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STATE OF ARKANSAS
ARKANSAS NATURAL RESOURCES COMMISSION

The Honorable Mike Beebe, Governor
Members of the Arkansas Legislature
Citizens of Arkansas

The Arkansas Natural Resources Commission respectfully submits for your consideration this 2014 update of the Arkansas Water Plan. The Arkansas Water Plan is a long-term strategy to guide the use, management, development, and conservation of water for all citizens.

This update was developed with unparalleled citizen involvement and interagency coordination and was informed by expert technical analysis. The issues identified in the Arkansas Water Plan 2014 Update validate those issues that were identified in the 1990 Arkansas Water Plan. This update provides recommended actions for resolving the identified issues. For this update, the recommendations were proposed by voluntary citizen participants. The public support for water planning demonstrated by the Arkansas citizenry bodes well for the future support of the actions contained in this plan.

Demands for water are projected to 2050, as is the supply available from groundwater and surface water sources. Overall, Arkansas has sufficient water supply to meet the projected demands, although the water is not necessarily in the location or season that it is needed. The planning process has benefitted from innovative suggestions to provide water where and when it is needed. The recovery of water levels in the Sparta aquifer in Union County shows that the combination of conservation, water development projects, and infrastructure can effectively meet water demands and protect the water resources of Arkansas. The success of Union County points out the importance of completing the Grand Prairie, Bayou Meto and similar water development projects.

The importance of data and technical tools for understanding water demand and supply became clear in the AWP 2014 Update planning process. Additional data is critical to understanding the complexity and interaction of Arkansas water resources. Applying that knowledge to manage water is crucial to using our State's water resources effectively.

Public involvement has been a cornerstone of developing the Arkansas Water Plan and will continue during implementation. The Arkansas Natural Resources Commission appreciates your consideration and interest in ensuring that Arkansas's water needs are met for all users and keeping us the Natural State.

Corbet Lamkin
Chairman
Arkansas Natural Resource Commission

J. Randy Young, P.E.
Executive Director
Arkansas Natural Resource Commission

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Acronyms

°F	degrees Fahrenheit
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
AF	acre-feet
AFY	acre-feet per year
AGFC	Arkansas Game and Fish Commission
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resource Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ASWCC	Arkansas Soil and Water Conservation Commission
AWP	Arkansas Water Plan
BMP	Best Management Practices
BOD	biochemical oxygen demand
CAPS	County Agricultural Production Survey
COA	Census of Agriculture
CWA	Clean Water Act
DO	dissolved oxygen
DWINSA	Drinking Water Infrastructure Needs Survey and Assessment
EIA	Energy Information Agency
EPA	U.S. Environmental Protection Agency
GPADP	Grand Prairie Area Demonstration Project
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
I&R	Issues and Recommendations
LCA	local cooperation agreement
MERAS	Mississippi Embayment Regional Aquifer Study
mg/L	milligrams per liter
mgd	million gallons per day
MKARNS	McClellan-Kerr Arkansas River Navigation System
MS4	Municipal Separate Storm Sewer System
MWh	megawatt hour
NASS	National Agricultural Statistics Services
NOAA	National Oceanic and Atmospheric Administration
NCDC	National Climatic Data Center
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
NWIS	National Water Information System
Region	Water Resource Planning Region
TDS	total dissolved solids
TSS	total suspended solids
UCWCB	Union County Water Conservation Board
UPP	Union Power Partners
USACE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	U.S. Forest Service
USGS	United States Geological Survey
WIA	Workforce Investment Area
WRID	White River Irrigation District
WUDBS	ANRC Water Use Databases

Foreword

Water is vital to the prosperity and health of Arkansas's people and their natural surroundings. As such, water must be managed in a sustainable manner to support local and state economies, protect public health and natural resources, and enhance the quality of life for all citizens by applying appropriate policies and best practices with limited regulation and preservation of private property rights.

Extensive public participation, interagency cooperation, and detailed technical evaluations were the hallmarks of this Arkansas Water Plan (AWP) 2014 Update. The plan recognizes that while we continue to struggle with known water issues, the recommendations in this plan, when implemented, can meet the water demands of the citizens of the State of Arkansas through 2050. We have identified six critical initiatives that are essential to securing Arkansas's water future—

* **Groundwater Declines:** Critical groundwater areas in eastern Arkansas continue to experience declining groundwater levels and a groundwater gap as large as 7 million acre-feet per year is projected for 2050. Adopting on-farm application efficiency and other conservation measures can reduce the magnitude of this projected groundwater gap; it will be necessary to develop infrastructure-based solutions to convert irrigated acres currently supplied by groundwater to surface water.

* **Insufficient Infrastructure:** Arkansas needs to construct and maintain water and sewer systems that furnish safe, clean, and reliable water supplies for its citizens and communities. The state's future viability and growth, especially with respect to the state's smaller rural communities, is threatened by the failure to provide these basic services. Resolution of this problem will require the combined commitment and actions of citizens and elected officials who must identify creative financing solutions and take advantage of regional infrastructure solutions and shared sources of supply.

* **Maintenance of Critical Water Infrastructure:** The safety of Arkansas's citizens and protection of property depends on maintaining and replacing, as necessary, flood and drainage infrastructure. Navigation structures and dams are also critical water infrastructure that is necessary for economic health. We will encourage the federal government to complete projects that have been started and provide adequate operations and maintenance funding for this critical infrastructure.

* **Proactive Management:** We have initiated proactive, systematic, and measured evaluation of existing water laws and procedures involving relevant agencies and appropriate stakeholders. The steps taken in this direction will help to maintain the stable and orderly use of water that is so critical to Arkansas's economic welfare and quality of life.

* **Regional Planning:** Integral to the AWP 2014 Update was recognition of regional issues and priorities identified by citizens, water users, and stakeholders. Statewide water planning will continue to provide the direction for water management. Engaging local citizens who are more in touch with their unique needs, challenges, and potential solutions is critical to regional water planning.

* **Reliable Data:** The combined efforts of elected officials and the agencies and entities associated with managing and protecting the state's water must be informed by quality information to justify extremely consequential and potentially costly decisions. Sound planning and decision-making regarding Arkansas's water resources requires data, information, and analysis of water uses and water availability. Acquiring this data means expanding the network of stream gages, monitoring wells, water quality monitoring sites, and improved information on water use as well as the tools necessary to quantify, manage, and allocate surface and groundwater resources confidently.

The AWP 2014 Update is the strategy for making meaningful progress on each of these initiatives.

J. Randy Young, P.E.
Arkansas Natural Resources Commission
Executive Director

1 Introduction

Arkansas is a state of distinct regions, from the low lying areas along the eastern and southern edges of the state to the mountains above the fall line that adorn the western edge. The occupations of the people of Arkansas are similarly varied—crop production, livestock production, aquaculture, silviculture, mining, industry, tourism, and recreation. What binds the people and regions of Arkansas together is the need for water—for living and working. As the Natural State, the importance of clean water to support healthy ecosystems cannot be overstated. Quite simply, water is crucially important for Arkansas. Water is the common denominator that underlies the quality of life and economic well-being of Arkansas.

Arkansas is a water-rich state. Surface water is abundant, with over 92 million acre-feet (AF) of water flowing through nine major river basins every year (**Figure 1-1**). This amount of surface water alone would provide over 30 acre-feet per year (AFY) of water for every person in Arkansas. However, surface water supplies are subject to seasonal fluctuations so that supplies are frequently at their lowest when demand is the highest. In some areas of the state, groundwater supplies have been easy to access through shallow wells and have been a plentiful source of water. As a result of over a century of agricultural reliance on groundwater for crop irrigation, the water levels in these aquifers have been declining and our projections suggest that by 2050, there will be demand for about 7 million AFY of groundwater that cannot be met with groundwater supplies in eastern Arkansas.

Despite the relative abundance of water, many citizens lack access to dependable water and wastewater services due to distance to supplies, insufficient infrastructure or storage, water quality constraints, and other limiting factors. A fundamental conclusion of this Arkansas Water Plan 2014 Update (AWP 2014 Update) is that investments in infrastructure, drinking water, wastewater service, and irrigation will be required to support growth and economic development for the next 40 years.

1.1 History of Water Planning in Arkansas

The Arkansas Natural Resource Commission (ANRC) (formerly the Arkansas Soil and Water Conservation Commission) received statutory authority to begin work on the first Arkansas State Water Plan in 1969. Specific authority was given to the ANRC by Ark. Code Ann. Sec. 15-22-503 (Sec. 2 of Act 217 of 1969), as amended, to be the designated agency responsible for water resources planning at the state level. This section mandated that the ANRC develop and engage in a comprehensive program called the AWP. An integral part of this program is the creation of a comprehensive master plan of sufficient detail to serve as the primary water policy document for the protection, development, and management of water resources in the state. The ANRC was required to publish the AWP under Ark. Code Ann. Sec. 15-22-504 (Sec. 2 of Act 555 of 1975). This section of the statute also requires the ANRC to update the AWP "when needed."

The first AWP was published in 1975. It included five appendices that addressed specific problems and needs in the state. As more data became available, the ever-changing nature of water resource problems and potential solutions made it apparent that the planning process must be dynamic and that periodic revision of the plan was necessary for the ANRC to meet its planning responsibilities.

In 1985, the Arkansas General Assembly enacted Ark. Code Ann. Sec. 15-22-301 (Sec. 2 of Act 1051 of 1985), which broadened the ANRC's planning responsibilities to include: (1) an inventory of the state's water resources, including areas in which water use has or will become critical in the next 30 years; (2) the determination of the current needs and the projection of future needs of all water uses in the state; and (3) the determination of whether excess surface water exists that might be put to beneficial use.

In 1990, the ANRC published a major revision and update of the AWP, which included the new responsibilities for the AWP. Eight basin reports covering the entire state were prepared that inventoried the water resources of the basins, identified current and future water problems within the basins, and recommended the actions to mitigate the problems.

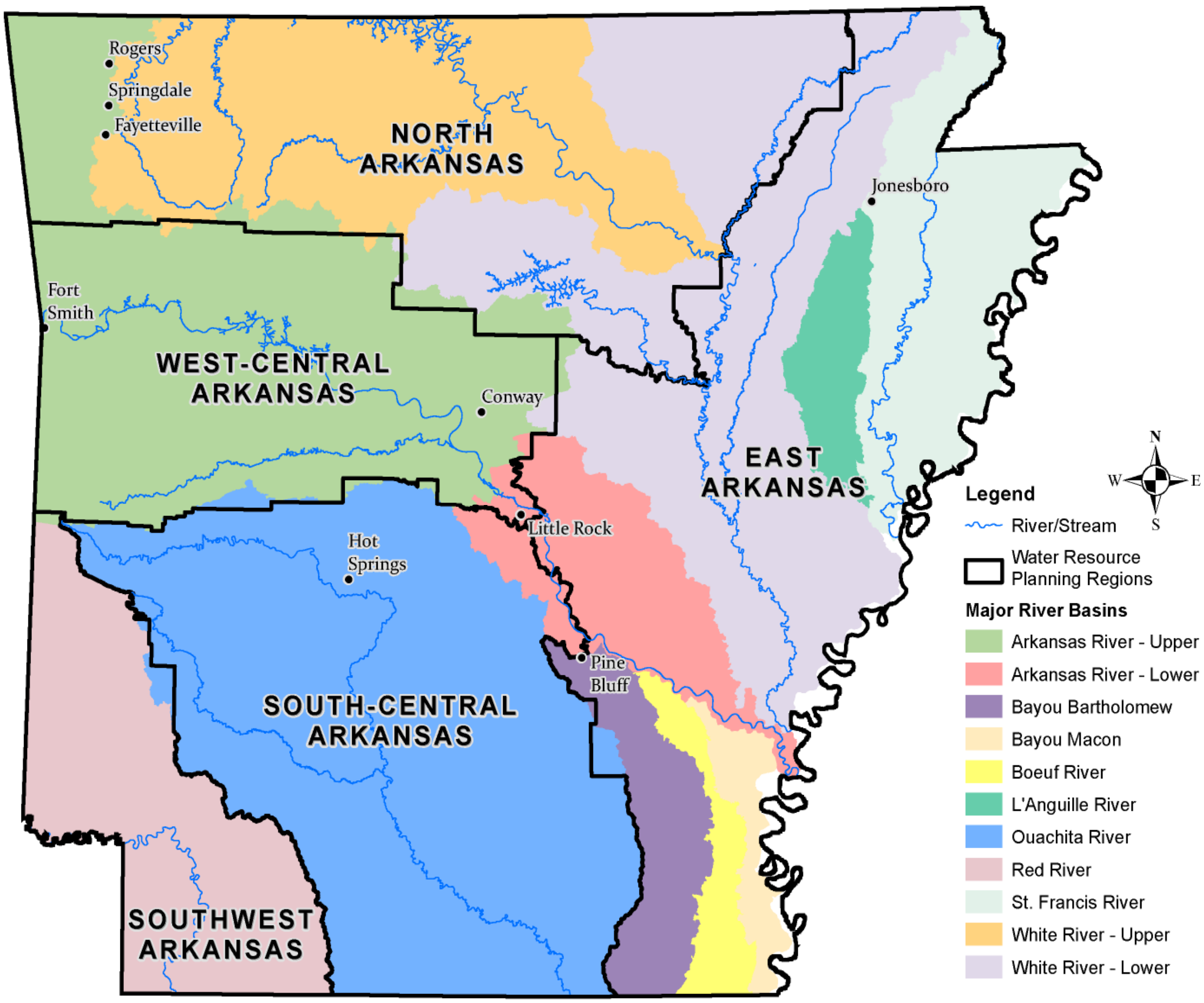


Figure 1-1. Overlay of Water Resources Planning Regions on Major Surface Water Basins

The AWP 2014 Update consists of this report and 12 appendices. It is the culmination of 2 years of data analysis and synthesis to understand the complexity of sources, available supply, and demand for water in Arkansas. The AWP 2014 Update is based on planning level projections of water demand and availability developed using consistent methodology on a statewide basis. The demand and availability analytical methodology was reviewed and concurred upon by stakeholder workgroups. The workgroups were created by inviting recognized experts throughout the state to assist in developing the AWP 2014 Update.

While the best available information and consistent methodology was used in developing the AWP 2014 Update, projections into the future require many assumptions and result in inherent uncertainty. While this is necessary and appropriate for statewide planning-level analyses, additional, more detailed feasibility- and design-level studies are required for regional and local scale projects. In particular, within the East Arkansas Water Resource Planning Region (region), a more detailed analysis of water availability and crop irrigation demands within the major basins is particularly important. This is especially true in northeast Arkansas (for example in the St. Francis River Basin) where regional stakeholders have identified issues with projected crop acreage and historical water use reporting that may be artificially increasing projected crop irrigation water requirements. Also, concerns regarding a lower than expected projected availability of groundwater in the region have been documented. Recognizing areas where there is a lack of reliable and verifiable data is an important goal of the AWP 2014 Update. However, data issues aside, there is no disputing that portions of the East Arkansas Region will have a significant groundwater gap if alternative strategies for supply and demand management are not implemented.

The state was divided into five water resource planning regions comprised of areas with distinct geographic, topographic, ecologic, and sociologic characteristics (Figure 1-1).

Water-related issues were identified and prioritized by stakeholders in the planning regions of the state. This AWP 2014 Update is founded on the best available data, the knowledge and experience of a wide range of agency experts, and the critique of stakeholders and the public throughout the process.

1.2 AWP Vision, Mission, and Goals

An initial step in the AWP 2014 Update process was to develop a vision, mission, and goals to guide the development of the AWP 2014 Update. The vision, mission, and goals were drafted by the Technical Advisory Committee, which consisted of the nine ANRC Commissioners, senior management, and staff of key state and federal agencies. Public input on the draft vision, mission, and goals was requested at public meetings held in November 2012 and June 2013. The final vision, mission, and goals for the AWP 2014 Update are described below.

Vision for Managing Water Resources in Arkansas

Water is vital to the prosperity and health of Arkansas's people and their natural surroundings. As such, water must be managed in a sustainable manner to support local and state economies, protect public health and natural resources, and enhance the quality of life of all citizens by applying appropriate policies and best management practices (BMPs) with limited regulation and preservation of private property rights.

Mission of the Arkansas Water Plan

The AWP is the state's comprehensive planning process for the conservation, development, and protection of the state's water resources, with a goal of long-term sustainable use for the health, well-being, environmental, and economic benefit of the state.

