

# Arkansas Water Resources Center

## Annual Technical Report

### FY 1998

## Introduction

## Research Program

### Basic Project Information

Basic Project Information	
Category	Data
<b>Title</b>	Vulnerability and Use of Ground and Surface Waters in the Southern Mississippi Valley Region
<b>Project Number</b>	C-01
<b>Start Date</b>	09/01/1996
<b>End Date</b>	08/31/1998
<b>Research Category</b>	Ground-water Flow and Transport
<b>Focus Category #1</b>	Non Point Pollution
<b>Focus Category #2</b>	Agriculture
<b>Focus Category #3</b>	Water Quality
<b>Lead Institution</b>	University of Arkansas

### Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
H. Don Scott	Unknown	University of Arkansas	01
T. Lavy	Unknown	University of Arkansas	02
E. Wailes	Unknown	University of Arkansas	03
A. Johnson	Unknown	Alcorn State University	04
D. R. Shaw	Unknown	Mississippi State University	05
S. W. Manley	Unknown	Mississippi State University	06

S. W. Young	Unknown	Mississippi State University	00
F. M. Kaminski	Unknown	Mississippi State University	07

## Problem and Research Objectives

There is a major concern in the Southern Mississippi River Valley of the non-point source pollution of surface and ground waters resulting from activities associated with agricultural production. The objectives of this regional research are to 1) determine the transport of contaminants such as pesticides to ground and surface waters, and 2) to evaluate those factors that are important in the quality and use of water in rice production.

## Methodology

Six research projects were conducted, all using differing techniques to examine the transport of water and solutes in the Southern Mississippi River Valley. Johnson used undisturbed soil cores to examine the simultaneous transport of two herbicides. Dixon and Scott used fuzzy logic techniques to examine their application to the prediction of pesticide contamination of the ground water. Shaw conducted a field study to ascertain the influence of the width of tall fescue filter strip on the off-site movement of two herbicides to surface water. Dewell and Lavy sampled the tailwaters, flood and reservoirs in flooded rice production fields for pesticides commonly applied during the growing season. Manley and Kaminski examined several conservation management alternatives for flooding rice fields. Young et al modified an existing reservoir model to estimate the economic value of on-farm reservoirs for irrigation of rice and soybeans.

## Principal Findings and Significance

Alton Johnson: A column study was conducted to quantify the simultaneous transport of two commonly used pesticides in the Southern Mississippi River Valley. The soil was the A horizon of a Memphis silt loam. Under saturated conditions metribuzin moved faster than metolachlor as shown by the were peak relative concentrations at 2.4 and 3.5 pore volumes for metribuzin and metolachlor, respectively. The retardation factors were 5.9 and 1.5 for metolachlor and metribuzin, respectively.

Dixon and Scott: Six fuzzy logic models were developed to compare with the modified DRASTIC model in predicting the potential contamination by pesticides of the ground water in Woodruff County, Arkansas. They concluded that the fuzzy logic models had a higher incidence of detecting the most vulnerable wells to pesticide contamination than the frequently used DRASTIC model. The use of the modified DRASTIC model for screening potential areas for vulnerability has an inherent risk of underestimation. The fuzzy logic-based model did not underestimate the vulnerability, and thereby, eliminate the risk of neglecting a potential vulnerable area. The model containing four fuzzy parameters was best in predicting the locations of the contaminated wells. This rule base had the soil physical characteristics related to leaching of contaminants as the dominant parameter.

David Shaw: A field study was conducted to ascertain the influences of tall fescue filter strip width on the off-site movement of metolachlor and metribuzin in surface water. This work has shown that by two days after treatment as compared with the unfiltered treatment the filter strips reduced metribuzin and metolachlor concentrations between 48 to 68% and mass flux from 91-98%, regardless of the width of the filter strip. The highest cumulative loss was from the unfiltered treatment.

Manley and Kaminski: Runoff volumes and concentrations of sediments and nutrients were measured

in order to estimate the losses from rice fields in relation to various post-harvest/winter flood treatments. Preliminary results indicated combination of flooding the fields and leaving the stubble standing after harvest resulted in runoff with the fewest suspended solids and nutrients lost. The nutrients included ammonium, nitrate and phosphate. Fall disking rice fields and leaving drain pipes open throughout winter yielded a greater export volume of suspended and dissolved solids and the highest loss of nitrates and sulfates. Similar results were found in the loss of suspended solids in fall disked and winter flooded fields compared with open fields with stubble left standing.

