has a common and correlative right to the use of the water. Each can make use of it as long as the supply is sufficient but each is entitled to a reasonable share if the supply is so scarce that the use by one affects the supply of the others. Thus, in example 4, neither groundwater user has the primary right to take all of the water and one user may be restricted in the pumping if it affects the supply of the other.

All of these examples illustrate one of the major criticisms of the riparian doctrine - uncertainty. Adjudication is required to determine the rights of the parties in conflict. Litigation is both expensive and ponderous. The riparian doctrine has also been critized for being inflexible in that it restricts transfers from riparian to non-riparian land and it restricts interbasin transfers as well. Lastly, the riparian doctrine is critized for a lack of coordination between surface and groundwater, or for a lack of coordination with other resource management programs.

Because of these criticisms a number of states have made changes in the riparian rights system, often involving permitting for certain types of diversion of water. Arkansas made some changes in 1969. The current law requires registration and reporting of diversions of surface water and the Soil & Water Conservation Commission has authority to make allocations of surface water between registered users in times of shortage.

Also, under legislation passed in the 1985 legislative session, groundwater use is now required to be reported. In addition, the Soil & Water Conservation Commission was mandated to do a major study of water supply and demand in the State and to make a determination as to whether surplus or excess water exists, and which areas are critically short. In addition, the Commission must develop guidelines to evaluate any proposed transfers of water. The legislation also placed some restrictions on the transport use of water outside the State and specifically requires a determination by the Soil & Water Conservation Commission as to whether the transfer would be in the public interest followed by approval of the General Assembly.

The information being developed by the Soil & Water Conservation Commission is probably a necessary step before major comprehensive changes in water legislation in Arkansas is likely.

S U M M A R Y

WATER RESOURCES MANAGEMENT

Mr. David Burrough
Corps of Engineers, Little Rock District

The geographic limits of our District are defined as parts of the Arkansas River Watershed from the Oklahoma state line to Pine Bluff with navigation responsibility for the McClellan-Kerr going to the Mississippi River, the upper White River Watershed (above Georgetown), and the Little River portion of the Red River Basin in southwest Arkansas. The other river basins in Arkansas are managed by the Memphis and Vicksburg Districts.

The Arkansas River Basin includes two multipurpose lakes on the Arkansas River, Ozark and Dardanelle, and ten other locks and dams and navigation pools. We also operate two small flood reduction dams, Nimrod and Blue Mountain, on tributaries of the Arkansas River. In the White River Basin we have one flood reduction dam, Clearwater, and five multipurpose projects, Greers Ferry, Norfork, Bull Shoals, Table Rock and Beaver. We have four multipupose dams in the Little River Basin in southwest Arkansas. They are, Millwood, DeQueen, Gillham and Dierks. We are responsible for the development and operation of projects for navigation, flood reduction, hydropower, improved drainage, water supply, recreation, fish and wildlife and other uses which Congress directs.

A major responsibility of the District is the operation and maintenance of the twelve locks and dams and 308 miles of channel that make up the McClellan-Kerr Arkansas River Navigation System. Probably the most important purpose of our dams and lakes in the White River and Little River Basins is flood control. Our twelve flood reduction and multipurpose projects prevented about 63.1 million dollars in damage last year and Federal levees in Arkansas prevented an additional 11.8 million dollars. Total damages prevented in Arkansas by these Federal projects from the time of their construction to 1985 is more than 375 million dollars. Hydropower production is another major part of our program. Water supply storage is included in Beaver, Norfork, Greers Ferry, Millwood, Dierks, DeQueen, Gillham, Dardanelle and Nimrod reservoirs. The Little Rock District has an outstanding and nationally-recognized recreation program, one of the largest and best in the Corps. Our projects have led the way to a well developed tourism industry which is the second largest revenue producer in Arkansas.

When we look beyond FY-86, we have numerous challenges, opportunities and potentials for a substantial workload for the next several years. Some of the potentials include nine needed remaining items of work on the Arkansas River navigation system, continuation of work on Clearwater under the dam safety and meeting the continuing flood reduction and municipal, industrial and water supply needs of the LRD portions of Arkansas and Missouri.