Arkansas Water Plan Goals

The AWP 2014 Update goals, as articulated by the Technical Advisory Committee, are:

- First and foremost, meet the drinking water needs of the state.
- Optimize the use of surface and groundwater for the differing economies of the unique regions of the state.
- Reliably meet agricultural water needs.
- Reliably meet industrial water needs.
- Manage water resources in a manner that protects the ecological needs of fish and wildlife.
- Reliably meet the water quantity and quality needs to help support navigation, recreation, and tourism.
- Use the best available science, data, tools, and technologies to support water resource decisions.
- Employ the latest supply management and water efficiency technologies among the different sectors of use including residential, commercial, industry, natural resources, and agriculture.
- Identify and address emerging water resource management needs as identified through the water planning process.
- Use best available science and data to update and implement the AWP, and identify and address data gaps and needs.
- Optimize existing water, wastewater, and flood control infrastructure, including identifying opportunities to cooperatively address regional water and wastewater needs.
- Maximize the current infrastructure reliability including dams, levees, and treatment and conveyance facilities.
- Plan for changing demographics and related infrastructure maintenance and operation implications.
- Improve and update existing infrastructure and address aging infrastructure.
- Sustainably use surface and groundwater sources for the multiple intrastate uses while complying with interstate compacts.
- Refine criteria for declaring drought, water shortages and excess water, and advance policies and procedures for allocating water during times of shortage or drought.

- Identify and recommend procedures and criteria to improve upon existing instream flow methodologies taking into consideration water quality, fish and wildlife needs, aquifer recharge, and navigation needs at the statewide and basin-specific level.
- Include recreation and tourism as nonconsumptive water uses.
- Identify opportunities to manage water, wastewater, and stormwater to improve the quantity and quality of water, while providing for wise land management, wetland, and riparian protection for fish and wildlife sustainability.
- Identify implementable water resources alternatives that are socially, fiscally, technically, and environmentally feasible to protect, enhance, and wisely use surface and groundwater.
- Identify and implement alternatives that are fair and equitable.
- Allow for adaptability with changing technology, water uses, and socioeconomic conditions.
- Provide education and open communication about the AWP and its implementation.
- Work cooperatively with other regions and states, and among agencies and entities responsible for stewardship of the state's natural resources.

Table 1-1 shows how the AWP goals as they were articulated at the beginning of the update process are addressed by the issues and recommendations in this AWP 2014 Update (Section 3). Table 1-1 should be considered as a report card for the AWP—it shows which goals were largely addressed, partially addressed, or not addressed at all. This table is considered as a starting point in formulating the next update of the Arkansas Water Plan.

Table 1-1. AWP 2014 Update Goals Addressed by Issues and Recommendations

Arkansas Water Plan Goals Explanation of Symbols ■ Indicates the goal was addressed ◆ Indicates the goal has been partially addressed	Arkansas Water Plan Issues and Recommendations									
	Conjunctive Water Management and Groundwater Decline	Incentives for Integrated Irrigation Water Conservation	Funding Water Resources Development Projects	Public Water and Wastewater Infrastructure	Excess Water for Nonriparian Withdrawal and Use	Drought Contingency Response	Reallocation of Water Storage in Federal Reservoirs	Improving Water Quality through Nonpoint Source Management	Public Awareness and Education	Water Use Reporting
Demands										
First and foremost, meet the drinking water needs of the state.	■				■	■	■			
Reliably meet agricultural water needs.	■				■					
Reliably meet industrial water needs.				■	■					
Reliably meet the water quantity and quality needs to help support navigation, recreation, and tourism.						◆	◆	◆		
Science and Technology										
Use the best available science, data, tools, and technologies to support water resource decisions.	■					■				■
Employ the latest supply management and water efficiency technologies among the different sectors of use including residential, commercial, industry, natural resources, and agriculture.		■						◆		◆
Use best available science and data to update and implement the AWP, and identify and address data gaps and needs.	■				■	■		■		■
Infrastructure										
Optimize existing water, wastewater, and flood control infrastructure, including identifying opportunities to cooperatively address regional water and wastewater needs.			■	■			■			

Table 1-1. AWP 2014 Update Goals Addressed by Issues and Recommendations

Arkansas Water Plan Goals	Arkansas Water Plan Issues and Recommendations									
Explanation of Symbols ■ Indicates the goal was addressed ◆ Indicates the goal has been partially addressed	Conjunctive Water Management and Groundwater Decline	Incentives for Integrated Irrigation Water Conservation	Funding Water Resources Development Projects	Public Water and Wastewater Infrastructure	Excess Water for Nonriparian Withdrawal and Use	Drought Contingency Response	Reallocation of Water Storage in Federal Reservoirs	Improving Water Quality through Nonpoint Source Management	Public Awareness and Education	Water Use Reporting
Maximize the current infrastructure reliability including dams, levees, and treatment and conveyance facilities.			◆	◆						
Plan for changing demographics and related infrastructure maintenance and operation implications.				■						
Improve and update existing infrastructure and address aging infrastructure.				■						
Ecological Protection										
Manage water resources in a manner that protects the ecological needs of fish and wildlife.	◆			■	◆	◆		◆	◆	
Identify and recommend procedures and criteria to improve upon existing instream flow methodologies taking into consideration water quality, fish and wildlife needs, aquifer recharge, and navigation needs at the statewide and basin-specific level.				■	■	◆			◆	
Identify opportunities to manage water, wastewater, and stormwater to improve the quantity and quality of water, while providing for wise land management, wetland, and riparian protection for fish and wildlife sustainability.				◆	◆	◆		◆	◆	
Water Management										
Identify and address emerging water resource management needs as identified through the water planning process.	■	■	■	■	■	■	■	■	■	■
Optimize the use of surface and groundwater for the differing economies of the unique regions of the state.	■									
Sustainably use surface and groundwater sources for the multiple intrastate uses while complying with interstate compacts.	■									
Identify implementable water resources alternatives that are socially, fiscally, technically, and environmentally feasible to protect, enhance, and wisely use surface and groundwater.	■			◆	◆	◆		◆	◆	
Identify and implement alternatives that are fair and equitable.		■								
Allow for adaptability with changing technology, water uses, and socio-economic conditions.	■	■	■	■	■	■	■	■	■	■
Work cooperatively with other regions and states, and among agencies and entities responsible for stewardship of the state's natural resources.	◆	◆	◆	◆	◆	◆	■	◆	◆	◆
Water Administration										
Refine criteria for declaring drought, water shortages and excess water, and advance policies and procedures for allocating water during times of shortage or drought.						■				
Include recreation and tourism as nonconsumptive water uses.						■				
Education										
Provide education and open communication about the AWP and its implementation.	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

2 Key Findings

The technical analyses completed for the AWP 2014 Update are described in detail in reports that are included as appendices to the AWP 2014 Update. These reports are: Water Availability (Appendix C), Demand Forecast (Appendix E), Gap Analysis Report (Appendix F), and Alternatives for Sustainability of Crop Irrigation in the East Arkansas Water Resources Planning Region (Appendix G). A summary of the key findings from each of these reports are summarized here because they influence the issues, recommendations, and implementation steps described in the next section.

2.1 Demand Projections

- Statewide water demand is expected to increase 14 percent from the current 12 million AFY (11 billion gallons per day [gpd]) up to about 14 million AFY (12.5 billion gpd) by 2050.
- Overall, about 71 percent of statewide water demand is supplied from groundwater sources and that is assumed for planning forecasts to remain the same through the 40-year planning horizon. Reduction of groundwater use depends on successful implementation of conservation, surface water use, and delivery of excess surface water. Water demand for crop irrigation is about 80 percent of the total statewide water demand, primarily in the East Arkansas Region.
- One factor in estimating the projected demand for crop irrigation is the water application rate for each crop. While the best available data was used for the AWP 2014 Update analysis, stakeholder input suggests that the reported application rate, particularly for rice, is too high. The Alternatives for Sustainability of Crop Irrigation in the East Arkansas Water Resources Planning Region (Appendix G) suggests that increasing the accuracy of water use reporting could decrease the crop irrigation water demand figures by about 1.3 million AFY.
- Livestock water demands are projected to increase approximately 9 percent to about 33,600 AFY in 2050. Future water demands for aquaculture are held constant at baseline period levels of 115,300 AFY for planning purposes.
- Industrial water demand (both municipally-supplied and self-supplied) are projected to decrease by 31 percent from 325,945 AFY in 2010 to 226,300 AFY in 2050. The decrease is attributed to a projected downward trend in water intensive manufacturing. Mining water demand for silica sand, construction sand and gravel, and crushed stone are forecasted to increase by 132 percent from 6,825 AFY in 2010 to 15,658 AFY in 2050.
- Water demand for shale gas exploration and production is met with surface water. The demand for water for shale gas extraction in nine counties is projected to decrease by 26 percent from 11,680 AFY in 2010 to 8,395 AFY in 2026, depending on the price of gas and innovations in production technologies.
- Statewide municipal and self-supplied drinking water supply demand is projected to increase by about 25 percent from 462,500 AFY in 2010 to 578,000 AFY in 2050, assuming "passive conservation" (federaly required installation of low-flow plumbing fixtures).
- Total surface water withdrawals for thermoelectric power production is projected to increase 15 percent from 1.3 million AFY in 2010 to 1.5 million AFY in 2050. However, the majority of water withdrawn for thermoelectric power production is returned, so the consumptive use is 0.09 million AFY in 2010 and is projected to increase to 0.1 million AFY in 2050.

2.2 Water Availability

- On an average annual basis, there is estimated to be 8.7 million AFY of excess surface water available for interbasin transfer or use by nonriparians. It is important to note that, although there is an abundance of water available on an average annual basis, demands for that water do not necessarily occur during the times of year when that water is available in a stream.
- The amount of surface water flow to support fish and wildlife is about 57 million AFY or 62 percent of the total Arkansas annual stream flow of 92 million AFY. Improved methodologies for estimating fish and wildlife flows, if adopted by ANRC, could be used to evaluate permits for nonriparian withdrawals, pre-allocation studies, and allocation

in times of water shortages, as well as in future updates of the AWP.

- Groundwater modeling of the Mississippi Embayment aquifers (primarily the East Arkansas Region) suggests that, under sustainable pumping conditions, only about 20 percent of the groundwater demand can be met with groundwater in 2050. Groundwater availability in regions outside the Mississippi Embayment model is assessed in the U.S. Geological Survey (USGS) report "Aquifers of Arkansas" (Kresse et al. 2014).[1] The general conclusions are that water supplies are limited by low yield and water quality concerns.

2.3 Water Quality

- Surface water quality assessments in 2008 showed that the quality of some streams and lakes is not adequate. Sediment and organic enrichment and low dissolved oxygen (DO) (caused by nutrients) are the pollutants most often identified as causing surface waters to not support uses. In some areas of the state, most typically northwest and central Arkansas, water quality is impacted by changes from traditional land uses and accelerated urbanization. Point source wastewater discharges and activities such as resource extraction are water quality issues in only some areas of the state.
- In surface water, there have been declining trends in suspended solids across most regions from 1990 to 2008.
- Groundwater quality in the Mississippi Embayment sedimentary aquifers in the East Arkansas and South-central Arkansas regions is generally good in the recharge areas and deteriorates to the southeast where the aquifers are deeper.
- Groundwater quality in the Interior Highlands of Arkansas is generally good, except where impacted by human activities.

2.4 Gap Analysis

- The projected annual average 2050 groundwater gap (the difference between supply and demand) across the state is approximately 8.2 million AFY assuming sustainable groundwater pumping. The groundwater supply gap is projected to occur primarily in the East Arkansas Region. Once complete, the Grand Prairie and Bayou Meto Projects will reduce this gap by providing surface water to 15 percent of the farmed acreage in east Arkansas.
- There is sufficient excess surface water in four major river basins to close the projected groundwater gap—Arkansas River, Ouachita River, Red River, and White River. However, very little, if any, infrastructure is in place in locations that are in need of the available surface water supply.
- Three major river basins are projected to have a water supply gap in 2050 taking into account both groundwater and surface water supplies—Bayou Macon, Boeuf River, and L'Anguille.
- The Boeuf River Basin is projected to continue to have a surface water gap (supply less than demand) in June, July, and August based on average flow conditions over the period of record.

2.5 Water and Wastewater Infrastructure

- The cost of infrastructure to deliver excess water to farms where groundwater decline is high but should be considered in the context of the $9.7 billion annual market value of agricultural products produced in Arkansas.
- The Grand Prairie Area Demonstration Project and Bayou Meto Water Management Project, when complete, will provide surface water sources for irrigation to 15 percent of the area with projected groundwater gaps.
- Arkansas water providers will need to spend $5.74 billion and wastewater providers will need to spend $3.76 billion to build, maintain, and replace required infrastructure through 2024 from system revenue, private lending, and state and federal public financing.
- Small water and wastewater providers pose a unique challenge when planning at the statewide level.
- Many of these providers also face the challenge of shrinking population resulting in reduced revenue streams, following the national trend of increased urban dwelling.

[1] Kresse, Timothy M.; Hayes, Phillip D.; Merriman-Hoehne, Katherine R.; Gillip, Jonathan A.; Fugitt, D. Todd; Spellman, Jane L.; Nottmeier, Anna M.; Westerman, Drew A.; Blackstock, Joshua M.; Battreal, James L., *Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical Characteristics of Arkansas's Groundwater Resources*, U.S. Geological Survey USGS Scientific Investigations Report: 2014-5149 (2014).

3 Issues and Recommendations

This AWP 2014 Update is built from the bottom up, starting with the fundamental building blocks of how much water do we need (water demands), how much water do we have (water availability), and what is the difference between demand and supply (the "gap"). However, the crux of the AWP 2014 Update is what can be done about the gaps. The issues, recommendations, and implementation strategies described in this section are the culmination of ANRC consideration of regional and statewide stakeholder-driven workgroup proposals.

The Issues and Recommendations (I&R) Workgroups identified and prioritized water issues and recommendations for resolving the water issues in the five regions and statewide in Arkansas. There were five Regional I&R Workgroups. The members of the I&R Workgroups were volunteer representatives from 11 water demand sectors:

- Agricultural Irrigation
- Agricultural Livestock/Poultry/Aquaculture
- Conservation Districts
- County Governments
- Fish and Wildlife
- Industry
- Municipal Governments
- Navigation
- Public Water/Wastewater Providers
- Recreation
- Thermoelectric Utilities

The formation of the I&R Workgroups and the process used to elicit I&Rs is described in the *Issues and Recommendations Workgroup Process and Outputs Technical Memo* (Appendix H).

The Regional I&R Workgroups were first asked to identify issues and prioritize those issues using a voting process. The workgroups were then asked to develop recommendations to address the issues. The recommendations were also prioritized using a voting process. Each of the I&Rs identified by the I&R Workgroups are presented in the *Issues and Recommendations Workgroup Process and Outputs Technical Memo* (Appendix I of the AWP).

The final step in the I&R process was the ANRC selection of priority issues. The Commissioners considered all of the I&Rs identified and prioritized by the I&R Workgroups and selected nine priority issues and one supporting issue. Each of the priority issues are presented in this section along with the prioritized recommendations and an implementation strategy.

The 1990 AWP also had I&Rs, many of which were the same or similar to the nine priority issues and recommendations selected by the ANRC in 2014. The relationship between the 1990 I&Rs and the 2014 priority I&Rs is shown on **Table 3-1** (located at the end of this section), which maps the 2014 priority issues to the 1990 issues, and the 1990 recommendations to the 2014 recommendations.

Each priority issue has an implementation strategy. These issue-specific strategies fit within the AWP Implementation Plan described in Section 4.

The AWP 2014 Update I&Rs presented in this section are considered by the ANRC as the priorities for the state. The order in which they are presented does not indicate the relative importance of the issue, rather the order reflects the interdependence of the issues. Any listing of organizations, agencies, or others as partners in efforts to implement the AWP 2014 Update is not meant to be exhaustive or limiting. The same inclusiveness from the update process will apply to implementation.