Lavy and Dewell: The monitoring of tailwaters from rice fields have indicated that some pesticides occasionally runoff from production fields. To provide a greater understanding of the fate of these pesticides under production conditions, a controlled greenhouse study involving eight pesticides was conducted. The results showed that sediment from previously treated fields appears to be important in supplying the appropriate microbial populations or other pesticide dissipation factors.

Wailes and Young: A literature review of previous on-farm reservoir use studies was conducted. The ARORA model which was used to analyze conjunctive use reservoir performance of soybean irrigation, developed by Edwards and Ferguson, was selected for use in this study. The economic framework and scope of the ARORA model is being improved and expanded. The major modifications include the addition of rice into the cropping system with soybeans as an irrigated crop, which is more representative of the Mississippi delta cropping patterns. Recycling of tailwater runoff to supplement the reservoir water supply is also being developed within the model. Irrigated farms with reservoirs and tailwater recovery systems were visited to obtain up-to-date costs and performance data. An analysis of the legal case law affecting water rights and use was also conducted.

## **Descriptors**

Irrigation Management, Hydrologic Models, Saline Soils, Surface-Ground Water Relationships, Cost-Benefit Analysis

## **Articles in Refereed Scientific Journals**

## **Book Chapters**

## **Dissertations**

## **Water Resources Research Institute Reports**

Scott, H. Don, T. Lavy, E. Wailes, A. Johnson, D.R. Shaw, S.W. Manley, and F.M. Kaminski, Vulnerability and Use Of Ground and Surface Waters in the Southern Mississippi Valley Region, Arkansas Water Resources Center, Technical Completion Report, 131 p.

## **Conference Proceedings**

Skulman, B.W., J.D. Mattice, R.W. Dewell, and T.L. Lavy, 1998, Monitoring Persistence and Environmental Factors Affecting the Fate of Rice Pesticides in Surface Water in Steele, K.F., ed., Proceedings of the Arkansas Water Resources Center Annual Research Conference-- Quality of Surface and Ground Water and Best Management Practices, Arkansas Water Resources Center Publication No. 270, University of Arkansas, Fayetteville, p. 38

## Other Publications

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### Basic Project Information

Basic Project Information	
Category	Data
Title	Fiscal Year 1998 Arkansas State Water Resources Research Program
Project Number	B-01
Start Date	03/01/1998
End Date	02/28/1999
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Education
Focus Category #3	Water Quality
Lead Institution	University of Arkansas

### Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Kenneth F. Steele	Professor	University of Arkansas	01

### Problem and Research Objectives

The following water problems/issues are currently important in Arkansas:

1. non-point source contamination (nutrients and pesticides)
2. development of methods for determination of total maximum daily loads (TMDLs)
3. declining ground water levels, especially in eastern Arkansas and associated saltwater contamination.
4. development of efficient septic systems
5. wetlands and flooding

All but problem 3 were the focus of 34 Center projects this year and are briefly discussed below. The Center's training and information dissemination programs were also focused on these areas.

Non-point Source Contamination and TMDL Development

Non-point source contamination by nutrients and pesticides, is an area of concern for the nation and Arkansas. This year three of the Center's projects, partially funded under section 104, were related to non-point source pollution. One project was related to animal production activities that produce significant amounts of manure which are applied to pastureland as fertilizer. Runoff from the pastures can result in excess nutrients being delivered to streams and lakes. The focus of this 104 project was determination of optimum sampling protocol for determination of total maximum daily loads, especially those from non-point sources.

Another 104 project related to non-point source pollution was located in the Mississippi River alluvial deposits in Arkansas and Mississippi. This region is a major U.S. producer of crops and thus significant amounts of pesticides are used in this potentially contamination sensitive region. This project was conducted in collaboration with the Mississippi Water Resources Research Institute and scientists are Mississippi State and Alcorn State universities. The project had six components: 1) modeling of herbicide movement in the Memphis soil, 2) use of fuzzy logic with modified DRASTIC parameters to predict ground water contamination, 3) use of vegetative filter strips of varying widths to reduce herbicides in runoff water, 4) identification of factors which influence the fate of pesticides in water used for rice production, 5) ecological and agricultural values of winter flooded rice fields and, 6) analysis of conjunctive use of on-farm reservoirs and irrigation wells.