S U M M A R Y

WATER RESOURCES MANAGEMENT

Mr. Fred Hoffman
Corps of Engineers, Memphis District

The Memphis District covers parts of six states: Mississippi, Tennessee, Kentucky, Illinois, Missouri and Arkansas. The Arkansas segment represents 41% of the area in the District and is by far the largest state segment served in both geographic area and number of authorized water resource projects. The 10,100 square miles in northeast Arkansas includes all or parts of 22 counties.

The bulk of Memphis District flood control work in the state is pursued under the authority of the Mississippi River and Tributary project (MR&T). The following General Investigation studies are conducted under the MR&T program: Eastern Arkansas Region Comprehensive Study, St. Francis below Wappapello Lake, AR&MO, Helena and vicinity, West Memphis in Arkansas.

After the survey (or feasibility) study is completed and the project authorized and funded by Congress, the next phase of work is Advanced Engineering and Design (AE&D). Since considerable time may have passed between the completion of the feasibility report and authorization by Congress, it is necessary to update the data and reaffirm the feasibility of the authorized plan, or alter it as necessary to ready the project for construction. The following MR&T projects are in the AE&D phase: L'Anquille River, Eight-Mile Creek, Big Creek and tributaries (Lower White River).

The major portion of construction under the MR&T project is largely concentrated in the St. Francis Basin. Authorized features include 922 miles of channel improvements, 438 miles of levees, 3 pumping plants, 8 flood control and diversion structures, and 1 dam and reservoir. The Corps is also responsible for maintenance of flood control features on the Mississippi River levees and St. Francis River and tributary projects as well as the White River backwater levees.

In the navigation category two reports have been submitted to the Secretary of the Army: Helena Harbor under the MR&T project and White River Navigation to Batesville, Arkansas.

The District maintains navigable channels on both the main stem Mississippi and the White Rivers. Maintenance of revetments and dikes on the Mississippi will be funded with $12,534,000 in FY-86, maintenance dredging on the White River up to Newport $1,073,000, and dredging to maintain the channel will require an additional $10,674,000.

Section 10 of the Rivers and Harbors Act of 1899 authorized the Corps to regulate all activities and structures in "navigable waters" of the United States. In addition to the Mississippi River, navigable waters in the Memphis District area of Arkansas include 245 miles of the White, 338 miles of the St. Francis, 22 miles of the Tyronza, 2 miles of Little River, 6 miles of Blackfish Bayou, 12 miles of Bayou Lagrue and 8.8 miles of the L'Anquille River.

Section 404 of the Clean Water Act quthorized the Corps to regulate the discharge of dredged or fill material in the "waters of the United States". The "waters of the United States" are defined as all navigable waters, those used for interstate commerce and other waters, the degradation of which could affect interstate commerce. It also includes impoundments, tributaries and wetlands adjacent to any of the previously described waters.

The Eastern Arkansas Region Comprehensive Study is the only Memphis District study or project which includes water supply as a separable component. It is directed at solving both flood control and water supply problems. Feasibility studies now under way will examine the conjunctive use of both surface water and groundwater to meet the current and future needs of municipal, rural, industrial, agricultural, commercial fisheries and instream users in a 24 county area of Eastern Arkansas. Both the Little Rock and Vicksburg Districts are cooperating in this study together with the U.S. Geological Survey and other State and Federal agencies. It will require about 3½ years to complete and will make recommendations for construction of feasible projects as appropriate.

The State of Arkansas represents a vital component of the traditional civil works mission of the Memphis District, Corps of Engineers. Even though water appears to be an abundant resource, it must be managed intensively to assure continued availability and high quality.

S U M M A R A Y

WATER RESOURCES MANAGEMENT

Mr. James B. Kazel
U.S. Army Corps of Engineers, Vicksburg District

The Vicksburg District presentation at the Arkansas Water Conference, December 3-4, 1985, consists of three parts; an overview of the Vicksburg District, a synopsis of the major water resources projects constructed by the Vicksburg District in Arkansas, and current planning studies being conducted in the State of Arkansas by the Vicksburg District.