Section	Issue, Recommendation, and Implementation Plan
3.1	Conjunctive Water Management and Groundwater Decline
3.2	Tax Incentives and Credits for Integrated Irrigation Water Conservation
3.3	Funding Water Resources Development Projects
3.4	Public Water and Wastewater Infrastructure
3.5	Excess Water for Nonriparian Withdrawal and Use
3.6	Drought Contingency Response
3.7	Reallocation of Water Storage in Federal Reservoirs
3.8	Improving Water Quality through Nonpoint Source Management
3.9	Public Awareness and Education
3.10	Water Use Reporting

3.1 Conjunctive Water Management and Groundwater Decline Priority Issue

Issue: Declining groundwater levels in the aquifers and the need to move toward sustainable use of the groundwater.

Background

The 1990 AWP stated that groundwater levels were declining in the Mississippi River Valley alluvial aquifer in the Grand Prairie region, the area west of Crowley's Ridge and in the Sparta Aquifer. There were several recommendations to address this issue in the 1990 AWP, including conversion from groundwater to surface water, and employment of a conjunctive water management strategy. As a result of the 1990 AWP, three critical groundwater areas were designated by the ANRC—South Arkansas, Grand Prairie, and Cache. A "critical groundwater area" is an area determined by the Commission to have significant groundwater depletion or degradation. Additionally, the Sparta aquifer was also determined to be a "sustaining aquifer," under the authority within Act 1426 of 2001. Any well withdrawing groundwater from a sustaining aquifer must have a properly functioning metering device.

Since 1990, groundwater levels in the Mississippi River Valley alluvial and Sparta aquifers have continued to decline. The ANRC, USGS, Union County Water Conservation Board (UCWCB), and conservation districts measure water levels in wells on an annual basis and ANRC publishes this information in the "Arkansas Groundwater Protection and Management Report." The Groundwater Protection and Management Report for 2013 found that static groundwater levels throughout the Mississippi River Valley alluvial aquifer declined in nearly 80 percent of the wells monitored in the 2012-2013 season resulting in average decline of 1.44 feet over the entire alluvial aquifer. This is consistent with the 10-year trend of groundwater levels in the Mississippi River Valley alluvial aquifer.

In its simplest context, conjunctive water management is the shared and coordinated use of surface and groundwater to satisfy water needs. However, there is a difference between conjunctive water use and conjunctive water management. Conjunctive water use simply implies that both sources of water are used without considerations of the benefits or impacts on either source. Conjunctive water management is managing both surface water and groundwater resources such that the total benefits of integrated management exceed the sum of the benefits that would result from an independent management of each water resource. Act 749, passed in 2011, amends Ark. Code Ann. § 15-22-201 to improve state water planning and ensure that water quality and quantity are considered. The provisions of Act 749 further reinforce the development and implementation of conjunctive water management in Arkansas.

The effectiveness of conjunctive management is clearly shown in the Union County area of Arkansas. During the 10-year monitoring period (2003-2013), there were declines in the Sparta aquifer in 78 percent of the wells monitored. However, the aquifer-wide average change was +6.75 feet, primarily due to the recovery of the Sparta aquifer in the South Arkansas Study Area. Union County alone had an average change of +36.83 feet over the 10-year period. The recovery of water levels in Union County are a testament to the positive impact of conjunctive management through the use of excess surface water from the Ouachita River, combined with education and conservation.

Workgroup Concerns

I&R Workgroup members acknowledged the greatest issue in the East Arkansas Region is the continued decline of the alluvial aquifer and the need to move toward sustainable use of the alluvial aquifer. There is a need to transfer from groundwater to surface water sources for agricultural irrigation. However, there is also an understanding that there might not be sufficient surface water resources to satisfy the irrigation demand.

Goals

- Reduce groundwater withdrawals and move toward sustainable groundwater use
- Provide sustainable yield protection for the Sparta aquifer
- Ensure water is available to satisfy irrigation uses through conjunctive water management

Recommendations

The following actions are recommended to address groundwater decline:

1. ANRC will seek opportunities to purchase, install, and read meters on selected alluvial wells.
2. Develop and implement conjunctive water management strategies based on storing surface water during months when excess water is available, for use during the summer irrigation months when excess surface water is not available (**Figure 3-1**). Groundwater use would supplement surface water use, rather than being the primary irrigation water source.
3. Encourage and increase irrigation water use efficiency through integrated irrigation water management and conservation practices over the next decade.

Implementation Plan

1. ANRC will continue to formulate, implement, and cooperate on conjunctive water management strategies for the East Arkansas Region, initially targeting critical groundwater areas. These strategies will include input from other agencies, organizations, and stakeholders through a process similar to that used by the I&R Workgroup for eliciting input for the AWP 2014 Update. These strategies will also focus on continued financing and progress on excess surface water delivery projects.
2. ANRC will work with state, regional, and local agencies with constitutional and statutory water management duties to develop a proposed amendment to the 1991 Arkansas Groundwater Protection and Management Act to create a designation for areas where groundwater levels are recovering, such as in the Sparta aquifer in Union County. The new designation would keep the existing critical groundwater area incentives in place while recognizing the success of groundwater recovery efforts.
3. ANRC will emphasize on-farm storage/tailwater recovery systems, to store water during the wet season for use during the irrigation season, and integrated irrigation water management practices to reduce water use.
4. ANRC will continue to: (1) document the economic benefits of using surface versus groundwater sources and the economic benefits of integrated irrigation water management and conservation practices; and (2) prepare stakeholder awareness and educational information to be disseminated to the agricultural community through multiple sources, including conservation districts, Cooperative Extension, and professional associations and organizations, concentrating in the East Arkansas Region.
5. ANRC, through conservation districts, will document the acres of on-farm storage, tailwater recovery, and irrigation water conservation practices that have been implemented, by county and critical groundwater areas, in the East Arkansas Region and report these findings annually.

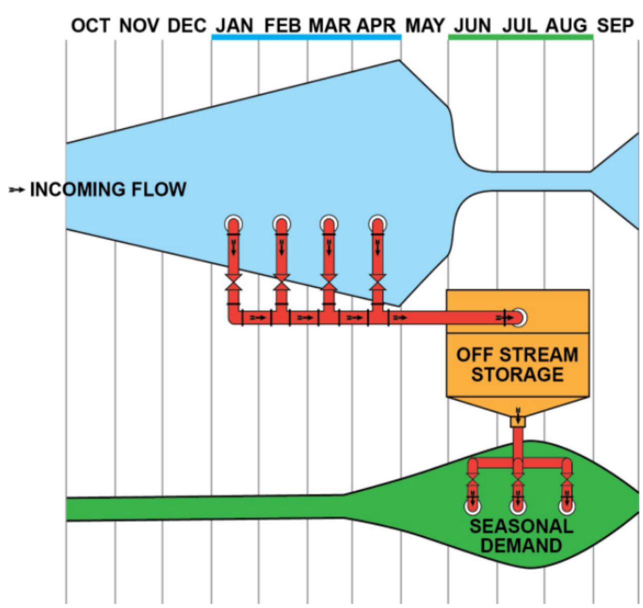


Figure 3-1. Operational Example of Conjunctive Water Management
(Original illustration by Bill McMurry)

3.2 Tax Incentives and Credits for Integrated Irrigation Water Conservation Priority Issue

Issue: Tax incentives and credits are needed to encourage the implementation and management of integrated irrigation water conservation practices.

Background

Groundwater decline in the East Arkansas Region is recognized as the greatest water issue in the region, if not in the state. Agricultural irrigation withdrawals represent about 80 percent of the total water withdrawals in the state, and these irrigation withdrawals are almost all groundwater withdrawals from the Mississippi River Valley alluvial aquifer. Tax incentives are available under the ANRC Water Resource Conservation and Development Incentives Act. These incentives include an income tax credit for construction of on-farm impoundments or storage systems, for the conversion from groundwater to surface water, for land leveling to conserve irrigation water, and for metering.

The analysis in the Alternatives for Sustainability of Crop Irrigation in the East Arkansas Water Resources Planning Region (Appendix G) includes an evaluation of water savings from increased irrigation efficiency. About 1.3 million AFY could be conserved if the application rates were reduced to the state average in the counties that are currently above the state average.

Workgroup Concerns

I&R Workgroup members stated greater emphasis was needed on tax incentives and credits to encourage the implementation and management of integrated irrigation water conservation practices. These integrated practices should include flow meters, surge valves, PHAUCET/Pipe Planner, multi-inlet irrigation systems, on-farm storage and tailwater recovery systems, remote controls, soil moisture monitors, irrigation scheduling, satellite monitoring of soils and crops, and cellular links to weather stations. Water conservation practices should be an integral part of irrigation water management, regardless of whether the source is groundwater or surface water.

Recommendations

The following was recommended for tax incentives and credits to encourage increased water use efficiency and conservation:

1. Determine the current irrigation water use efficiency for various crops and subwatersheds in the East Arkansas Region and establish a goal or target efficiency to be achieved for integrated irrigation water management and conservation practices.

2. Evaluate the effectiveness of the existing tax credits and incentives and, based on this assessment, consider[2]:

   a. Increasing the percentage of the total project cost available for tax credits based on applicants improving their irrigation water use efficiency compared with the goal or target efficiency,

   b. Extending the period for claiming tax credits for implementing water conservation practices,

   c. Increasing the annual cap on tax credits so additional tax credits can be claimed, and

   d. Tracking the acreage on which water conservation practices have been implemented along with the tax credits.

Implementation Plan

1. ANRC will work with agencies, academic institutions, and stakeholders to determine the current water use efficiency for various types of irrigation water management practices and reasonable targets for near maximum efficiency. Tools, such as the U.S. Department of Agriculture-Natural Resource Conservation Service (USDA-NRCS) Farm Irrigation Rating Index and development of a statewide evapotranspiration network, should be considered in this work.

2. ANRC will work with conservation districts to develop a ranking system for district-based cost-sharing support that encourages multiple, integrated conservation practices, with flow meters being included in these suites of practices.

[2] Recommendations 2.a., b., and c. are actions that ANRC will take that may lead to recommendations to the General Assembly.

3. ANRC will evaluate tax credit and incentive programs to determine how incentives may be improved through legislation to encourage further reduced water use. These should include, but not be limited to: an increase in the cap on total tax credits available in any year; cost sharing of installation costs of irrigation water supply projects that are also federally cost-shared; financing state cost-share programs via revenue bonds; encouraging federal farm program payments comparable to Conservation Reserve Program, Wetlands Reserve Program, or similar programs for cropland that has been converted to surface water irrigation reservoirs; and streamlining the procedures for land leveling and irrigation reservoir construction. In areas of significant groundwater level decline, groundwater depletion sources of revenue should be studied for groundwater to surface water conversion projects, and revenue bonds could be available for long-term low interest loans or state financing could be made available to "buy-down" interest on commercially available loans for the construction and use of irrigation reservoirs and tailwater recovery systems. These projects could be prioritized to watersheds that have been declared to have impaired water quality or are within critical groundwater areas.

4. ANRC, in conjunction with the Arkansas Water Foundation, conservation districts, academic and extension institutions, stakeholder groups, and nonprofit organizations, will develop and expand efforts to increase water conservation awareness, provide technical assistance, share data and information, and provide incentives.

5. ANRC will develop a method to record water conservation management practices, associated acreages, and water savings during annual water use reporting.

6. ANRC will continue to plan by periodically (e.g., 5-year intervals) evaluating success in implementing water conservation practices and opportunities for increased effectiveness.

3.3 Funding Water Resources Development Projects Priority Issue

Issue: State-issued general obligation bonds are vital to finance and refinance the development of water; waste disposal; pollution control, abatement, and prevention; drainage, irrigation, flood control, wetlands, and aquatic resources projects to serve the citizens of the State of Arkansas.

Background

Funding typically is the issue for most major state projects, and it is especially so for water projects. In general, water is undervalued and, subsequently, underfunded. For example, Arkansas municipal and county infrastructure financing needs for water and wastewater projects alone are estimated to be about $5.75 billion by 2024. Federal grants, cost-share, and loans, and programs for water and wastewater projects, are continuing to decline and are not anticipated to increase in the future.

The Grand Prairie Area Demonstration Project was initially estimated to cost about $350 million, but project delays have increased this cost to over $600 million, with even greater costs projected if additional financing cannot be obtained or is delayed.

Large-scale water infrastructure, particularly irrigation and navigation infrastructure, are also in need of financing. The range of estimated costs to build the infrastructure necessary to switch from irrigation using groundwater to surface water irrigation in the nine major river basins in the East Arkansas Region is $3.4 to $7.7 billion (Appendix G). The cost of this infrastructure should be considered in the context of the $9.7 billion annual market value of agricultural products in Arkansas. The Grand Prairie Area Demonstration Project and Bayou Meto Water Management Project, when complete, will provide surface water sources for irrigation to 15 percent of the area with projected groundwater gaps.

Workgroup Concerns

I&R Workgroup members identified numerous projects in need of financing. These ranged from completing the Grand Prairie and Bayou Meto projects to failing infrastructure; repair of PL566 structures (flood control structures constructed with financing from the NRCS); additional flood control projects; navigation infrastructure, continuing support of conservation districts; research on more efficient water conservation and management practices; and public awareness and education programs. In addition, delays in project financing contribute to escalating costs. Sustainable sources of money are needed not only to meet current financing needs, but also to address future needs.

Goals

- Provide sustained financing for water resources projects, from new construction to maintenance and replacement of failing projects.
- Create, sustain, and integrate financing across programs to enhance sustainable water resources management.

Recommendations

The following is recommended to address additional financing for water resources development projects:

1. As an initial step, authorize an additional $300 million under the Water, Waste Disposal, and Pollution Abatement Facilities General Obligation Bond Program at the appropriate time. Additional authorization will be requested as needed to finance and refinance the development of water resources projects.
2. ANRC will seek the authority to merge water systems or sewer systems where necessary in order to bring them into economic viability.

Implementation Plan

1. ANRC will estimate financing needed for existing water resources projects and anticipated future needs by region. These estimates shall include existing cost-share requirements associated with current federal and state financing.
2. ANRC will collaborate with other state and federal agencies and other organizations to integrate additional financing opportunities with ANRC assistance for water resources projects, such as Grand Prairie Area Demonstration Project and Bayou Meto Water Management Project.
3. ANRC will encourage projects to seek out all financing options from state, federal, and local sources, including consumer use fees.

3.4 Public Water and Wastewater Infrastructure Priority Issue

Issue: Public water and wastewater infrastructure is failing, and in need of repair and replacement throughout Arkansas.

Background

Public water and wastewater infrastructure, including navigation, flood control, levee, and drainage, both municipal and county, is failing, and is in need of repair, upgrades, and replacement throughout Arkansas, just as it is throughout the U.S. To assess public water and wastewater infrastructure needs throughout Arkansas, surveys were sent to the 699 public water and wastewater providers. The survey collected information on planning efforts by each provider, including projects identified in master plans, asset management plans and strategies, and current and planned financing sources. Overall, through 2024, Arkansas water providers **will need $5.74 billion** to build, maintain, and replace required infrastructure **(Table 3-2)** (Appendix F). The survey results largely confirmed U.S. Environmental Protection Agency's (EPA) Drinking Water Infrastructure Needs Survey and Assessment (DWINSA), which estimated that the water infrastructure need in Arkansas is approximately $6.10 billion through 2031 (EPA 2013).[3]

Table 3-2. Water and Wastewater Infrastructure Survey Results

	Small Systems	Medium Systems	Large Systems
Drinking Water Infrastructure Needs			
Number of Responses	37/534*	55/154	1/1
Estimated Total Need	$3,059,700,000	$2,393,100,000	$291,100,000
Wastewater Infrastructure Needs			
Number of Responses	14/238	15/94	1/1
Estimated Total Need	$1,259,000	$33,883,070	$271,911,362

* Number Responding/Number Sent

New levels of treatment require additional capital and increase operational costs. Small water and wastewater providers pose a unique challenge when planning at the statewide level, as their individual needs are small and widespread, but together they make up a large portion of the needs. Many of these providers also face the challenge of shrinking population and result in reduced revenue streams, following the national trend of increased urban dwelling. Complexity of regulations and lack of financial resources make finding and retaining trained operational and managerial personnel difficult for small systems.

In areas of Arkansas where water supplies are inadequate to meet needs, water conservation and reuse programs could be effective in extending the water supply.

The State of Arkansas depends on federal investment in its navigation facilities. Navigation and the pools for navigation on both the Ouachita and the McClellan-Kerr Arkansas River Navigation System (MKARNS) play a critical part in providing much needed water resources to the State of Arkansas. The economic benefits of water transport are well known, but there are numerous others, including municipal and industrial water supply, fish and wildlife recreation, thermoelectric power generation, flood risk reduction, groundwater recharge, and abundant excess surface water.