The third project was a supplemental award related to both non-point and point source pollution. This project in conjunction with the U.S. Geological Survey Little Rock District, the Arkansas Health Department and the University of Arkansas Center for Advanced Spatial Technology is assessing the potential for contamination of the source water (ground water or surface water) for public drinking water systems. This project covers the entire state, which has over 1400 public supply systems. Geographical Information Systems and hydrologic information are being used to assess each system.

There were a total of 27 non-104 projects administered by the Center this year involving non-point source pollution. Two of these projects were focused on development of optimum sampling for determination of TMDLs, which directly complimented the 104 project. Nine projects were concerned with water quality (nutrients and pesticides) and an additional 13 dealt with development and evaluation of best management practices (BMPs). In addition three GIS projects and one constructed wetland were also related to non-point source pollution.

#### Efficient Septic Tank Design

Work has continued on the development of efficient septic tank design for problem areas of Arkansas, e.g., those areas with shallow soils, or high ground water tables. The project is funded by the state through the University of Arkansas (AWRC). The principal investigators work closely with the Arkansas Department of Health in development of projects and technical information transfer.

#### Wetlands and Floods

Wetlands are an important issue nationally and the Center has recognized the importance of these areas. The Center currently is administering one constructed wetland study. This project is investigating the remediation of wastewater at a swine rearing facility. Another project is

developing a method of determining the amount of inundation of stream floodplains and specific stream gage data.

### Declining Water Levels and Salt Water Contamination

Declining water levels, especially in eastern Arkansas, are the result of agricultural, industrial and municipal over pumpage of aquifers. This has led to the legal designation of areas in eastern Arkansas as "critical ground water areas." Both the Alluvial and Sparta aquifers now have such designation. Models for management of these aquifers are available but could be refined. The Center expects to be involved in projects related to these problems in the future.

### **Methodology**

AWRC has a Technical Advisory Committee composed of representatives of all of the state/federal water resources agencies, academia, industry and private groups that select proposals for Regional Competition and that provides general advice for the Center's operation. The Center also assists agencies and other groups in forming research teams to address water resource issues. In addition, the Center helps academic researchers in presenting their ideas for research to the correct agency and agency representative. The Center acts as the liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Accounting, reporting, and water analyses (through the AWRC Water Quality Laboratory), are major areas of support offered to principal investigators.

The Center's training and information dissemination programs are intricately involved with the research projects. Many students are trained through participation in research projects and also at the Water Quality Laboratory. The information dissemination program consists of the publication of journal articles and other reports, presentation at professional meetings, and organization of conferences and short courses related to the research program.

### **Principal Findings and Significance**

Expansion of the Center's research support and capabilities continues to be one of the major goals of the Center. The Cooperative Extension Service and the Housing and Urban Development Agency cooperate with the Arkansas Water Resources Center Water Quality Laboratory in a water quality program for farmers and rural residents. The Laboratory is certified for drinking water by the Louisiana Health Department and for waste water by the Arkansas Department of Pollution Control and Ecology. This facility provides services to researchers and through its cooperators to citizens and state and federal agencies.

The Center's program includes significant effort in information dissemination. In addition to the publication of reports, journal articles, and books, the Center sponsors and co-sponsors conferences for dissemination of information. This past year the Center sponsored a conference on "Water Quality of Surface and Ground Water and Best Management Practices," a short course titled "Watershed Management-Modeling and GIS Aspects." and was co-sponsor of the "International Water Resources Engineering Conference, Memphis TN, August 3-7, 1998."

Although the Center has a strong cooperative research programs with state and federal agencies, these can be expanded and strengthened. Cooperative efforts with environmental and industrial organizations can be strengthened.