Within the U.S. Army Corps of Engineers' organization the Vicksburg District is among the largest of the districts, and it is also among the oldest being formed in the 1880's. The overall mission of the District has included; disaster relief, military preparedness, and civil works water resources development.

Some of the major water resources projects constructed by the Vicksburg District in the State of Arkansas are; the multi-purpose lakes located in the northwestern region of the District (Lake Ouachita, DeGray Lake and Lake Greeson), the Ouachita navigation project with lock and dams at Calion and Felsenthal, the Lake Chicot pumping plant, and various recreation developments associated with these water resources projects.

The District recognizes that water resources of the State of

Arkansas are becoming one of its most important assets. It believes that skilled planning and careful management are essential to achieve the level of efficiency in water use which will be required in Arkansas' future. To this end, the U. S. Congress, at the urging of State and local interests, has directed the Vicksburg District to carry out various water resources studies.

The Vicksburg District has a large water resources planning program in the State of Arkansas. This program is addressing the water problems and needs of the Bayou Meto Basin, the Ouachita River Basin, the Red River Basin, and the Boeuf-Tensas Basin. The problems and needs being addressed include navigation, flood damage reduction, water supply, recreation, hydropower, water quality, and wildlife and fisheries.

S U M M A R Y

REAL-TIME HYDROLOGIC DATA COLLECTION

Mr. W. G. Shope, Jr.
U.S. Geological Survey

Communication of hydrologic data using a relay of radio-transmissions directed from remote data collection stations to an earth-orbiting satellite for immediate broadcast back to earth provides a viable alternative to onsite visits for the collection of hydrologic data. Satellite Data Collections Systems (DCS) support collection of hydrologic data in near real-time for hazard warning systems and water management. The efforts to provide a reliable satellite DCS began with tests in the 1960's and have been followed by technical improvements to the satellites, the transmitting radios (Data Collection Platforms or DCP's) and earth receive stations. The operational use of satellite DCS has grown to more than 3,500 active DCP's and shows promise of continuing to expand.

The satellites most often used for the relay of environmental sensor data are known as the Geostationary Operational Environmental Satellites (GOES) and are operated by the National Oceanic and Atmospheric Administration (NOAA). Numerous GOES satellites have been launched beginning in 1977 to maintain operational satellites over the equator of 75°W and 135°W longitudes with in-orbit spares at intermediate longitudes.

The GOES DCS was designed to support two modes of DCP communication. One is the interrogatable mode, where the DCP is commanded to transmit a message by an operator-initiated message relayed to the DCP via one of the GOES satellites. The second, is the ordered self-timed mode where each DCP is programmed to transmit a message to the satellite under control of a precise clock within a rigidly defined time period. Generally, a DCP is allocated a one-minute time slot every three or four hours with the capability to transmit alert messages in near real-time based on event detection.

The DCP is located at the remote data collection station and is made up of a radio, clock, microprocessor and computer memory. The microcomputers that control the operations of the DCP are used to provide many capabilities for the acquisition of data from the sensors in accordance with the sensor update cycles and stored in the memory of the DCP. Advanced microprocessors provide the DCP with the capability of examining hydrologic data as it was collected from the sensors. Decisions can be made by the microprocessor based on the magnitudes of the values, or the change in data values. If the magnitude or change in values exceed user program parameters within the DCP, the DCP has the capability of either transmitting an immediate alert message or increasing the frequency of transmission corresponding to the magnitude of the detected event. New platforms can provide on-site data conversion, calibration, statistical summaries, and resolution of multiple parameter equations. The computing power of the microprocessors used in DCP's now rival the computing capabilities of the large office computers used in the early 1960's.

Although large strides have been made in instrumentation, the effective management of a satellite telemetry system and the development of the necessary computer software tools for data handling and processing require future improvements. During the 1970's the Geological Survey's management and data handling activities for satellite DCS were centralized, with data collected through the NOAA facilities and processed and distributed through the Geological Survey's computers in Reston, Virginia. The centralized approach proved to be costly, inflexible and, in some cases, unreliable.