Though the AWP focuses on actions that state, regional, and local governments can take, the update process produced a strong recommendation that we encourage the federal government to pass legislation to fund the dredging and maintenance of the navigation system.

Arkansas River barge – *Photo courtesy of Arkansas Department of Parks and Tourism*

[3] EPA, Drinking Water Infrastructure Needs Survey and Assessment: Fifth Report to Congress. www.epa.gov. Retrieved March 1, 2014 from http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf. (2013).

Workgroup Concerns

I&R Workgroup members acknowledged public water and wastewater infrastructure is failing, and in need of repair and replacement throughout Arkansas, from small to large systems. In addition, much of the existing state financing available for infrastructure projects—Water Resources Development General Obligation Bond Program; Water Development Fund Program; Water, Sewer, and Solid Waste Management Systems Program; Water Resources Cost Share Revolving Fund Program; and Water, Waste Disposal, and Pollution Abatement Facilities General Obligation Fund Program—are unfunded or limited in financing capacity. Based on the survey results, at least 25 percent of providers rely on state financial assistance programs, but smaller providers are significantly more likely to seek grants rather than rely on bonds, loans, or system revenue. The costs reflected in the survey may not include the increasing need for water providers to devote resources to source water protection efforts. Finally, there are also issues with maintaining and operating existing facilities as both the facilities and personnel age. Small and medium-sized systems have difficulty hiring and retaining licensed water and wastewater treatment operators.

Goals

- Provide adequate water and wastewater services.
- Repair, replace, and maintain state water infrastructure across all communities in Arkansas.
- Develop and implement programs that will provide for sustainable infrastructure programs available to communities in Arkansas.

Recommendations

The following are recommended to address maintenance, repair, and sustainability issues facing water infrastructure and water and wastewater systems:

1. Public entities operating water and wastewater infrastructure or flood control and drainage projects should develop sustainability plans that evaluate:
   a. Current infrastructure status and historical trends in status;
   b. Needed infrastructure repairs, replacement, and maintenance and associated schedules;
   c. Federal and state programs available to support infrastructure projects; and
   d. Contingency plans, including the potential for regionalization or privatization (private water wells, septic systems, decentralized systems, etc.), if the utilities are assessed to be unsustainable.
2. Receivership proceedings should be initiated for public water and wastewater providers that have defaulted on loans.
3. Training programs should be developed for utility boards of directors on sustainability planning and how these plans relate to the operation of their facilities and infrastructure. Utilities that submit a sustainability plan with financing applications could receive lower rates on loans.

Implementation Plan

1. ANRC should convene an advisory team including, Arkansas Department of Environmental Quality (ADEQ) and Arkansas Department of Health (ADH) to assist in identifying elements of sustainable infrastructure plans, formulating the planning process, and defining the roles of each of these agencies in the planning process, using information from EPA and other federal agencies, and state and local drinking water and wastewater utility organizations.
2. Follow up on the survey responses from utilities statewide to determine which utilities currently have long-range plans for sustainable infrastructure, which utilities have the capabilities for developing these plans, and which utilities will need assistance.
3. Develop and implement an awareness campaign to promote the development of sustainable infrastructure plans for water and wastewater utilities and all other operators of water-related infrastructure, including watershed, levee, drainage, irrigation, and other improvement districts statewide. This campaign should include the process and criteria to be used in providing assistance to local entities that operate water and water-related infrastructure in preparing sustainable infrastructure plans. Work with water-related organizations to implement this campaign.

4. Track the number of utilities that request assistance in developing sustainable infrastructure plans, the number of plans prepared, and the number of plans being implemented by these utilities.

5. In collaboration with ADEQ, ADH, federal agencies, and water related organizations, develop training programs and modules that emphasize the importance, development, and implementation of sustainable infrastructure plans, the performance measures that can be used to track progress, and the process for periodically updating these plans. These training modules should be structured primarily for small to medium sized facilities.

6. Seek federal and state financing to maintain critical navigation system infrastructure.

7. Encourage the continued federal support of the Clean Water and Drinking Water Revolving Loan Funds by EPA and provide the required state match.

8. Encourage the continued investment in the United States Department of Agriculture (USDA) Rural Development Community Program and Water - Wastewater Program to assist small communities and rural water systems in the state.

9. Encourage the continued federal financing of the Community Development Block Grant Program to the state and continue to use a significant portion of money provided to the state for water and wastewater projects to serve the low to moderate income citizens of the state.

10. Increasing the state support of the Water Development Fund and Water, Sewer, and Solid Water Fund through additional General Revenue and General Improvement Funds.

11. Continue the use of the Water-Wastewater Advisory Committee to coordinate financing of water and wastewater projects. Explore the possibility that the committee might play an additional role in the coordination of regulatory and financing governmental agencies with respect to water and wastewater systems.

3.5 Excess Water for Nonriparian Withdrawal and Use Priority Issue

Issue: The statutory definition of excess surface water should be based on sound science.

Background

Although riparian water users may withdraw as much water as they need from a stream so long as they don't unreasonably interfere with a fellow riparian's use, withdrawals by nonriparians are statutorily limited by the definition of excess surface water. Arkansas Code section 15-22-304, and ANRC Rules Title 3 define excess surface water as 25 percent of the average annual yield from any watershed above that amount, as determined by the ANRC, required to satisfy all of the following:

1. Existing riparian[4] rights as of June 28, 1985.
2. The water needs of federal water projects existing on June 28, 1985.
3. The firm yield of all reservoirs existing on June 28, 1985.
4. Maintenance of instream flows for fish and wildlife, water quality, aquifer recharge, and navigation.
5. Future water needs of the basin of origin as projected in the AWP.

The 25 percent defined by law was a negotiated limit that does not have a clear scientific basis and was adopted by the Arkansas General Assembly to provide a level of protection to riparian and instream uses. Because there is no clear scientific basis for the 25 percent limitation, there has been increasing interest as to whether this percentage is unduly restrictive of potential nonriparian uses.

The Gap Analysis Report (Appendix F) evaluated the "total available" surface water, which is water that is available over and above the amount necessary to satisfy riparian and instream needs as required by law. If the 25 percent legal limitation on nonriparian use is removed, there would be sufficient water available on an average annual basis to satisfy total projected water demands in the Lower White River, St. Francis River, and Bayou Bartholomew watersheds. However, during the summer irrigation months in Bayou Macon, Boeuf, and L'Anguille River watersheds, there is not sufficient water available for nonriparian use to meet the projected water demands even with the 25 percent limitation removed.

Additional nonriparian use limitations have been enacted by the Arkansas General Assembly for the White River Basin. For purposes of nonriparian water use and permitting in the White River Basin, "the nonriparian transfer amount shall not exceed on a monthly basis an amount that is 50 percent of the monthly average (for each individual month) of excess surface water." Arkansas Code section 15-22-304(e).

Workgroup Concerns

Some I&R Workgroup members stated the 25 percent restriction on excess surface water is insufficient to meet current and future demands and the percentage should be raised to 75 percent as recommended in the 1990 AWP. Other I&R Workgroup members stated the percentage should not be changed solely on the basis of meeting out-of-stream demand requirements, but should be scientifically based on satisfying instream needs. Some workgroup members encouraged the implementation of the Framework for Documenting Alternative Approaches for Estimating Fish and Wildlife Flows in Arkansas and Implementing the State Water Plan (Appendix C) to employ the best available science to determine instream needs and to quantify out-of-stream water demands, then employ a stakeholder process to set the amount available for nonriparian permitting on a stream-specific basis.

The East Arkansas Region has the greatest and most immediate supply need, and that is the region that expressed the greatest concern about the current statutory limitation on excess surface water. While the other regions are projected to have sufficient excess water to satisfy demand, there were concerns expressed in all of the regions about the excess water restriction. The following considerations focus on the East Arkansas Region.

[4] Arkansas case law indicates that riparian water use is a property right protected by the Arkansas Constitution. Any statutory change to the definition of excess surface water must protect these rights from harm by non-riparian transfers. See, *Harrell v. City of Conway*, 224 Ark. 100, 271 S.W. 2d 924 (1954), and *Harris v. Brooks*, 225 Ark. 436, 283 S.W. 2d 129 (1955).

Goals

- Protect public drinking water while ensuring adequate water is available to meet demands and to satisfy nonriparian withdrawals and transfers.
- Implement the AWP through adaptive management, incorporating better scientific methods and BMPs as they become available.

Recommendations

The following are recommended to address the excess water issue:

1. A deficit of legally available water has been identified within certain basins of the East Arkansas Region. The General Assembly should consider raising the 25 percent limitation for permitting excess surface water within these basins for nonriparian transfer upon completion of scientific studies in East Arkansas validating the need for an increase and confirming water is seasonally available to protect and sustain instream, riparian, and other uses specified in state law. Similar scientific analyses should be conducted in the remaining planning regions in this order: South-central, West-central, North, and Southwest. These studies will be conducted in collaboration with Arkansas Game and Fish Commission (AGFC), ADEQ, ADH, and other state, regional, and local agencies with constitutional and statutory water management duties.
2. Continue to use the Arkansas Method in estimating the proportion of total available water needed to satisfy fish and wildlife flow needs in estimating excess water for nonriparian withdrawals and transfers. Through adaptive management, the ANRC will evaluate and assess alternative methods for estimating fish and wildlife flows, or other instream needs and uses, as more accurate, scientifically reviewed, and defensible methods become available.
3. Engage stakeholders in the planning regions through an open and transparent process as the scientific study is being conducted by ANRC and as better scientific approaches become available and are proposed for use.

Implementation Plan

1. ANRC will develop the study plan and conduct the study for determining the proportion of total available water that could be permitted for nonriparian withdrawals in collaboration primarily with AGFC, ADH, and ADEQ. Following the Framework for Documenting Alternative Approaches for Estimating Fish and Wildlife Flows in Arkansas and Implementing the State Water Plan (Appendix C), the study will review and validate the administrative process for determining instream flow needs as well as the scientific component of fish and wildlife flows. The study plan will be presented at appropriate professional and scientific meetings and made available for public review on the ANRC website.
2. Based on the outcome of this study, ANRC will consider recommending to the General Assembly any alternate percentage of water that the study indicates should be available for nonriparian withdrawal. If feasible, subsequent studies will be conducted in the order provided in the above recommendation. Informational public meetings will be conducted by ANRC before any proposal is made to the legislature.
3. ANRC will periodically (e.g., 5-year intervals) evaluate existing and new methods for estimating instream flows used in determining excess water. Within its statutory authority, as better methods become available, ANRC will refine the estimates of excess water.
4. Long-term planning should assess excess surface water's potential for regional and statewide economic development and interstate transfers when not in conflict with the public welfare of Arkansas's citizens or the conservation of its waters.

3.6 Drought Contingency Response Priority Issue

Issue: Planning for allocation during drought is needed before droughts occur.

Background

Based on Arkansas Code section 15-22-217, ANRC "Rules for the Utilization of Surface Water" (ANRC Rules Title 3) has several sections specifically related to allocation of surface water during times of shortage:

- Subtitle VII. Allocation of surface water during periods of water shortage
- Subtitle VIII. Procedure for allocation of surface water during periods of shortage
- Subtitle IX. Formal allocation of surface water during period of water shortage
- Subtitle X. Commission initiated allocation
- Subtitle XI. Implementation of allocation plan
- Subtitle XII. Penalties
- Subtitle XIII. Emergency allocations

A water shortage has never been declared in Arkansas. Droughts, however, have occurred in the past and will occur in the future. In fact, extremes of both drought and flooding are projected to increase in the future.

Threats to drinking water during periods of water shortage are a major concern to the people of Arkansas. Historically, case law has protected public water systems, and the legislature has continued these protections, especially in the laws governing allocation during shortage and limiting nonriparian transfers during low-flow periods to protect drinking water.

Workgroup Concerns

I&R Workgroup members identified drought contingency planning as an issue that needed to be addressed in the AWP. Members expressed concern that adequate water may no longer be available to meet demands by the time a shortage is declared. This is especially a problem when ANRC is petitioned to declare a shortage well after the shortage occurs. At that point, the time it takes to use the allocation process often is longer than the period of shortage. Of as great a concern was the lack of a coordinated response among agencies, organizations, and the private sector when the onset of a drought was imminent. Having a drought response network in place with information on voluntary conservation measures that could be implemented is needed.

Goals

- Prioritize and protect public drinking water while ensuring all water uses and users have water to meet their needs, even if limited, during times of drought or water shortage. Provide a framework for water users within the various use sectors to share consistent, coordinated information about drought, drought responses, and conservation.
- Consideration of maintenance of instream flows to support fish and wildlife during shortages and droughts.

Recommendations

The following are recommendations for drought contingency responses:

1. Develop a coordinated drought contingency response network among state, regional, local, and agencies with constitutional and statutory water management duties; federal agencies, drinking water utilities, organizations, and institutions; and the private sector for alerting the public about impending droughts, sharing consistent messages and information, and providing information on voluntary conservation measures to reduce water use.
2. Seek financing and ensure stream gaging networks throughout the state are adequate to provide streamflow information needed to make informed decisions about impending or advancing droughts statewide and within each planning region.

Implementation Plan

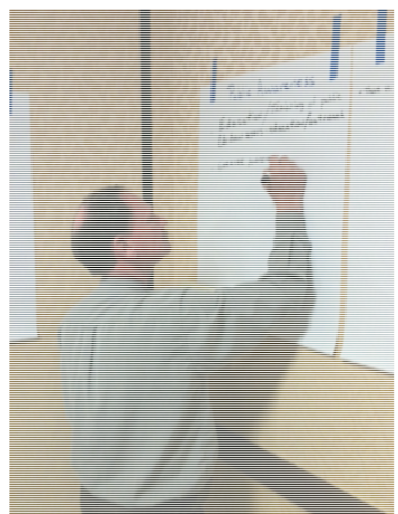
The following steps will be considered in implementing the recommendations:

1. ANRC will form a Drought Response Team to coordinate and collaboratively disseminate information on emerging drought conditions across the state. This team will include state and federal agencies, including emergency response agencies,

conservation districts, the University of Arkansas Division of Agriculture and other academic institutions, as well as drinking water and wastewater utilities, agricultural organizations, nonprofit organizations, and private sector professional organizations with stakeholder networks.

The state agencies that will be part of the Drought Response Team are those agencies whose constitutional and statutory missions are directly tied to water management, including: ANRC, ADEQ, AGFC, ADH, and Department of Agriculture (including its associated agencies).

2. The Drought Response Team will review existing drought response resources and build on these to develop communication networks and links across the state and within each planning region. The team, as needed, will prepare and disseminate consistent, coordinated messages and voluntary conservation practices to reduce water use. Water use sector representatives from the AWP 2014 Update I&R Workgroup will be asked to help disseminate these messages.
3. The Drought Response Team will interact with ANRC and other entities to identify educational programs to help the public better understand how to reduce the likelihood of drought responses through everyday conservation practices (reducing water loss and water reuse (e.g., gray water for watering lawns), and programs that encourage and assist with water conservation activities (e.g., Cooperative Extension; EPA WaterSense; and USDA-NRCS Regional Climate Hubs). In addition, these educational programs can also include information on what the potential impacts and outcomes might be during drought.
4. ANRC will encourage the development of pre-allocation plans in basins or subbasins where shortages repeatedly occur. Consistent with state law, these plans must prioritize riparian use, public water supply, water quality, fish and wildlife, navigation, and interstate compacts above nonriparian uses. These pre-allocation plans will initiate discussions among water users and other stakeholders on how water would be allocated during shortages and drought. Pre-allocation can overcome the social, administrative, time, and other barriers to successful, post-shortage allocation.
5. Periodically review the stream monitoring network in each of the planning regions and assess its adequacy to provide suitable information for decision-making during drought. While the emphasis of this recommendation is on drought response, review must also consider data necessary to support decision-making in response to flooding.
6. The stream network review should include collaborative meetings among agencies, utilities, and organizations that fund stream gages to evaluate the potential for leveraging or apportioning costs among entities to increase the information per unit cost among all entities.



Identifying issues – *Photo courtesy of Terry Horton*

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3.7 Reallocation of Water Storage in Federal Reservoirs Priority Issue

Issue: Reallocation of water storage in U.S. Army Corps of Engineers (USACE) reservoirs is needed to increase available water for existing and new uses.