The research priorities of the Center were reviewed and re-authorized at the January 7, 1999 Technical Advisory Committee meeting and are as follows:

#### Arkansas Water Research Priorities by Rank

1. Investigate the physical, chemical, and biological characteristics of streams, reservoirs, etc. (storm events, substrate/water interactions, identification of new resources, reference systems, etc.).
2. Quantify and qualify the trophic levels and associated parameters in lentic and lotic ecosystems (e.g., modeling, energy transfer, production).
3. Determine the impact of natural and synthetic chemicals on surface water quality (e.g., point and non-point sources, toxic material, pesticides, industrial and mining wastes).
4. Develop analytical techniques and protocols for assessing water quality (e.g., quality control, quality assurance, microbiological, indicator species).
5. Develop mechanisms for improving quality and quantity of water supplies for surface applications and the impact of the applications (e.g., water treatments, Irrigation, return flow, leaching).

#### Regional Research Priorities:

In addition to the state priorities the Southeastern and Islands Region of the National Institutes of Water Resources has the following priorities:

Water Quality: Needs in the water quality area involve information, information management, and the protection of surface and ground water from degradation. It includes industrial and municipal wastewater treatment and municipal wastewater treatment and subsurface disposal of hazardous/toxic wastes. In addition, problems from non-point sources of both municipal and agricultural sources, including soil erosion, agricultural runoff, and pesticides, pertain to this area. The development and improvement of monitoring techniques and analysis are also important, as well as water quality problems associated with eutrophication and weed control.

Water Management: Research needs in the area of water management include legal, institutional, and financial arrangements. Specific items such as basin planning, water use control, transfers and/or diversions of water, flood control, and drought planning are all priority issues. It also includes construction of facilities, financing and pricing, and water conservation and reuse. Management includes quality protection studies, upgrading of supplies, and state and/or federal and interstate interactions or compacts.

Water Quantity: Research needs in the water quantity area include studies of the basin

water cycle for an understanding of prediction. It also includes items of surface water flow, basin planning, low flow predictions (7Q10), flood control, water use, and water allocation. Included also are studies of ground water availability and the locations, movement, and volume of ground water. Also of importance are use and user impacts and surface and ground water interaction.

Aquatic and Environmental Protection: Research needs in this area include studies of wetlands, swamps and marshes, fish and other biota, and the quality of life. It also includes studies of ecological balance, protection of endangered species, and studies of dredging and filling.

Emerging Problems: Studies not included in other priority areas, but which are dedicated to solving emerging water problems which are identified as critical issues by key state water management officials in the region, are included in this category.

During the next year, these research priorities will be reviewed with the Technical Advisory Committee. Although no major changes in the priorities are anticipated, more focus will probably be placed on current specific problems, e.g., non-point source contamination, wetlands, and ground water quantity. This focus should allow the Center and the state/federal agencies to continue to cooperate effectively in solving water resource problems in Arkansas.

The Arkansas Water Resources Center, in conjunction with state and federal agencies, is addressing many of the issues described under Water Problems and Issues of Arkansas.

## **Descriptors**

Ecosystems, Groundwater Quality, Streams, Water Quality, Water Quality Monitoring

## **Articles in Refereed Scientific Journals**

## **Book Chapters**

## **Dissertations**

## **Water Resources Research Institute Reports**

## **Conference Proceedings**

Steele, K.F., Proceedings of the Arkansas Water Resources Center Annual Research Conference, "Water Quality of Surface and Ground Water and Best Management Practices" University of Arkansas, Fayetteville, April 8-9, 1998.

Steele, K.F., D.S. Hicks and Jose M. Lopez, Comparison of the Nutrient Loads to Laguna Joyuda, Puerto Rico, Proceedings Tropical Hydrology and Caribbean Water Resources—Third International Symposium on Tropical Hydrology and Fifth Caribbean Islands Water Resources Congress, American Water Resources Association, Herndon, VA, p. 27-32.

## Other Publications

Steele, Kenneth F., Illinois River Summary (Field Trip Guide for National Poultry Waste Management Symposium, October 19-21, 1998, Springdale), Arkansas Water Resources Center, University of Arkansas, Fayetteville, AR, 4 p.