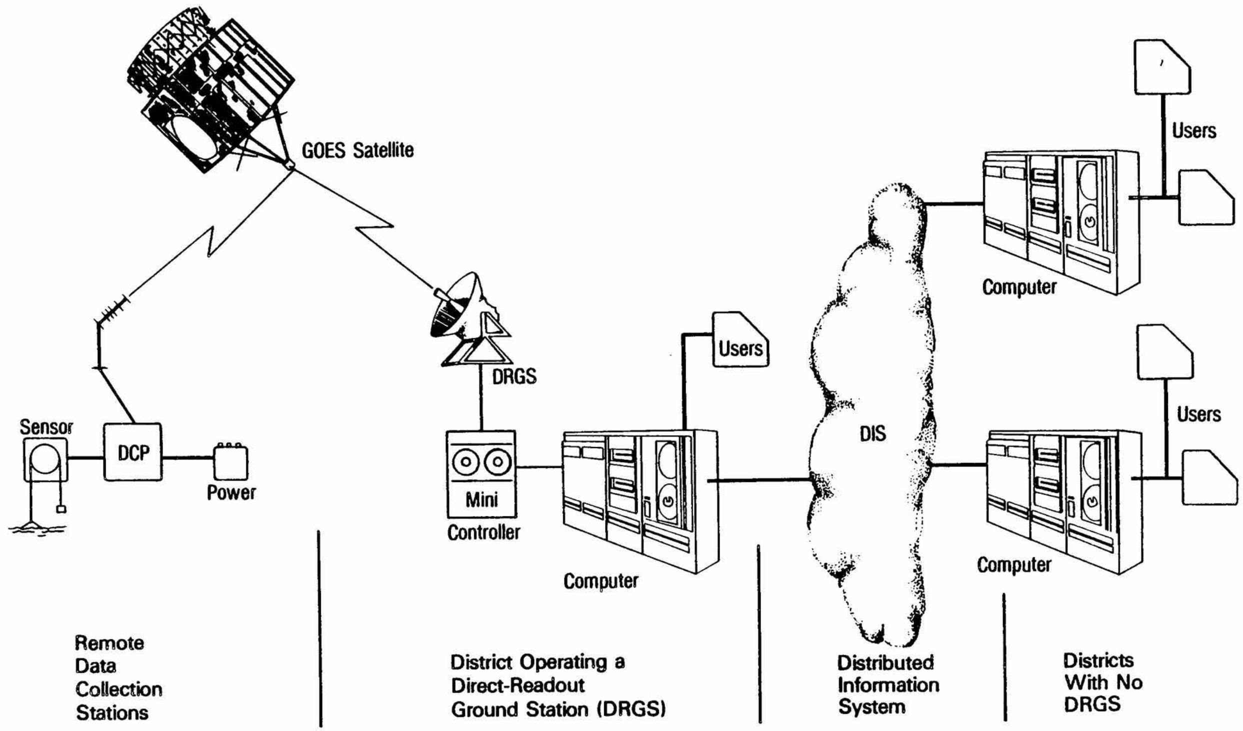
In the 1980's the Geological Survey began testing other procedures for managing a network using, in one case, a contractor effort and in another, a distributive approach for both acquiring data from the satellite and processing it. The contracted effort proved to be too expensive but the distributive system, based on a network of Direct-Readout Ground Stations (DRGS) connected into the Geological Survey's national network of mini-computers, known as the Distributed Information System (DIS), shows promise for providing the flexibility and control needed for a complete remote data acquisition system.

The DRGS comprises an antenna, radio receiver and decoding equipment, and a mini-computer that functions as a system controller. These controllers are powerful enough to manage the operation of the radio receiver, decode the DCP messages, flag and disseminate alert messages, store the decoded data in a temporary file, monitor the performance of the DCP transmissions, provide access for multiple users, and forward environmental data to the DIS mini-computers colocated at the Geological Survey's field offices. Because the DRGS can be colocated with the user or data collection network field manager, responsiveness to user needs has been improved, control has been returned to the field manager, and system flexibility has increased considerably. As a result of these and other factors, the use of these stations has become increasingly attractive to users of the GOES telemetry system.