Background

Many of the USACE reservoirs in Arkansas were completed before 1970. The authorized project purposes for many of these reservoirs did not include drinking water supply, recreational use, or downstream aquatic life use discharges. Water use and demand has changed considerably in Arkansas over the past 40 to 50 years with minimal corresponding change in water storage allocation in USACE reservoirs.

Workgroup Concerns

I&R Workgroup members identified reallocation of water storage in USACE reservoirs as an issue, and one way of increasing available water for uses other than those congressionally authorized in the original project purposes. This is seen as an issue because the Water Supply Act of 1958 requires congressional approval of reallocation of water storage if water supply storage would seriously affect the original project purposes or involve a major operational change for the project. Given the current status of congressional actions, congressional approval of a reallocation request could be delayed for a significant number of years.

After passage of the 1958 Water Supply Act, USACE developed a guidance manual for implementing the act. In 1977, a provision was added to this guidance manual, which states:

> Modifications of project purposes to allocate all or part of the storage serving any authorized purpose from such purpose to storage serving domestic, municipal, or industrial water supply purposes are considered insignificant if the total reallocation of storage that may be made for such water supply uses in the modified project is not greater than 15 per centum of total storage capacity allocated to all authorized purposes or 50,000 acre feet, whichever is less.

Fortunately, reallocation of storage for water supply has already occurred in seven USACE reservoirs in Arkansas based on this guidance manual provision.

Goals

- Provide sustainable sources of water for water supply in Arkansas.
- Integrate federal water projects with state, county, and municipal water projects to ensure sustainable water supply in the future.

Recommendations

Reallocation of water storage in USACE reservoirs, based on the revised 1977 Water Supply Act guidance manual, should be sought if there is a documented need for additional water for domestic, municipal, or industrial water supply.

Implementation Plan

1. ANRC will review water supply needs within each of the regions and, in conjunction with the public drinking water utilities in recognition of their existing water rights, determine if these water needs might be supplied through reallocation of water storage in USACE reservoirs within the planning regions.
2. If reallocation of water storage is a feasible alternative and local sponsors are interested, if requested, ANRC will assist the appropriate entity to prepare and submit a request to the appropriate USACE district for a reallocation study to support the reallocation of water storage.
3. In the long-term effort to provide water for the future of Arkansas, an active and aggressive effort to reauthorize water storage from federal reservoirs should be considered, without adversely affecting other benefits and water needs provided by these facilities.

3.8 Improving Water Quality through Nonpoint Source Management Priority Issue

Issue: Water quality is affected by nonpoint sources of pollutants and nonpoint source management projects need state financing in addition to federal financing.

Background

Water quantity and water quality are intertwined in a complex relationship. Water quality must be adequate to ensure that water sector uses can be satisfied. The authority for protecting, managing, and restoring water quality in streams, rivers, reservoirs, and lakes in Arkansas resides primarily in three agencies—ADEQ, ADH, and ANRC.

ADEQ is tasked with protecting the quality of the waters of the state under their regulatory authority. Regulation 2 states that these "standards are designed to enhance the quality, value, and beneficial uses of the water resources of the State of Arkansas, to aid in the prevention, control and abatement of water pollution, to provide for the protection and propagation of fish and wildlife and to provide for recreation in and on the water." The AWP 2014 Update acknowledges and endorses the water quality protections and management strategies adopted into ADEQ Regulation Number 2.

ANRC has primary authority for nonpoint source (NPS) pollution management, while ADEQ has primary authority over point sources, surface water quality criteria, enforcement, and assessment. The ADH has primary authority over drinking water quality. While authority and responsibilities are delegated among different agencies, water quality is holistic and requires interaction, collaboration, cooperation, and coordination among all three agencies, with the participation of other agencies, organizations, institutions, and the private sector. There are, and have been, numerous interactions among all these agencies since the publication of the 1990 AWP, through the Arkansas Watershed Forum, financing of water and wastewater treatment facilities, prioritizing and targeting watersheds with impaired water bodies for watershed management plans and practices, and agency representation on the Arkansas Pollution Control and Ecology Commission (APCEC).

The ANRC NPS Pollution Management Program is described in the Arkansas 2011-2016 NPS Pollution Management Plan. The main components of this program include demonstration and technology transfer of BMPs, education and outreach, planning, instream water quality monitoring, and technical assistance. These components are made possible through a wide array of partnerships with federal and state agencies, conservation districts, and nonprofit organizations.

The NPS Pollution Management Plan is complementary to the List of Impaired Waterbodies (303(d) report) and Water Quality Assessment Report (305(b) report) prepared every other year by the ADEQ. The plan's purpose is to provide an over-arching guide to develop, coordinate, and implement plans and programs to reduce, manage, or abate NPS pollution. It provides a focal point for public agencies, nonprofit organizations, interest groups, and citizens to discuss and address NPS pollution together. The plan addresses both statewide NPS issues associated with specific identified land uses, and the NPS issues in a set of priority watersheds. The priority watersheds are selected using stakeholder input to a computerized process that evaluates over 30 risk factors for impacts to human and environmental health. The 2011-2016 NPS Pollution Management Plan identifies 10 priority watersheds—Bayou Bartholomew, Upper White River (Beaver Reservoir), Cache River, Illinois River, Lake Conway Point Remove, L'Anguille River, Lower Ouachita Smackover, Poteau River, Strawberry River, and Upper Saline River. The plan promotes adaptive management of the changing circumstances of available resources, need, and knowledge.

Funding assistance for NPS pollutant control projects in Arkansas comes primarily from federal programs of the EPA (administered by ANRC) and USDA-NRCS. A few state and local programs offer technical assistance, tax incentives, and financial incentives to promote the use of practices that reduce NPS pollution, e.g., riparian buffers.

Workgroup Concerns

I&R Workgroup members noted that finances continue to be an issue for financing NPS management projects. Currently, only federal appropriations are available for paying for NPS pollution and management programs. While federal funds are desirable, there are restrictions on where, when, and how NPS management practices can be implemented. Having an alternative source of revenue would increase the effectiveness of the NPS water quality program.

In addition to alternative financing sources, teamwork among ANRC, AGFC, Arkansas Natural Heritage Commission (AHNC), ADEQ, USGS, and other state, regional, and local agencies/organizations that engage with or have water quality management interests was reiterated as critical to improving water quality throughout the state. Collaboration and communication is essential for a holistic and adaptive management approach to assess and ultimately enhance water quality.

Goals

- Adaptively manage watersheds so all designated uses of water can be attained and sustained over time.

Recommendations

Recommendations for improving water quality include:

1. Propose legislation to designate funding specifically for financing NPS pollution management programs and implementing NPS management practices.
2. ANRC will collaborate with ADEQ, AGFC, ANHC, ADH, USGS, and other state, regional, and local agencies/organizations that engage in or have water quality management interest through:
    i. The biennial Clean Water Act (CWA) water quality review processes, and
    ii. The water quality criteria review to determine attainment or nonattainment of water quality standards in streams and identify the sources and causes of nonattainment.
    c. Streams impaired because of NPS pollution will be considered as priority streams for restoration through the NPS management program.
    d. Streams currently attaining water quality standards in priority watersheds will be considered for protection through the NPS management program.
3. Encourage the General Assembly to require nutrient management plans for the application of poultry litter and animal manure throughout the state.
4. Leverage funding from multiple sources such as Source Water Protection under the Safe Drinking Water Act, administered through the ADH, to address NPS pollution in watersheds with drinking water sources.

Implementation Plan

The following steps will be considered in implementing the recommendations:

1. Evaluate and assess the fiscal needs of the NPS management program, including existing federal money, priority watershed needs, both for restoration and protection; and monitoring requirements for documenting water quality changes over time. Continue to leverage funds among programs that reduce NPS pollution.
2. Propose legislation to authorize appropriations specifically for the NPS management program, based on the evaluated needs of the program.
3. Provide data for evaluation and comments on the Arkansas's Impaired Waterbodies List, required under the CWA Section 303(d), focusing on NPS pollution, and NPS management practices to restore streams to their designated uses and protecting streams currently attaining those uses.
4. Participate in the Triennial Review of water quality standards, including the stakeholder workgroup proceedings, to ensure that proposals to change water quality criteria support the goal of protecting the quality of Arkansas's waters and those waters' designated uses.
5. ANRC will facilitate public review of the state nutrient reduction strategy and coordinate implementation of nutrient reduction activities with public and private entities.
6. ANRC will continue to encourage research and education on NPS pollution. An excellent example is Arkansas Discovery Farms, which conduct water quality research on both crop and livestock based production systems and represent the diversity of Arkansas agriculture.
7. Consider an Unpaved Road Initiative with local leaders to include grants and a conservation water resources education component. Training local road and bridge departments and county officials can reduce sediment loading and water quality impairment in rural areas.

3.9 Public Awareness and Education Priority Issue

Issue: Public awareness and education are critical for water planning in Arkansas.

Background

The 2008 Winthrop Rockefeller Foundation Water Issues in Arkansas Report found that the greatest water issue in Arkansas was lack of public awareness and knowledge about water and water resources in Arkansas. This situation has not changed in the 6 years since this report was published, and was reinforced during the scores of public meetings held over the past 2 years in updating the 1990 AWP. This is not surprising, given the complexity of water issues.

As challenges mount for landowners and communities related to environmental concerns, our 75 conservation districts are the first line of defense. Through voluntary, incentive-based programs, outreach and education, as well as having a position of trust with their landowners,' conservation districts have provided assistance to landowners since 1937. Their mission is to improve soil health, enhance water quality and water usage, and provide technical assistance to landowners for such issues as water quality impairment, threatened and endangered species, critical habitat designation, invasive species, wildlife habitat, air quality, and energy-related activities.

Workgroup Concerns

I&R Workgroup members identified the need for public awareness and education not only statewide, but also in every region. While the public awareness and education issues varied among regions, the need for additional public awareness and education on water issues was invariant within and among regions. One challenge is that many water use sectors desire their water use issues receive priority over the issues of other sectors. As a result, the public hears multiple messages that, in many cases, are in conflict with each other. While differences are to be expected, and, in some cases, needed, there are also fundamental themes related to water that are universally true across all sectors.

Goals

- Encourage public engagement in water planning in Arkansas

Recommendation

The following is recommended to address the need for public awareness and education:

1. The ANRC will collaborate with the Arkansas Water Foundation, the Arkansas Association of Conservation Districts, the University of Arkansas Cooperative Extension Service, and others to develop and disseminate public information. This information should focus on water conservation practices being implemented by agriculture in Arkansas, the contributions of agriculture to the economy, food security, the quality of life in Arkansas, advances in water conservation technology, and trends in groundwater and surface water use.

Implementation Plan

The following steps will be considered in implementing the recommendation:

1. Establish a periodic water forum organized and funded through an entity such as the Arkansas Water Foundation. This water forum would bring together leaders from all water use sectors to receive information on water policy, innovative ideas, brainstorm ideas, identify additional stakeholders who should be invited to participate in water forum planning and activities, initiate planning, and commit to improving public awareness and education.
2. Through the water forum and stakeholders from each water sector in each region, integrate and coordinate public awareness and education campaigns and programs formulating consistent messages about water, with illustrations and examples from each of the water use sectors and important regional issues. These efforts would emphasize the inter-relationships with water among all sectors, whether environmental, social, or economic.
3. Periodically review the educational efforts, resurvey, and modify the messages as different media, communication vehicles, technological advances, and public knowledge about water changes over time.

3.10 Supporting Issue 1: Water Use Reporting

Supporting Issue: The accuracy of water use reported for agricultural irrigation has been questioned because the water use is not measured or metered.

The accuracy of water use reported for agricultural irrigation has been questioned because most water use is not measured or metered. Water use reporting, which primarily consists of estimates of the water used, is required for each nondomestic withdrawal site in the state. There are quality assurance criteria embedded within the reporting system to ensure that unreasonable water uses (extreme high or low estimates) are not recorded. For example, reporters of agricultural irrigation withdrawals are required to submit crop acreage by crop type in addition to estimated quantity of water used. An average crop water use factor is applied to estimate water used by the crop type and acreage reported for agricultural irrigation withdrawal permits. An average water use for irrigating rice, for example, might range between 32 and 38 inches per acre. If the reported use for rice were significantly outside this range, the estimated water use would not be accepted at the time of reporting.

Recommendations

To address the issue of water use reporting for agricultural irrigation, it is recommended that:

1. ANRC should form an Agricultural Irrigation Science Technical Work Group to:
   a. Review the water use reporting process for agricultural irrigation,
   b. Modify the ranges for accepted water use by crop type, if needed for greater accuracy,
   c. Evaluate various quality assurance criteria and approaches for confirming crop type and acreage,
   d. Assess the adequacy of the surface water and groundwater monitoring network in providing confirmation of the aggregate or cumulative withdrawal of groundwater and surface water for agricultural irrigation, and
   e. Propose incentives for agricultural users to report water use more accurately.
2. This workgroup should also periodically review advances in technology for measuring and estimating water use and water use reporting and provide recommendations to the ANRC on incorporating these advances in their water use reporting programs.
3. Finally, ANRC should continue and improve awareness and education programs, in conjunction with conservation districts, to explain and promote the water use reporting program currently in place and any future improvements.

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
Conjunctive Water Management and Groundwater Decline **Issue: Declining water levels in the aquifers and the need to move toward sustainable use of groundwater.**	▪ A1. Groundwater levels are declining in the alluvial aquifer in the Grand Prairie region and the area west of Crowley's Ridge. ▪ A2. Water levels are declining in the Sparta Sand aquifer of the Gulf Coastal Plain. ▪ G1. Cities and towns along Hwy. 67 from Searcy to near Arkadelphia presently lack, or will in the future, adequate water supplies to support economic expansion because groundwater supplies are limited, to nonexistent, along the corridor.	▪ A1. The most efficient response to the problem of declining water levels is conversion from groundwater to surface water, and employment of a conjunctive use management strategy. ▪ A2. The most efficient response to the problem of declining water levels is conversion from groundwater to surface water, and employment of a conjunctive use management strategy. ▪ G1. Develop and implement a master plan for distribution of water from existing reservoirs and develop new reservoirs.	▪ Groundwater Recommendation 1: ANRC will seek opportunities to purchase, install, and read meters on selected alluvial wells. ▪ Groundwater Recommendation 2: Develop and implement conjunctive water management strategies based on storing surface water during months when excess water is available, for use during the summer irrigation months when excess surface water is not available (Figure 3-1). Groundwater use would supplement surface water use, rather than being the primary irrigation water source. ▪ Groundwater Recommendation 3: Encourage and increase irrigation water use efficiency through integrated irrigation water management and conservation practices over the next decade.
Tax Incentives for Integrated Irrigation Water Conservation **Issue: Tax incentives and credits are needed to encourage the implementation and management of integrated irrigation water conservation practices.**	▪ D3. Water conservation needs to be more aggressively used as an alternative to development to meet future needs.	▪ D3. Water conservation methods must be encouraged by providing both education about current methods and technical assistance from the ANRC and conservation districts. Conservation plans should be developed and implemented as a condition of eligibility for commission programs.	▪ Conservation Recommendation 1: Determine the current irrigation water use efficiency for various crops and subwatersheds in the East Arkansas Region and establish a goal or target efficiency to be achieved for integrated irrigation water management and conservation practices. ▪ Conservation Recommendation 2: Evaluate the effectiveness of the existing tax credits and incentives and, based on this assessment, consider: – Increasing the percentage of the total project cost available for tax credits, based on applicants improving their irrigation water use efficiency compared with the goal or target efficiency; – Extending the period for claiming tax credits for implementing water conservation practices; – Increasing the annual cap on tax credits so additional tax credits can be claimed; and – Tracking the acreage on which water conservation practices have been