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## Basic Project Information

Basic Project Information	
Category	Data
<b>Title</b>	Continuation of Investigation of Optimum Sample Number and Timing for Determining Pollution Loads
<b>Project Number</b>	C-02
<b>Start Date</b>	09/01/1998
<b>End Date</b>	08/31/1999
<b>Research Category</b>	Water Quality
<b>Focus Category #1</b>	Hydrology
<b>Focus Category #2</b>	Non Point Pollution
<b>Focus Category #3</b>	Nutrients
<b>Lead Institution</b>	University of Arkansas

## Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Thomas S. Soerens	Unknown	University of Arkansas	01
Marc A. Nelson	Unknown	University of Arkansas	02
Jean Spooner	Unknown	North Carolina State University	03

## Problem and Research Objectives

This project is a continuation of the same project from the previous year.

Accurate measurements of pollution loads in streams are critical for determining the impacts of non-point source (NPS) pollution and for developing TMDLs. A common sampling method for determining pollution loads is to continuously monitor flow and intermittently collect water samples. The purpose of this study was to determine the optimum number and timing of storm and baseflow water quality sampling to determine pollutant loads in streams with high precision and accuracy.

The objectives of this study were to: (1) accurately determine pollutant loads at two sites by sampling storm runoff events at thirty-minute intervals; (2) develop sub-sampling and other data analysis techniques to determine the effect of sample interval on load calculation accuracy; and, (3) find the minimum sample interval required to determine storm loads at a required accuracy.

## **Methodology**

Two stream sites in the Illinois River basin were sampled: 1) Moores Creek, a small 1st order stream with a drainage area of about 1000 hectares in the headwaters of the Illinois River. Moores Creek is impacted primarily by non-point source pollution from agriculture, forest, and low-density housing. 2) Illinois River near Siloam Springs, Arkansas, a larger 3rd to 5th order stream with a drainage area of about 150,000 hectares. The Illinois River is impacted by urban point source and rural non-point source pollution.

Gauges at the sites continuously measured and recorded stage and calculated discharge. Automatic samplers installed at the sites were triggered by the state gauges to take storm samples at 30 minute intervals during the rising limb and 60 minute intervals during the falling limb of the storm hydrographs. All samples were collected from the sites within 24 hours and analyzed at the Arkansas Water Quality Lab using EPA approved analysis and QA/QC procedures. The samples were analyzed for NO<sub>3</sub>-N, NH<sub>4</sub>-N, TKN, Ortho-P, Total-P, and TSS. This study (i.e., the continuation) was designed to sample four storms at both the Illinois River and the Moores Creek sites (the same storms). Storm loads were calculated by multiplying discharged volume by concentration for each sampling interval and summing over the storm. The loads calculated using the 30 minute interval data were termed the "best estimate" load. Loads were also calculated for 60, 120, and 240 minute sampling intervals using subsets of the data. The load estimates for the longer sampling intervals were expressed as a percentage of the best estimate load.

## **Principal Findings and Significance**

Sampling has begun and is ongoing. Storm load results show that as a sampling interval increased, the error of the load estimate increased. Optimum sampling intervals for the sites were calculated. For example, if we desire that the calculated load is within 5% of the best estimate load with a 95% confidence level, the optimum sampling interval for TSS at the Moores Creek site is 50 minutes. This optimum sampling interval varies with the parameter measured and with the stream order. The pollutants that show the most peaking effect during a storm require the smallest sampling interval. Also, Moores Creek, which is flashier than the main branch of the Illinois River, requires a shorter sampling interval for accurate storm load calculations. The results lead to the following conclusions: 1) The sample interval affects load calculation precision and accuracy. 2) An optimum sample interval can be calculated using sub-sampling techniques. 3) The optimum sample interval varies by parameter measured and by drainage basin size.

The information gathered and the methods developed in this research will be useful in all parts of the country for optimizing sampling strategies used in the determination of TMDLs. The information gained will allow water quality investigators to design sampling schemes for their particular sites and conditions that use only enough samples to adequately characterize pollutant loads and concentrations, saving time and money. It will also increase the precision and accuracy of the load calculations, making assessments of improvements from Best Management Practices more reliable and assisting in setting more accurate TMDL limits. The project will continue until 8/31/99.