In the early 1980's the Geological Survey also began the development of the DIS network of mini-computers. These mini-computers are linked together as nodes in a dedicated nationwide communications network. Survey District offices in almost every state now have on-site capabilities for processing basic data, running hydrologic simulation models, and a variety of administrative and scientific applications. The DRGS' that are being deployed in Geological Survey field offices have been interfaced with local nodes of the DIS. Real-time hydrologic data acquired by a DRGS are entered into the local node of the DIS and accessed by users at the local mini-computer, or automatically distributed to other nodes within the nationwide system. This configuration provides an excellent opportunity for a large number of users to share the resources of a small number of DRGS', as well as providing backup support capabilities for the network of DRGS's. By mid-1985 the Geological Survey had approximately 40 DIS nodes and

7 DRGS' in operation all linked directly to a local node.

The flow of data from sensor through satellite relay to the network of Survey mini-computers is shown in the Figure (attached). The collection, distribution, processing and storage of data is automated for data delivery to the mini-computer of the office responsible for operation of the data collection stations. Future activities include enhancement of the GOES DCS by NOAA to provide more capability, a new generation of low cost DRGS' that will take advantage of commercially available resources, and improved reliability in the Survey's distributed data collection and processing system through added communication and computer hardware and implementation of new computer software.



Hydrologic Data Collection Using Satellite Telemetry and a Distributed Information System

S U M M A R Y

SIGNIFICANCE OF THE STATE WATER PLAN

Mr. Earl Smith
Arkansas Soil & Water Conservation Commission

For many years the demand on Arkansas' apparently abundant ground and surface water supplies have seemed negligible in comparison with the quantities available. However, the lowering of groundwater levels and the potential for degradation of water quality has awakened many individuals to the need of a strategy for the wise use of Arkansas' water resources. Water use has quadrupled in the last 20 years and is expected to triple by the year 2020. Continued increases in the population and increased economic growth will not only add to the water demand, but will also pose a threat to the quality available. Skilled planning and careful management will be essential to achieve the level of efficiency in water use which will be required in the future.

The Arkansas Soil & Water Conservation Commission received general statutory authority to begin work on the first Arkansas State Water Plan in 1969. Act 217 gave specific authority to the Commission to be the designated agency responsible for state level water planning and mandated the preparation of a comprehensive State Water Plan of sufficient detail to serve as the basic document for defining water policy for the development of land and water resources in the State of Arkansas.

The first completed component of the 1975 State Water Plan was the Ouachita River Basin Report in 1970, followed by the Bartholomew-Beouf-Macon River Basin Report in 1972. In 1975 the main report of the State Water Plan was published. Five appendices were completed by 1978 that included: (a) Lakes of Arkansas, (b) Projections of Water Use, (c) Use of Red River Water for Irrigation, (d) AWRMIS Data Base, and (e) Public Supply Inventory. The objective of the 1975 plan was to develop a statewide plan to assure the best and most effective use of water in the implementation of local plans to meet current and projected demands of the people of Arkansas. As more data becomes available, it is apparent that the ever-changing nature and severity of water resource problems and potential solutions require that the planning process be dynamic to accurately address current issues. Periodic revisions to the State Water Plan are necessary if the document is to remain valid and reliable.

In 1980, planning activities began on the 1986 State Water Plan. The main objective of the revised plan was to incorporate new data available from recent research, evaluate new and existing problems, and present specific solutions and recommendations that would result in the best and most efficient use of water to meet current and projected demands.

The planning process will consist of six phases. The first four will consist of gathering, compiling and analyzing data to publish in the basin Reports. Phase five will be the development of an Executive

Summary, and phase six will be periodic reporting of the status of ongoing planning activities in accordance with the requirements of Act 1051 of 1985.

The Arkansas State Water Plan of 1986 will consist of basin reports and an Executive Summary. Each basin report will include an inventory of soil and water resources, current and projected water use, problems and potential solutions and recommendations.

The Executive Summary will consist of a comprehensive statewide report that summarizes the most significant land and water resource problems in the State and prioritizes the more feasible solutions, recommendations and strategies to address those concerns.