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
			implemented along with the tax credits.
Funding Water Development Projects **Issue: State-issued general obligation bonds are vital to finance and re-finance the development of water, navigation, waste disposal, pollution control, abatement, and prevention; drainage, irrigation, flood control, wetlands, and aquatic resources projects to serve the citizens of the State of Arkansas.**	▪ E1. The ANRC lacks the authority to require conformance with the Plan. Federal Water Policy requires cost sharing by local sponsors, who in turn request state assistance. The need exists to prioritize these projects. ▪ E2. Some levee and drainage districts fail to perform proper maintenance after the debt service is paid off. ▪ H1. Impaired drainage and floodwater damages are continuing to greatly limit agricultural production in Arkansas.	▪ E1. Amend Act 217 of 1969, as amended, to require AWP compliance and provide for a mechanism for establishment of a state priority when assistance is requested and/or required under a federal program. ▪ E2. Oversight control to ensure proper operation and maintenance should be authorized at the state level. ▪ H1.The ANRC should cooperate with federal agencies and local communities to provide appropriate assistance in addressing the adverse impacts on agricultural production caused by impaired drainage and floodwaters.	▪ Development Projects Recommendation 1: As an initial step, authorize an additional $300 million under the Water, Waste Disposal, and Pollution Abatement Facilities General Obligation Bond Program at the appropriate time. Additional authorization will be requested as needed to finance and refinance the development of these water resources projects. ▪ Development Projects Recommendation 2: ANRC will seek the authority to merge water or sewer systems where necessary in order to bring them into economic viability.
Public Water and Wastewater Infrastructure **Issue: Public water and wastewater infrastructure is failing, and in need of repair and replacement throughout Arkansas.**	▪ F1. Local governments participating with the federal government in water resource development projects must enter into a local cooperation agreement (LCA) that requires varying rates of cost sharing that cannot be provided without assistance from some source. Current state financial assistance programs contain restrictions on type of assistance available to local sponsor and type of water resources projects that may be funded. ▪ F2. Most water and wastewater projects across the state cannot be financed by loan only. To keep water and sewer rates within acceptable levels, sources of grants or deferred loans must be established and maintained. ▪ F3. Arkansas communities need an estimated $460 million to construct currently needed sewage collection and treatment facilities. The Farmers Home Administration – the traditional source of loans for both water and sewer projects – has insufficient funds to fill this need. ▪ G3. The most extensive groundwater problem in the Interior Highlands of Arkansas is the	▪ F1. Authorize a water resources development project financing program under the authority and management of ANRC specifically for the purpose of assisting local entities in meeting their obligations under the terms of LCA(s). ▪ F2. Additional financing of the Water Development Fund and the Water Sewer and Solid Waste must be appropriated. Therefore, amending Act 81 of 1957 to set the minimum dam permit fee at $25.00; raising the fee per AF to $0.05; and establishing application review fee of 1 percent of estimated constructed costs with a minimum fee of $100.00, and a maximum fee of $500.00 will increase revenues to the fund by $21,000/year. ▪ F3. Implement issuance of bonds under the Arkansas Waste Disposal and Pollution Abatement General Obligation Bond Program, which was passed by the legislature in 1947. ▪ G3. There are two solutions to this problem: Drill deeper wells into high yielding aquifers such as the Roubidoux and Gunter, in areas where the aquifers are available and contain good quality water; and development of	▪ Infrastructure Recommendation 1: Public entities operating water and wastewater infrastructure, and flood control and drainage projects should develop sustainability plans that evaluate: – Current infrastructure status and historical trends in status; – Needed infrastructure repairs, replacement, and maintenance and associated schedules; – Federal and state programs available to support infrastructure projects; and – Contingency plans, including the potential for regionalization or privatization (private water wells, septic systems, decentralized systems, etc.), if the utilities are assessed to be unsustainable. ▪ Infrastructure Recommendation 2: Receivership proceedings should be initiated for public water and wastewater providers that have defaulted on loans. ▪ Infrastructure Recommendation 3: Training programs should be developed for utility boards of directors on sustainability planning and how these plans relate to the operation of their

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
	naturally occurring low yield of water and poor quality in shallow formations.	surface water resources by importation or construction of impoundments.	facilities and infrastructure. Utilities that submit a sustainability plan with financial assistance applications could receive lower rates on loans.
Excess Water for Nonriparian Withdrawal and Use **Issue: The statutory definition of excess water should be based on sound science.**	▪ B1. Water use along Bayou Meto and Plum Bayou far exceeds the supply during irrigation season. ▪ B2. Water demand in the Boeuf Basin and Bayou Bartholomew exceeds available supplies during irrigation season. ▪ B3. Use of excess surface water will be required in order to reduce current groundwater pumpage by approximately 20 percent and to provide for future needs. Authorization of such use must be provided in a manner so as to negate adverse impacts to instream needs. ▪ D1. Water may not be available from natural flows for direct diversion from surface sources for irrigation in dry years. ▪ D2. The authority to manage excess surface water at the local level is ambiguous. ▪ D4. Over 26 million AF of water is being allowed to flow downstream due to the 25 percent limit on water transfer in Act 1051. ▪ I1. Proposals to develop surface water supply sources are often in conflict with efforts dedicated to the preservation and conservation of significant streams so they can be enjoyed by present and future generations. ▪ I2. Water resources development projects often have significant environmental effects.	▪ B1. Excess water should be provided from the Arkansas River to Plum Bayou and Bayou Meto. ▪ B2. Excess water should be provided from the Arkansas River to Boeuf Basin and Bayou Bartholomew. ▪ B3. Implement Rules and Regulations as defined in Appendix A of 1990 AWP ▪ D1. Storage reservoirs, both public and private, should be constructed and present storage reallocated to provide low flow augmentation during the irrigation season. Incentives under a federal program should be provided for on-farm storage. ▪ D2. Rules and Regulations are recommended for adoption to implement provision for authorization of nonriparian use of surface water. ▪ D4. Increase the percentage that may be transferred to 75 percent. ▪ I1. If it is determined to be in the interest of the state to construct impoundments, a recreation/ conservation purpose should be included. ▪ I2. Water resources development projects can and must be designed to minimize takeoffs between economic and environmental concerns.	▪ Excess Water Recommendation 1: A deficit of legally available water has been identified within certain basins of the East Arkansas Region. The General Assembly should consider raising the 25 percent limitation for permitting excess surface water within these basins for nonriparian transfer upon completion of scientific studies in East Arkansas validating the need for an increase and confirming water is seasonally available to protect and sustain instream, riparian, and other uses specified in state law. Similar scientific analyses should be conducted in the remaining planning regions in this order: South-central, West-central, North, and Southwest. These studies will be conducted in collaboration with AGFC, ADEQ, ADH, and other state, regional, and local agencies with constitutional and statutory water management duties. ▪ Excess Water Recommendation 2: Continue to use the Arkansas Method (Filipek et al. 1987) in estimating the proportion of total available water needed to satisfy fish and wildlife flow needs in estimating excess water for nonriparian withdrawals and transfers. Through adaptive management, the ANRC will evaluate and assess alternative methods for estimating fish and wildlife flows, or other instream needs and uses, as more accurate, scientifically reviewed, and defensible methods become available. ▪ Excess Water Recommendation 3: Engage stakeholders in the planning regions through an open and transparent process as the scientific study is being conducted by ANRC and as better scientific approaches become available and are proposed for use.

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
Drought Contingency Response **Issue: Planning for allocation during drought is needed before droughts occur.**			▪ Drought Recommendation 1: Develop a coordinated drought contingency response network among state and federal agencies, drinking water utilities, organizations, and institutions, and the private sector for alerting the public about impending droughts, sharing consistent messages and information, and providing information on voluntary conservation measures to reduce water use. ▪ Drought Recommendation 2: Seek financing and ensure stream gaging networks throughout the state are adequate to provide streamflow information needed to make informed decisions about impending or advancing droughts statewide and within each planning region.
Reallocation of Water Storage in Federal Reservoirs **Issue: Reallocation of water storage in USACE reservoirs is needed to increase available water for existing and new uses.**			▪ Reservoir Recommendation: Reallocation of water storage in USACE reservoirs, based on the revised 1977 Water Supply Act guidance manual, be sought if there is a documented need for additional water for domestic, municipal, or industrial water supply.
Improving Water Quality through NPS Management **Issue: Water quality is affected by nonpoint sources of pollutants and NPS management projects need state money in addition to federal funding.**	▪ C1. Much of the problem in water-quality degradation is from NPS pollution. ▪ G2. Many areas along the Arkansas River have insufficient sources of water for municipal, industrial, and agricultural uses. Where water is not suitable due to economic or quality reasons, the development of off-stream tributaries or off-stream storage to catch water of the Arkansas River, when quality is acceptable, should be encouraged. ▪ G2. Develop and implement a master plan for distribution of water from the Arkansas River and existing reservoirs. Develop new reservoir sites as needed to satisfy projected needs.	▪ C1. The ANRC, in cooperation with the conservation districts and with technical assistance provided by the USDA Soil Conservation Service, should initiate an aggressive information and education program to encourage implementation of BMPs to curtail nonpoint sources of pollution.	▪ NPS Recommendation 1: Propose legislation to designate money specifically for financing NPS pollution management programs and implementing NPS management practices. ▪ NPS Recommendation 2: ANRC will collaborate with ADEQ, AGFC, ANHC, ADH, USGS, and other state, regional, and local agencies/organizations that engage in or have water quality management interest through: – The biennial CWA water quality review processes, and – The water quality criteria review to determine attainment or nonattainment of water quality standards in streams and identify the sources and causes of nonattainment. – Streams impaired because of NPS pollution

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
			will be considered as priority streams for restoration through the NPS management program. – Streams currently attaining water quality standards in priority watersheds will be considered for protection through the NPS management program. ▪ NPS Recommendation 3: Encourage the General Assembly to require nutrient management plans for the application of poultry litter and animal manure throughout the state. ▪ NPS Recommendation 4: Leverage funding from multiple sources such as Source Water Protection under the Safe Drinking Water Act, administered through the ADH, to address NPS pollution in watersheds with drinking water sources.
Public Awareness and Education **Issue: Public awareness and education are critical for water planning in Arkansas.**	▪ J1. The public is generally unaware of the nature of problems associated with effective conservation and use of our water resources. Many individuals with legal and planning responsibilities at the local level are not trained in resource management.	▪ J1. Legislative and Executive action is needed to provide finances and personnel for the development of a statewide information, education, and awareness program that will train local authorities and managers about water issues and their broad implications for resources planning.	▪ Awareness Recommendation: The ANRC will collaborate with the Arkansas Water Foundation, the Arkansas Association of Conservation Districts, the University of Arkansas Cooperative Extension Service, and others to develop and disseminate public information on water conservation practices being implemented by agriculture in Arkansas, advances in water conservation technology that are emerging, trends in groundwater and surface water use, and the contributions of agriculture to the economy, food security, and quality of life in Arkansas.
	▪ C2. Saltwater intrusion is a significant problem in several aquifers of Arkansas as described in Section V.B. Saltwater contamination also occurs where oil, gas, and water wells penetrate saltwater aquifers that are under artesian pressure.	▪ C2. Halting the migration of saltwater into freshwater zones can be accomplished by reducing groundwater withdrawals in the areas where migration is occurring, and by better well construction and abandonment practices. Ideally, groundwater withdrawals should be guided by a sustained yield pumping strategy. Existing regulatory agencies should be given continued support. Federal regulations will likely be imposed if the state does not act.	

Table 3-1. Comparison of Issues and Recommendations in the 1990 AWP and the AWP 2014 Update

Issues from 2014 Plan	Issues from 1990 Plan	Recommendations from 1990 Plan	Recommendations from 2014 Plan
	▪ C3. Poorly constructed and abandoned oil, gas, and water wells threaten the water quality of our groundwater throughout the state.	▪ C3. Programs to encourage location of abandoned wells should be implemented to lessen groundwater contamination potential from surface runoff. County-wide projects should be given financial and technical assistance.	
	▪ E4. Act 14 of 1963 treated the ANRC and gave it powers of the old Water Conservation Commission under Act 81 of 1957. Both these acts have been amended several times and are in some instances, in conflict with themselves.	▪ E4. Acts 217 and 81 should be updated to resolve any conflicts and to reflect the current status of administrative law.	
Water Use Reporting **Supporting Issue: The accuracy of water use reported for agricultural irrigation has been questioned because the water use is not measured or metered.**	▪ E3. Crop data reporting from several agencies are not in agreement. There are at least four different sources of crop data. In addition, water use reporting is required by legislation; however, the accuracy of the data being reported is questionable.	▪ E.3 There must be a greater degree of accuracy in crop and water use data. Additional technical assistance and flow measurement equipment is needed in order for conservation districts to provide the level of service necessary to attain the degree of accuracy required. A penalty should be assessed for not reporting a water use of more than 5 AF (1,629,500 gallons).	▪ Supporting Recommendation 1: ANRC should form an Agricultural Irrigation Science Technical Work Group to: – Review the water use reporting process for agricultural irrigation. – Modify the ranges for accepted water use by crop type, if needed for greater accuracy. – Evaluate various quality assurance criteria and approaches for confirming crop type and acreage. – Assess the adequacy of the surface water and groundwater monitoring network in providing confirmation of the aggregate or cumulative withdrawal of groundwater and surface water for agricultural irrigation. ▪ Supporting Recommendation 2: This workgroup should also periodically review advances in technology for measuring and estimating water use and water use reporting and provide recommendations to the ANRC on incorporating these advances in their water use reporting programs. ▪ Supporting Recommendation 3: ANRC should develop awareness and education programs, in conjunction with conservation districts, to explain and promote the water use reporting program currently in place as well as future improvements.

4 Implementation

Water is the lifeblood of the Arkansas economy, so sustainable management, conservation, and development of Arkansas's water resources is critical to the state. Water planning for current and future needs will continue. The AWP 2014 Update builds on successes of the past, and more importantly, it calls on water managers, decision-makers, and members of the general public alike to seize future opportunities.

4.1 Implementation Progress

Since the completion of the 1990 AWP, the state has seen progress and successes in implementing the AWP. While it is important to recognize that the large-scale water projects have progressed slowly because of the many obstacles that often face projects today, there have been some notable successes. The following summary provides just a few examples of progress that has been made and milestones that have been met on the priority water development efforts over the course of the last 24 years.

In the 1990 AWP, 28 policy issues were identified, vetted, and recommendations adopted for the following policy areas—groundwater depletion (two issues), surface water depletion (three issues), water quality (four issues), water management (four issues), legal and institutional considerations (four issues), financial assistance needs for water development, (four issues), drinking water-supply deficiencies (three issues), impaired drainage and floodwater damages (one issue), environmental and recreational considerations (two issues), and public awareness of resource problems (one issue). The 1990 AWP issues and recommendations are shown in Table 3-1.

To illustrate implementation successes, several projects and programs are described below. These descriptions are by no means an exhaustive catalog of AWP implementation.

OVERARCHING THE WORK DONE TO ADDRESS THE ISSUES DISCUSSED BELOW IS THE ABILITY OF THE STATE OF ARKANSAS TO ASSIST IN THE FINANCING OF WATER AND SEWER PROJECTS, A MAJOR AND PERENNIAL FOCUS OF ARKANSAS WATER PLANNING.

4.1.1 Grand Prairie Area Demonstration Project

Issue A.1 in the 1990 AWP concerned the decline of groundwater levels in the Grand Prairie region and the area west of Crowley's Ridge. The Grand Prairie Area Demonstration Project (GPADP), when operational, is expected to slow the decline of groundwater in the aquifers in the Grand Prairie critical groundwater area by providing surface water for crop irrigation. In 1991, the U.S. Congress empowered USACE to develop the GPADP in cooperation with the ANRC, NRCS, and White River Irrigation District (WRID) to find and implement an effective solution to the problem of groundwater resources depletion.

The GPADP includes construction of new reservoirs on approximately 8,800 acres of farmland providing more than 1,000 farmers in Arkansas, Lonoke, Monroe, and Prairie counties with surface water for irrigation. The project will have 102 miles of canal and 290 miles of pipeline, and, when completed, will double the current amount of usable above-ground water storage in the form of reservoirs and tailwater recovery systems. The GPADP also includes a pumping station on the White River at DeValls Bluff that is capable of lifting 1,640 cubic feet per second from the river's flow during specific times of the year to help keep the on-farm reservoir network supplied. On an as-needed basis, farmers will use this water to irrigate their crops or flood their rice fields. Water that does not infiltrate or evaporate will be recovered by a ditch and pipeline system and pumped back to the reservoir.

White River – *Photo courtesy of USDA-NRCS*

The water supply portion of the project is projected to cost $400 million for the primary delivery system and another $100 million for on-farm infrastructure requirements (Carman 2014).[5] To date, a total of $172,000 has been invested in the project ($127,000,000 federal and $45,000,000 nonfederal including farmer's contributions for on-farm recovery systems).