## Descriptors

Streams, Suspended Sediments, Nutrient Transport, Water Quality Monitoring

## Articles in Refereed Scientific Journals

## Book Chapters

## Dissertations

## Water Resources Research Institute Reports

## Conference Proceedings

Nelson, M.A., Optimizing Storm Event Sampling for Determining Pollution Loads, International Water Resources Engineering Conference, August 3-7, 1998, Memphis, TN

Soerens, T.S., Investigation of Optimum Sample Number and Timing for Determining Pollution Loads and TMDLs, U.S. Environmental Protection Agency Meeting on Water Quality Standards, Water Quality Criteria, and Implementation, including Water Quality-Based Permitting, Philadelphia, PA, August 24-27, 1998.

Soerens, T.S., Parker, D.G., and Nelson, M.A., "Phosphorus Transport in the Illinois River: Preliminary Results of Intensive Sampling," in Steele, K.F., ed., Proceedings of the Arkansas Water Resources Center Annual Research Conference, Arkansas Water Resources Center Publication No. 270, University of Arkansas, Fayetteville, p. 39-44.

## Other Publications

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## Basic Project Information

Basic Project Information	
Category	Data
Title	Assessment of Public Drinking Water Supplies in Arkansas
Project Number	C-03
Start Date	09/01/1998
End Date	08/31/1999
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Water Supply
Focus Category #3	None
Lead Institution	University of Arkansas

## Principal Investigators

<b>Principal Investigators</b>			
<b>Name</b>	<b>Title During Project Period</b>	<b>Affiliated Organization</b>	<b>Order</b>
W. F. LIMP	Unknown	University of Arkansas	01
R. K. Davis	Unknown	University of Arkansas	02

## **Problem and Research Objectives**

The purpose for the proposed work was to obtain information on the location of all public water intakes in the state of Arkansas and the location and characteristics of Potential Sources of Contamination (PSOC) that are within their immediate vicinity (either one-quarter or one-half mile – for wells). The purpose of this work was to develop base data to be used by the U.S. Geological Survey to assess the potential for contamination for the state's public water intakes. PSOC data needed for assessment of public surface water sources (impoundment's, rivers, etc.) will be provided to the USGS. The individual assessment's performed by USGS will be provided to the Arkansas Department of Health as part of the EPA required program on source water assessment (EPA 816-R-97-009 "State source water assessment and protection program guidance").

## **Methodology**

Due to the large number of public water intakes and potential PSOCs it would be enormously expensive and almost impossible to field map all these data using traditional methods; therefore, the use of Geographic Information Systems (GIS) technologies enables such a large project to be completed in a timely manner. The goal of this data collection task is to develop a GIS data set that can serve as a useful basis for assessing the potential for contamination for every public water system within Arkansas. As of 2/28/99 we have assembled all of the relevant PSOC data identified by the Arkansas Department of Health as seamless, statewide GIS coverages. There have been approximately 1400 field maps produced at CAST that have been mailed to each individual water system for data verification. These maps have since been returned to CAST for data correction.

Other project members see the current work as the first aspect of a long-term program that will involve more intensive field investigations.

Completed Tasks as of 2/28/99:

TASK 1 - Convert key base map GIS data into common digital format/projection

TASK 2 - Convert key PSOC data to digital format

TASK 3 - Geo-code PSOC databases

TASK 4 - Seamless Data Base Assembly

TASK 5 - Macro Development

TASK 6 - Draft Map production

## **Principal Findings and Significance**

We have collected approximately 850,000 individual point locations of potential sources of contamination within Arkansas. These data have been compiled and are contained within a common GIS format that is accessible by the USGS, Arkansas Department of Health, and Arkansas Water Resources Center. These data have been mapped at the best available scale and field verified by approximately 85% of the public water systems within Arkansas. After these field maps are "error corrected" by CAST, these datasets will represent the best available, baseline information for the statewide assessment of Arkansas' Public Water Systems.