The first basin report of the 1986 Plan was the Boeuf-Tensas Report released in March of 1984 by the Commission. Currently, planning activities have concentrated on the lower Ouachita basin, expected to be released for review by January, 1986. The Commission will then shift to the Upper Ouachita basin, followed by the Grand Neosho basin. To assist with the basin reports, an I.P.A. (Intergovernmental Personnel Act) from the Soil Conservation Service and the U.S. Geological Survey have been placed on temporary assignment with the Commission. Additional assistance will be provided by the Soil Conservation Service and the Corps of Engineers, as follows:

(A) The Little Rock District of the Corps of Engineers are publishing the Upper White and Upper Arkansas basin reports financed by Section 22 monies, (Planning Assistance to the States).

(B) The Soil Conservation Service is publishing the Upper and Lower Red River basin reports by direct contract.

(C) The Memphis District of the Corps of Engineers has recently published a reconnaissance report covering Bayou Meto, Lower White, and the St. Francis River basins in eastern Arkansas. With the addition of data by the ASWCC staff to satisfy Act 1051 of 1985, this document will serve as the State Water Plan for three basins.

All basin report are due for completion by mid-1986 with an Executive Summary published for the 1987 legislative session. The 1986 State Water Plan will serve as a guide for the efficient development of Arkansas' water and related land resources in the years to come.

S U M M A R Y

Dr. Richard Peralta, U/A Dept. of Agricultural Engineering
and
Mrs. Ann Peralta

About 80% of the water consumed in Arkansas is obtained by pumping from aquifers, underground water-bearing geologic formations.

Pumping by agriculture, industry and municipalities has caused groundwater levels to decline dangerously in some areas. Where the water level nears the base (bottom) of the aquifer, the saturated thickness (distance between the water level and the base of the aquifer) may become too thin to allow wells to yield their designed discharge.

In Arkansas, land owners are entitled to the reasonable use of groundwater pumped from aquifers underlying their property and no one is to pump so much that it deprives another of his reasonable use.

Pumping from one well causes a decline in water levels at other nearby wells. As a result, water users in areas with dangerously thinning saturated thicknesses may be caught in a dilemma in which they must either; (1) reduce water use and production, (2) procure an alternative source of water or (3) continue to deplete the supply, becoming increasingly vulnerable to drought and successful litigation by injured groundwater users.

A remedy to the problem is the development and implementation of water use strategies which assure the maintenance of adequate saturated thicknesses while insuring the perennial availability of groundwater.

For areas where recharge to an aquifer cannot possibly replace current pumping from the aquifer, such strategies may require the conjunctive or coordinated use of groundwater and diverted surface water if current production is to be maintained.

A groundwater pumping strategy that maintains groundwater levels at fairly constant levels over the long-term is called a sustained yield strategy.

In recent years the authors collaborated in conceiving the Target Level Approach (TLA), a concept and methodology for developing a sustained yield strategy to maintain a predetermined regional set of groundwater levels (potentiometric surface) and satisfy saturated thickness constraints.

Since that time, the physical and legal feasibility of implementing such strategies in critical groundwater regions in Arkansas has been reported in the Arkansas State Water Plan.

The TLA is significant for two major reasons: First, a TLA computer model calculates a sustainable pumping strategy that will maintain specific levels, unlike traditional groundwater models which predict the effect of known pumping water levels. Second, the TLA is a hydrologically and legally integrated approach to groundwater especially attractive for riparian rights/reasonable use states like Arkansas because it can be implemented without making radical changes in the basic water rights system.

There are an infinite number of possible sustained yield strategies for any aquifer system and each particular strategy will cause the evolution and maintenance of a different regional potentiometric surface.

The question is naturally asked, "Which strategy and 'target' surface is most desirable?" The Target Objective Approach (TOA) addresses that issue. Basically, the TOA involves the development of sustained yield strategies and 'target surfaces' that maximize attainment of a particular predetermined regional policy subject to appropriate constraints.

The TOA is a management oriented tool which allows for a prior analysis of alternative water management policies. It has been used to demonstrate that if all agricultural and industrial water users in the Grand Prairie were to reduce pumping by a common proportion in order to achieve a sustained yield, less than 20% of current pumping could be continued.