4.1.2 Sparta Recovery in Union County

Issue A.2 in the 1990 AWP concerned the decline of water in the Sparta aquifer. The Sparta aquifer is an important source of groundwater for southeastern Arkansas and northern Louisiana. It is the only viable aquifer in Union County, Arkansas. Prior to 2004, 29 municipalities and rural water associations, and 11 major industries in Union County, used the Sparta as a raw water source. A hydrogeologic model of the Sparta aquifer in Union County, developed in 1999 by the USGS, estimated that in order to restore aquifer levels to the top of the Sparta Sand, groundwater usage in Union County would need to be reduced to about 28 percent of 1997 rates. This represents a reduction from about 21 million gallons per day (mgd) to about 6 mgd. The Sparta aquifer was designated as the state's first Critical Groundwater Area in 1996.

In the late 1990s, stakeholders throughout the county—industry, economic development leaders, elected officials, private citizens, the Arkansas Farm Bureau, the Arkansas Poultry Federation, Rural Water Associations, the Union County Conservation District, state and federal agencies, and others—coalesced to write, support, and enact legislation authorizing the state's first and thus far only county water conservation board. The UCWCB's first project was to provide excess surface water from the Ouachita River as an industrial supply alternative to the rapidly depleting Sparta aquifer. Public hearings throughout the county incorporated stakeholder input, and built consensus that resulted in the unopposed legislation, even though Act 1050 of 1999 also authorized a 24¢ per 1,000 gallon conservation fee on all significant Sparta water consumers.

Ouachita River alternative water supply project intake structure in Union County near El Dorado – *Photo courtesy of Union County Water Conservation Board*

[5] *Operations of the Grand Prairie Area Demonstration Project* (May 2014).

The UCWCB's first actions were to implement the conservation fee and begin developing the $65 million project to provide Ouachita River water as an industrial supply alternative to the rapidly depleting Sparta aquifer.

The UCWCB determined that providing an alternative surface water source to three major industries offered the most feasible, fastest, and most cost-effective way to reduce groundwater consumption, and immediately undertook construction of the $65 million Ouachita River Alternative Water Supply Project. In 2001, the UCWCB again conducted public meetings around the county, this time resulting in county-wide passage of a temporary 1¢ sales tax to complete infrastructure funding. Both the sales tax and the conservation fee have since been eliminated and the debt-free, completed project is funded through water sales.

The project consists of a 65-mgd intake structure and pump station at the Ouachita River, a clarification facility, and a pump station and storage tank approximately 9 miles from the Ouachita River. Over 20 miles of pipeline connects the infrastructure to deliver clarified river water to industrial customers. Converting three of the industries from ground to surface water reduced aquifer water consumption by over 6 mgd, allowing for aquifer recharge, halting water quality degradation trends, and conserving the Sparta for current and future users. In planning for Union County's future economic development needs, the project currently has a 13-mgd capacity and is expandable to provide an additional 19 mgd.

The first phase was completed in 2002 and serves the project's first and largest customer; Union Power Partners (UPP). UPP designed, built, and paid for the $52 million water infrastructure during construction of its power plant. Upon completion of the water infrastructure, UCWCB reimbursed UPP with $14 million for the incremental cost of doubling the facility's capacity. UPP then deeded the entire $52 million facility to Union County; a gift of historic proportion. The second phase was completed in 2005, serving the clarified water to industrial customers.

Local leadership has been the key to the success of this project. County residents wrote the law that created the state's first critical county conservation board with unprecedented authority over groundwater, allowed themselves to be taxed once, then voted an additional temporary sales tax on themselves to conserve the Sparta aquifer, and provide an abundant supply of water for future growth.

The success of the Ouachita River Alternative Water Supply Project is outstanding. Between October 2004 and April 2014, groundwater levels have risen in all eight USGS real-time monitoring wells in South Arkansas and North Louisiana from about 10 feet to over 70 feet. Water levels in three of the eight monitoring wells (at Smackover, Arkansas; Spencer, Louisiana; and Union School grounds in eastern Union County) are now above the top of the Sparta aquifer.

4.1.3 Bayou Meto Water Management Project

Issue B.1 in the 1990 AWP addressed irrigation water shortages in the Bayou Meto area. The Bayou Meto Water Management Project is planned to divert excess surface water from the Arkansas River to nearly 268,000 irrigated acres that depend primarily on dwindling groundwater supplies. Major features of the project include 4 pump stations, 107 miles of canals, and 464 miles of underground pipelines. The project area includes portions of Lonoke, Prairie, Arkansas, and Jefferson counties. The project has multiple benefits and will provide increased flood control and enhanced waterfowl management. The water supply portion of the project is projected to cost $574 million for the primary delivery system (does not include the cost of on-farm improvements).

On-farm reservoirs increase water security and mitigate the impact of drought – *Photo courtesy of USDA-NRCS*

This project was first funded for construction in 2010. To date, a total of $111 million has been invested in the project ($76 million federal; $35 million nonfederal), and the project is 17 percent complete. Pump Station No. 1 is 100 percent complete, and the Little Bayou Meto pump station (to reduce flooding and manage water for wildlife habitat) is about 92 percent complete.

4.1.4 Plum Bayou Project

Issue B.1 in the 1990 AWP concerned the lack of sufficient water in Plum Bayou during irrigation season. The Plum Bayou Project is an example of one of several projects constructed on a much smaller scale than the Grand Prairie and Bayou Meto. This project pumps excess surface water from the Arkansas River into the bayou for farmers to use to water their crops. A small oxbow lake is also recharged using water from the project. Recreational benefits include boat ramps and sufficient water year-round for fishing. The Plum Bayou project was completed in 1993 at a cost of $977,000 and serves 14,200 irrigated acres. It consists of three pumps with a total capacity of 79,500 gallons per minute (gpm), three road crossings, an irrigation canal, 10.5 miles of underground pipelines, and 77 flow meters. The sponsors are NRCS, ANRC, Lonoke County Conservation District, Pulaski County Conservation District, and the Plum Bayou Irrigation District (USDA 2014).[6] The success of the Plum Bayou project can partially be attributed to the relatively low capital cost that is a result of efficient and innovative utilization of natural features versus infrastructure.

Large pipes convey Arkansas River water to Plum Bayou for farmers to irrigate their crops – *Photo courtesy of ANRC*

Other successful irrigation projects similar in scale to Plum Bayou are Point Remove Wetlands Reclamation and Irrigation District, Walnut Bayou Irrigation Project, and Little Red River Irrigation Project.

[6] United States Department of Agriculture: Natural Resources Conservation Service, COMPLETED IRRIGATION PROJECTS, http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ar/water/?cid=nrcs142p2_034918 (last visited May 21, 2014).

4.1.5 Agricultural Water Conservation

Issue D.3 in the 1990 AWP addressed water conservation as an alternative to development to meet future needs. Since then, farmers in some of the critical groundwater areas were the first to experience the effects of groundwater decline—lower well yields, more expensive pumping, and dry wells. These farmers began irrigating with more surface water, but not always water diverted from a river or stream. Rain and recaptured water stored in on-farm reservoirs is used and reused for crop irrigation. Tailwater recovery systems allow for reuse of the water. Not having to rely solely on groundwater for irrigation is the obvious benefit of on-farm storage and reuse. Other benefits are decreased pumping costs, sometimes lower fertilizer cost, and water quality benefits of not allowing runoff of sediment and nutrients into streams. As an example of potential cost savings, Henry et al. (publication pending) report that the cost of rice irrigation in Arkansas averages about $44 per acre in fields with surface water sources and about $75 per acre in fields with groundwater sources.[7]

4.1.6 Nonpoint Source Pollution

NPS is rainfall or snowmelt moving over and through the ground that picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, streams, wetlands, and even underground sources of drinking water. It does not include regulated "point sources" such as wastewater discharges. Issue C.1 in the 1990 AWP identified NPS pollution as the primary water quality concern in the state. Since then, a number of federal and state programs have been initiated that encourage, support, or require implementation of BMPs to reduce NPS pollution.

At the federal level, the EPA and USDA-NRCS have made significant efforts to reduce NPS pollution. In 1987, a grant program for NPS management projects was established through the CWA Section 319 (33 USC sec. 1329).

Arkansas took full advantage of this program to implement the 1990 AWP. Since 1990, ANRC has been the lead agency for the Arkansas NPS Pollution Management Program. This program provides planning and targeting for the federal, state, and local programs addressing NPS pollution, through the Arkansas NPS Management Plan, and supporting development of watershed management plans. This program also supports water quality monitoring to document the effectiveness of NPS pollution BMPs. Over $22 million of grant money has been spent in Arkansas on implementing NPS pollution management practices. Since the program requires matching from participants, approximately $22 million has been contributed by nonprofits and state and local government sources for these projects. It has been estimated that BMPs implemented from 2000 through 2012 could reduce NPS nitrogen loads by 450,000 pounds per year, phosphorus loads by 200,000 pounds per year, and sediment loads by 690,000 tons per year.

In addition to the ANRC's Section 319 grant program, federal, state, local, and private, nonprofit entities have worked to reduce NPS pollution.

Big Piney Creek – *Photo courtesy of ANRC*

In 1990, EPA initiated a stormwater quality regulatory program that applies to Municipal Separate Storm Sewer Systems (MS4) for urban areas meeting certain population criteria. The goal of the MS4 program is to improve the quality of stormwater runoff from urban areas through the use of BMPs. In 2013 there were over 55 Arkansas communities involved in this program.

In 2007, EPA began an initiative to encourage and support the voluntary use of green infrastructure BMPs for management of urban stormwater quantity and quality. As part of this initiative, Section 319 funds can be used by nonMS4 communities for green

[7] G. Henry, E. D. Vories, M. M. Anders, S. L. Hirsh, M. L. Reba, K. B. Watkins, and J. T. Hardke, *Characterizing Irrigation Water Requirements for Rice Production from the Arkansas Rice Research Verification Program*, UNIVERSITY OF ARKANSAS RICE RESEARCH AND EXTENSION CENTER, (2013, publication pending).

infrastructure projects. EPA funding has been utilized for green infrastructure projects in Rogers, Fayetteville, Little Rock, Faulkner County, and the Illinois River watershed.

In 2007, the National Forest Service also initiated a strategy for helping communities and private landowners manage land for public and ecosystem benefits. The Southern Region of the National Forest Service and the Southern Group of State Foresters committed funding for green infrastructure planning. An award-winning green infrastructure plan for Washington County was funded through this program in 2009.

Several NRCS programs provide technical and funding assistance for BMPs and other activities to reduce NPS water quality impacts of agricultural activities. NRCS agricultural conservation easement programs (Conservation Reserve Program and Wetland Reserve Program) provide incentives and technical support to landowners for protecting and restoring environmentally sensitive lands and wetlands to improve water quality. Between 1996 and 2013, landowners throughout the state received over $200 million to conserve and restore over 2 million acres through NRCS conservation easement programs.

Several NRCS initiatives have addressed water quality concerns in Arkansas, including the Mississippi River Basin Healthy Watershed Initiative, the National Water Quality Initiative, and the Illinois River Sub-basin and Eucha-Spavinaw Lake Watershed Initiative. These initiatives, as well as the Environmental Quality Incentives Program, provide technical and financial assistance to landowners for BMPs to reduce NPS pollution and improve water quality. Between 2005 and 2012, NRCS provided over $150 million of financial assistance to landowners for implementing water quality BMPs on over 4 million acres in Arkansas through these initiatives and programs.

State programs to address NPS pollution have also been initiated since the 1990 AWP. Examples include establishment of wetland and stream mitigation banks, tax incentives for creation and protection of riparian buffers and wetlands, and nutrient surplus areas and associated nutrient management programs. Twenty-three sites in Arkansas have been designated as mitigation banks since 1990.

In 1995 the state legislature established a tax credit incentive for creation and restoration of wetlands and riparian areas to improve water quality. Since 1997 the Wetlands and Riparian Zone Creation, Restoration, and Conservation tax credit program has received over 100 applications with a total of approximately 2,757.35 acres and 9,115.62 linear feet of wetland and streambank restoration, and 12.7 acres donated for a conservation easement to reduce sediment loading in eight different Arkansas streams for a total of $2,297,535 in tax credits to landowners in several Arkansas counties.

In 2003, the legislature established state nutrient surplus watersheds (termed "nutrient surplus areas"), and regulations for poultry litter and commercial fertilizer application within these areas. This legislation requires poultry production operations anywhere in Arkansas above a specified size to register with the state and registered operations within nutrient surplus areas to prepare and implement nutrient management plans, and established requirements for training and certification of nutrient applicators and planners that work within nutrient surplus areas. Several waterbodies in the nutrient surplus areas are exhibiting declining phosphorus levels, a condition that is attributed in part to improved management of NPS nutrient pollution.

4.2 2014 AWP Implementation

Ongoing review and update of the AWP is essential to ensure that we successfully evaluate emerging issues and prepare ourselves to meet future challenges. The AWP 2014 Update priority I&Rs were presented with detailed issue-specific implementation plans that are addressed to a wide variety of agencies, organizations, and decision-makers in Section 3. Thus, implementation of the AWP 2014 Update recommendations, subject to changing needs, will require a cooperative and coordinated effort. In addition to the issue-specific implementation plans (see Section 3), broader actions will help make the water planning process continuous and successful. These actions are stakeholder involvement, scheduled review and updates, and public education.

The AWP 2014 Update provides the policy framework through which the state manages its water resource programs. As water management is within the jurisdiction of multiple federal, state, and local entities, implementation will require the cooperation of those agencies that have a constitutional or statutory authority or responsibility for water resources management. These agencies may cooperate as an informal workgroup on water policy to assist and track the progress of the implementation of the AWP 2014 Update recommendations. Communication and information sharing will aid the directors of these agencies in allocating their agency resources to implement components of the AWP 2014 Update. The workgroup has the potential to assist the ANRC in assessing the AWP 2014 Update recommendations for economic, technical, environmental, and political feasibility; developing rulemaking initiatives; and turning AWP 2014 Update recommendations into actions.

4.2.1 Stakeholder Involvement

Public input is vital to any planning process. The AWP 2014 Update planning process has offered Arkansans a unique opportunity to help decide how the state's water resources should be managed. The AWP 2014 Update has been significantly enhanced by the willingness of the Arkansas community to participate in its development, and to share thoughts, ideas, and perspectives. A successful planning process leads to implementation, which most often occurs with broad stakeholder support. Three types of stakeholder groups are envisioned for implementing the AWP 2014 Update:

- **Regional Groups**—These groups were established during the AWP update process. They consist of people who volunteered to participate based on their interest in water planning in their area of the state. The ANRC will continue to foster these interests involving these groups in reviewing reports, information, proposals, or projects that affect their areas. The regional groups can provide region-specific insight to proposed implementation projects or actions.

- **Issue-specific Implementation Teams**—These teams will be composed of appropriate state agency staff and stakeholders who express an interest in working on specific issues. These teams will be tasked with following through on the implementation plan presented with each AWP 2014 Update priority issue.

- **Agricultural Irrigation Science Technical Workgroup**—As outlined in Section 3, this workgroup will include technical experts and stakeholders who will assist in ensuring the best possible data and science is used to make agricultural water use policy. The ANRC Executive Director will empanel this workgroup.

4.2.2 Scheduled AWP Updates

The AWP is based on a comprehensive planning process that addresses all core water planning elements. However, an exhaustive approach is not necessary for the production of valuable, incremental updates. For example, updates to irrigation application rates for the purpose of revising and refining water demand projections will be useful without waiting on a full update of the AWP. ANRC will continuously update planning data by systematically monitoring, collecting, analyzing, and reporting updated estimates of water availability, demands, and challenges on recurring report cycles. Examples of this ongoing work include the annual Arkansas Groundwater Protection and Management Report, the Nonpoint Source Pollution Management Plan, and resource assessments conducted by conservation districts.

ANRC will continuously work with stakeholders, conduct region-specific water studies, and provide revised estimates of water use by sector, by water user, and by region.

Water demand and supply availability forecasts should be used to perform gap analyses for nonpopulation-driven uses, such as agriculture, industry, and thermoelectric power generation approximately every 5 years. The data compilation, analysis, gap-identification, and I&R processes will benefit from the full involvement of the public as did this update.

For AWP updates associated with the national census (draft census results are routinely released in April-May of the year after census, with the next release being in 2021), a more comprehensive planning effort will be warranted. The census-based AWP update should focus on public water supply and include:

1. Updates to population projections and updates to water demand projections;

2. Updates to water supply availability (quantity and quality) evaluations;

3. Updates to gap analyses;
4. Updates to cost information for water management strategies; and
5. Full public involvement.