Compiled GIS Data Layers:

1. Geology (1:500k) vector
2. Soils (STATSGO 1:250k) vector
3. Poultry/swine houses
4. Land cover reclass of GAP (30m raster)
5. Canals and ditches (1:100k TIGER/DLG)
6. Irrigation wells (ASWCC)
7. NPDES and TRI (EPA)
8. Highways by classification, railroads, airports, bridges (AHTD)
9. Pipelines (TIGER 1:100k)
10. RCRA
11. ERNS
12. Cemeteries (AHTD/GNIS)
13. Schools (AHTD/GNIS)
14. Septic systems (AHTD)
15. Mines (GNIS)
16. Elevation (30m where available; else 80m)
17. Streams/rivers (DLG 1:100k)
18. Dairies (Ark. Dept. of Health)

Potential Sources of Contamination:

As identified by the USGS and Arkansas Department of Health

1. Above ground storage tanks
2. Under ground storage tanks
3. Leaking storage tanks
4. Agri Industry
5. Pesticides applied per acre
6. Airports
7. Repair shops
8. Cemeteries
9. Chemical storage
10. Dry cleaners
11. Electric substations
12. Golf courses
13. Gravel pits (PC&E Streaming Mining)
14. Highways
15. Manufacturing facilities (non-specific)

16. Pipelines
17. Oil and gas wells
18. Salvage yards
19. Sewage treatment plants (NPDES facilities)
20. Septic tanks
21. Landfills
22. Water wells
23. Confined animal operations
24. Aqua-culture
25. Land application of Solid Waste (PC&E)
26. Waste water lagoon (Discharge data)
27. In-stream gravel removal (PC&E Permits)
28. RCRA
29. CERCLA (Superfund)
30. Marinas
31. Mining

### **Descriptors**

Water pollution potential, geographical information systems, drinking water

### **Articles in Refereed Scientific Journals**

### **Book Chapters**

### **Dissertations**

### **Water Resources Research Institute Reports**

### **Conference Proceedings**

### **Other Publications**

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## **Information Transfer Program**

The professional presentations and publications by the principal investigators of Section 104 grants are listed under the individual research projects in the Research Program section of this report. The Center sponsored a conference attended by over 100 persons titled "Water Quality of Surface and Ground Water and Best Management Practices," along with a short course titled "Watershed Management - Modeling and GIS Aspects," by Kent Thornton of FTN Associates, Little Rock, and Fred Limp of the Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville. In addition to these efforts, the Director and many of the investigators have communicated information to various groups and individuals in less formal discussions. These activities include discussions of research topics with state and federal agencies and private groups, and interviews with media reporters, including appearances on television news and information programs. Most of these activities have served the dual purpose of informing professional groups and the public of:

1. water resources problems and solutions, and;

2. the Center's activities in water resources.

During the grant period, the principal investigators and Director produced the following from USGS funded projects:

1. Presentations: 6
2. Professional Publications: 2

In addition, the Center staff publishes the Arkansas Water Resources Center Newsletter annually.

Several technology transfers were conducted during the last year involving 104 funded projects as shown below:

Project B-01 - Kenneth F. Steele, Director, Arkansas, Water Resources Center, conducted the "Quality of Surface and Ground Water and Best Management Practices," in Fayetteville, Arkansas, April 9, 1999

Project B-01 - AWRC hosted a short course titled "Watershed Management - Modeling and GIS Aspects," by Kent Thornton of FTN Associates, Little Rock, and Fred Limp of the Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville, April 8, 1998.

Project B-01 - Co-sponsor with American Society of Civil Engineers of the "International Water Resources Engineering Conference," Memphis TN, August 3-7, 1998.

Project C-01 - Presentation of "Investigation of Optimum Sample Number and Timing for Determining Pollution Loads and TMDLs" by Nelson, Soerens, Spooner, Steele and Vendrell at EPA meeting, "Strengthening the Foundation of the Nation's Water Quality Program," in Philadelphia, August 24-28, 1998.

## USGS Internship Program

### Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	0	4	0	5	9
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
<b>Total</b>	0	4	0	5	9

### Awards & Achievements

Project C-01 Models were developed for pesticide movement and conjunctive use of reservoirs and ground water and associated evaluation of BMPs will be important to water resources in the lower Mississippi Delta.

Project C-02 Presentations on the development of optimum sampling to determine loads and TMDLs has received attention and interest from state agencies and EPA.

Project C-03 The development of GIS data layers and other information that are critical for assessment of Arkansas' 1400 plus public system source water supplies has been instrumental in the state's program.

## **Publications from Prior Projects**

**Articles in Refereed Scientific Journals**

**Book Chapters**

**Dissertations**

**Water Resources Research Institute Reports**

**Conference Proceedings**

**Other Publications**