On the other hand, a more hydrologically sound sustained yield pumping strategy has been designed that permits 50% of current pumping to continue. Most interestingly, however, a strategy has been developed that will assure a sustained yield and perennially satisfactory saturated thicknesses in all parts of the region, and will replace all but about 10% of current groundwater use by a combination of groundwater and diverted river water.

To date, several computer simulation/optimization models have been developed by the staff and graduate students at the Agricultural Engineering Department Water Resources Management Laboratory for both the TLA and the TOA.

For the TLA, these models combine the use of linear or quadratic goal programming techniques with embedded equations describing porous media flow.

TOA models, also containing embedded flow equations, have been devised which use linear optimization to determine maximum feasible sustainable groundwater pumping, and to either minimize unsatisfied demand or to minimize the common proportion that all water users would need to reduce their current pumping if recharge cannot keep pace with current demand.

Quadratic TOA models minimize the cost of attempting to satisfy current water demand from conjuntive water supplies and accomplish multiobjective optimization. These models have been applied in evaluating the water supply problem of either the Grand Prairie or the Boeuf-Tensas Basins in Arkansas.

Other valuable methodologies have been developed to assure that individual water users are affected as favorably as possible under regionally optimal strategies. Target Modification Methods (TMM) permit refinement of a regionally optimal strategy to better satisfy local (or quarter-township-sized) needs.

TMM include interactive modification of optimal linear or quadratic strategies, modification of a strategy to constrain groundwater contaminant movement, and the selection of a compromise strategy from a pareto optimum of conflicting objectives.

In addition, dynamic Target Attainment Methods (TAM) and Optimal Mining Methods (OMM) have been developed. Both utilize embedded porous media flow equations, linearized influence coefficients describing the dynamic effect of pumping on transient water levels, and optimization.

TAM create regional strategies that maximize the evolution of a particular 'target' potentiometric surface within a specific planning period. OMM create strategies that maximize either the volume of groundwater that can be mined (pumped without being replaced by a recharge) or the net economic return from such mining.

In summary, a comprehensive group of tools have been developed to aid in the systematic planning and evaluation of regional water resources policy and use. The techniques are applicable for many regions where the coordinated use of groundwater and surface water is desirable. They are currently being used to try to develop strategies which best assure the sustained availability of water for users in two multi-county regions in Arkansas.

Whether or not such strategies are implemented will ultimately be decided by water users through their influence with legislators and water management districts.

CLOSING REMARKS AND RECOMMENDATIONS

Mr. Randy Young
Arkansas Soil & Water Conservation Commission

I want to express my appreciation to members of the Advisory Committee for their effort to ensure that this conference was a success. I want to personally thank Charles Bryant (USGS), Chuck Bennett (ADPC&E), Bill Bush (AGC), Tom Dennis and Ray Linder (SCS), Danny Goodwin and Earl Smith (ASWCC), Dr. Les Mack (UAWRRC), Don Potter (AH&TD), Harold Seifert(ADH), Jim Shell (ADPC&E) and Gene Washburn (LRD-COE).

The panelists did an exceptional job in responding and defining the questions from the audience that demanded answers. I recommend that the Advisory Committee digest the information and facts presented, then summarize and prepare a definitive listing of those questions, along with the solutions and recommendations presented for incorporation into the conference proceedings. In addition, an appropriate plan of action should be devised for dissemination of this information to the decision makers.

While attending the conference, I have sensed a true spirit of cooperation among the participants and attendees. This is a very positive signal that the process of discovering equitable compromises has been initiated, which will eventually lead to solutions for these difficult, complex and sensitive water issues. I am truly convinced that we can adequately address these issues by working closely with each other. I liken this to one thing my dad taught me while growing up on a dairy farm near Dover, "breaking a first calf heifer into milking in the dairy barn". If you try to milk her at arms length, you will be kicked and probably injured. Your best chance to avoid this danger is to get as close to her as possible.

In closing, let me thank all of you again for making the First Annual Arkansas Water Conference a success.

Edited and Typed

by

Alice T. Gamache
Fayetteville, AR

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ARKANSAS WATER CONFERENCE
1985

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