4.2.3 Public Education and Awareness

During the AWP 2014 Update process, the ANRC has actively involved the public and provided information on the progress of the AWP. Public awareness and appreciation for the AWP 2014 Update is a critical part of implementing the recommendations in the AWP 2014 Update, particularly when implementing recommendations that require additional public investment or changes in water management practices. As was shown in Union County with the Ouachita River Alternative Water Supply Project, when the public understands and agrees with the purpose and need for a project, they will support it. Public involvement work will not always take the form of workgroup meetings, but will also include continuing presentations to interested groups, active involvement in water conferences, developing and maintaining internet and social media tools, and distributing newsletters on a routine basis.

5 General Description of the State

This section provides a general description of the state to serve as background for updated discussion and analysis of state water supplies, water use and demand, and alternatives for managing water resources in Arkansas. It includes general descriptions of surface and groundwater resources and the associated physiography, geography, geology, ecoregions, climate, and land uses found within the state. It also includes general descriptions of federal and state laws, regulations, and programs that apply to managing water resources.

5.1 Physical Environment

Understanding the physical environment of the state is important to recognizing the ubiquitous role that water plays. There are complex interactions between the geology, climate, hydrology, and the imprint of the people that reside here. A detailed description of the physical environment is provided in Appendix I.

5.1.1 Landforms and Geology

Arkansas is divided into two major physiographic regions whose boundaries divide the state into nearly equal parts—the Interior Highlands that includes the Ouachita and the Ozark Plateaus provinces; and the Coastal Plain province (**Figure 5-1**). The Interior Highlands include the part of Arkansas that lies northwest of a line passing from a point on the Missouri boundary near the northeast corner of Randolph County southwestward through Little Rock to a point near Arkadelphia and thence nearly due west to the Oklahoma border. The Gulf Coastal Plain province includes two sections—the West Gulf Coastal Plain, located in the southwestern portion of the state; and the Mississippi alluvial plain, located in the eastern part of the state (see http://tapestry.usgs.gov/physiogr/physio.html).

The Interior Highlands occupy about 25,155 square miles, or 48 percent of the total area of the state. The Ozark Plateaus include two prominent physiographic sections—the Springfield-Salem Plateaus that represent a karst terrain and erosional topography; and the Boston Mountains, a northward-facing escarpment that consists of uplifted sedimentary formations. The Ouachita province includes the Ouachita Mountains, which consist of narrow ridges and valleys of folded sedimentary strata, and the Arkansas Valley, which includes the Arkansas River Valley alluvial strata, and the prominent isolated mountain structures such as Mount Magazine, Mount Nebo, and Pinnacle Mountain, commonly referred to as "monadnocks." The lithology of the Interior Highlands generally is described as consolidated strata of sandstone, shale, dolostone, limestone, chert, novaculite, and some shallow alluvial deposits along the Arkansas River and other streams.

The Gulf Coastal Plain occupies about 27,370 square miles, or about 52 percent of the total area of the state. It is a southward-sloping, hilly terrain of unconsolidated sedimentary strata that eventually dips beneath the Mississippi River Valley alluvial plain, a relatively flat topographical plain with underlying clay, silt, sand, lignite, and gravel strata.

A prominent geophysical feature located within the Mississippi River Valley alluvial plain is Crowley's Ridge. This ridge extends from southeastern Missouri to near Helena in eastern Arkansas, and has a topographic prominence of 250 to 550 feet above the mean elevation of the surrounding alluvial plain. The ridge consists of underlying sand and clay strata, which divides the surrounding alluvial plain, and a surface layer of fine-grained loess deposits.

Arkansas River bank – *Photo courtesy of Arkansas Natural Heritage Commission*

The Interior Highlands and the Gulf Coastal Plains are divided by the "Fall Line"; a prominent geophysical and hydrogeologic line generally identified as the line between the consolidated Paleozoic formations of northwestern Arkansas, and the unconsolidated Cretaceous, Tertiary, and Quaternary sand and clay strata of southeastern Arkansas. "This line is one of the most strongly marked physiographic and cultural lines on the surface of the

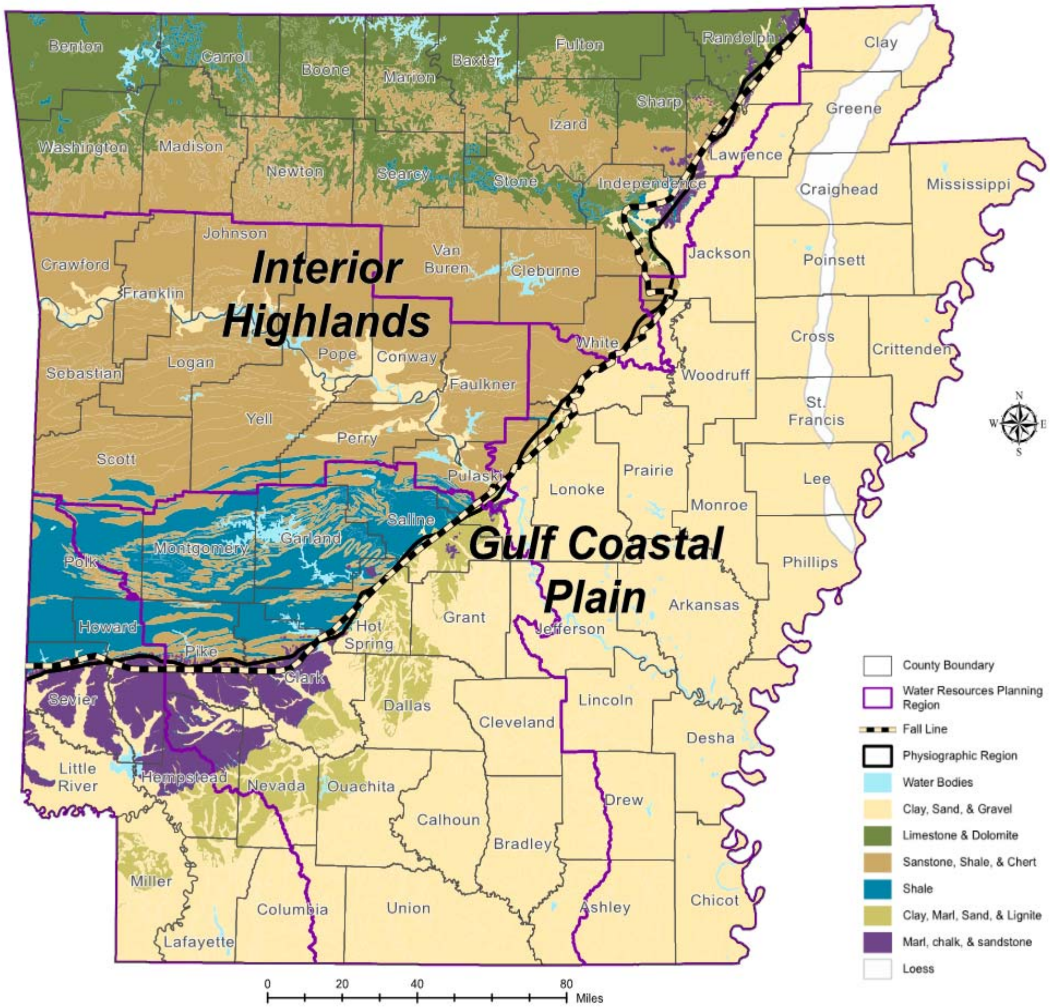


Figure 5-1. General Geology of Arkansas

globe" (McGee 1988).[8] The Fall Line may be viewed as a separation of Arkansas into the two major regions that impacts the state's geology, hydrology, culture, agriculture, demographics, and economics.

5.1.2 Climate

Strongly influenced by the Gulf of Mexico, the climate of Arkansas is humid sub-tropical and is characterized by long summers, relatively short winters, and a wide range in temperatures. Summaries of temperature, precipitation, and evaporation data are presented below, along with discussions of factors that influence Arkansas's climate and long-term climate trends in the state. A detailed description of climate in the State of Arkansas is in Appendix I.

[8] McGee, American Journal of Science (1988).

Average annual temperatures vary little over the state. However, extremes in temperature can vary from winter lows around 0 degrees Fahrenheit (°F) to summer highs above 100 °F. The average growing season ranges from 180 days in the northwest to more than 230 days in the southeast (National Oceanic and Atmospheric Administration National Climatic Data Center [NOAA NCDC] 2013b).[9]

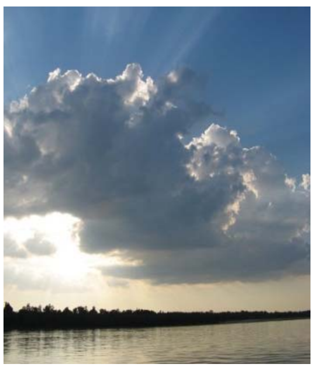
The interaction of warm, moist air from the Gulf of Mexico to the south with dry, cool air from the Rocky Mountains to the west strongly influence weather in Arkansas (Buckner 2011).[10] Weather patterns in the

[9] NOAA NCDC, *Climate of Arkansas*, NOAA NATIONAL CLIMATIC DATA CENTER, http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AR_01.pdf (last visited May 15, 2013).

[10] E. Buckner, *Climate and Weather,* ENCYCLOPEDIA OF ARKANSAS HISTORY AND CULTURE,

state are also influenced by the Ozark Mountains and the Ouachita Mountains (NOAA NCDC 2013b).[8] These mountains can cause moist air from the Gulf of Mexico to rise, producing rainstorms. The flat terrain of the eastern part of the state offers little friction to slow down these storms, allowing them to become stronger as they move east across the state (Buckner 2011).[9]

Arkansas is a precipitation-dominated state. Average precipitation in the state ranges from 43 to 69 inches per year. Late spring and late fall are typically the wettest months, while August is typically the driest month. Although the state receives precipitation throughout the year, droughts of short duration are frequent and are accentuated by high evaporation rates during the growing season. Periods of multiple consecutive years of drought have occurred in Arkansas, including 1930 - 1935, 1953 - 1957, and 1963 - 1967. During these periods, large areas of the state experienced conditions that were classified in the Palmer Drought Severity Index as severe or extreme drought for a number of consecutive months (National Weather Service 2013, NOAA NCDC 2013a).[11] The state is currently experiencing a period of mild to moderate drought that began in 2011.



Clouds over Camp, Arkansas – *Photo courtesy of Arkansas Natural Heritage Commission*

The estimated potential evapotranspiration is highest in July, and exceeds the normal precipitation 6 months out of the year. Potential evapotranspiration rates are lowest during the winter months, when sunlight and plant growth are at a minimum.

In 2007, the Arkansas Governor's Commission on Global Warming was established to evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The commission's literature review identified the following climate change effects anticipated for the state (Arkansas Governor's Commission on Global Warming 2008):[12]

- Increased incidence of severe weather events, flooding and drought;
- Possible saltwater intrusion into aquifers resulting from sea level rise; and
- Changes in climatic zones.

5.1.3 Ecology

Seven Level III and thirty-two Level IV ecoregions have been defined within Arkansas. An ecoregion is an area containing generally similar ecosystems, as well as type, quality, and quantity of environmental resources (EPA 2013).[13] These ecoregions represent a diverse range of habitats and are based on perceived patterns of a combination of causal and integrative factors including land use, land surface form, potential natural vegetation, and soils (Omernik 1987).[14] Factors associated with spatial differences in the quality and quantity of ecosystem components, including soils, vegetation, climate, geology, and physiography, are relatively homogeneous within an ecoregion. Within these ecoregions, the AGFC has further classified 47 different land habitats within Arkansas (AGFC 2006).[15] These habitats support a large number of plant and animal species, such that in 2002, Arkansas was ranked as the 19th most biodiverse state in the U.S. (Stein 2002).[16]

Arkansas also ranks in the nation's top tier in natural aquatic biodiversity where there are a number of aquatic and semi-aquatic species that occur only in Arkansas, i.e., endemic species. Almost 200 native fish species, 74 native species of mussel, and nearly 60 native crayfish occur in the state (Robison and Buchanan 1988, Jones-Shulz 2009, Wagner 2011).[17, 18, 19]

http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579 (last visited March 15, 2013).

[11] NOAA NCDC, *Climate at a Glance*, http://www.ncdc.noaa.gov/cag/time-series/global (last visited May 24, 2013).

[12] Arkansas Governor's Commission on Global Warming, ARKANSAS GOVERNOR'S COMMISSION ON GLOBAL WARMING: FINAL REPORT, 8-3(2008).

[13] U.S. Environmental Protection Agency, ARKANSAS SITE STATUS SUMMARIES. 2013A. http://www.epa.gov/region6/6sf/6sf-ar.htm (last visited July 2013).

[14] Omernik, J.M., Ecoregions of the conterminous United States (map supplement): Annals of the Association of American Geographers, v. 77, p. 118-125, map scale 1:7,500,000 (1987).

[15] Arkansas Game and Fish Commission ARKANSAS WILDLIFE ACTION PLAN, 1190 (ed. 2006).

[16] B.A. Stein, *States of the Union: Ranking America's Biodiversity*, NATURESERVE, 27 (2002).

[17] Henry W. Robison, and Thomas M. Buchanan, *Fishes of Arkansas*, UNIVERSITY OF ARKANSAS PRESS, xxi (1988).

Arkansas lakes, rivers, and wetlands also support a large number of nesting and migrating birds. Arkansas is located in the Mississippi Flyway where large numbers of migratory waterfowl and shorebirds move through the state in the spring and fall. Significant numbers make Arkansas their winter home. For instance, Eastern Arkansas hosts one of the world's largest wintering populations of mallards every year and is considered the most important wintering area for these birds in North America.

Mammoth Spring Lake – *Photo courtesy of ANRC*

5.2 Hydrologic Environment

A general overview of Arkansas's surface water and groundwater resources is provided in this section. More detailed information on the water resources in the state is provided in **Appendix I.**

5.2.1 Surface Water

There are over 87,000 miles of rivers, streams, ditches, and canals and over 515,000 acres of lakes, reservoirs, and ponds in Arkansas (**Figure 5-2**) (Dewald and Olsen 1994).[20] The ADEQ has further classified these surface water bodies by water resource type (**Table 5-1**) (ADEQ 2009).[21] Major rivers in the state include the Arkansas River, Mississippi River, Ouachita River, Red River, St. Francis River, and White River. Wetlands and impoundments such as lakes, reservoirs, and ponds are located throughout the state. Note that the water flowing in Mississippi River is not included in the Arkansas surface water resources in this AWP 2014 Update.

Table 5-1. Surface Water Resources in Arkansas (ADEQ 2009)

Water Resource Type	Quantity
Total streams	87,617 miles
Perennial streams	28,408 miles
Intermittent streams	53,465 miles
Ditches and canals	5,250 miles
Border streams	493 miles
Lakes, reservoirs, and ponds	515,635 acres

Major Basins

Arkansas has nine major river basins shown in Figure 5-2:

- Arkansas River
- Bayou Bartholomew
- Bayou Macon
- Boeuf River
- L'Anguille River
- Ouachita River
- Red River
- St. Francis River
- White River

Streamflow Characteristics

Approximately 33.6 million AFY of water enters Arkansas from other states through the Arkansas River, White River, and St. Francis River and their tributaries. An average of 235.2 million AFY flows along the state border through the Mississippi River (ADEQ 2009; Howard, Colton, & Prior 1997).[20, 22] Streamflow based on gaged flow data in the state averages about 92 million AFY.

[18] Jane Jones-Shulz, *Freshwater Mussels - The Silent Sentinels*, ARKANSAS NATURAL HERITAGE COMMISSION NATURAL NEWS, 3, (September 2009).
[19] Brian K. Wagner, *Crustaceans*, THE ENCYCLOPEDIA OF ARKANSAS HISTORY AND CULTURE, http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6596 (last visited October 2013).
[20] T. G. Dewald and M. V. Olsen, *EPA Reach File: A National Spatial Data Resource. Washington, DC*, U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Office of Water, and Office of Research and Development, (1994).
[21] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).
[22] J.M. Howard, G.W. Colton, and W. L. (eds.) Prior, Mineral, Fossil-Fuel, and Water Resources of Arkansas, Arkansas Geological Commission Bulletin 24, ARKANSAS GEOLOGICAL SURVEY, 91 (1997).

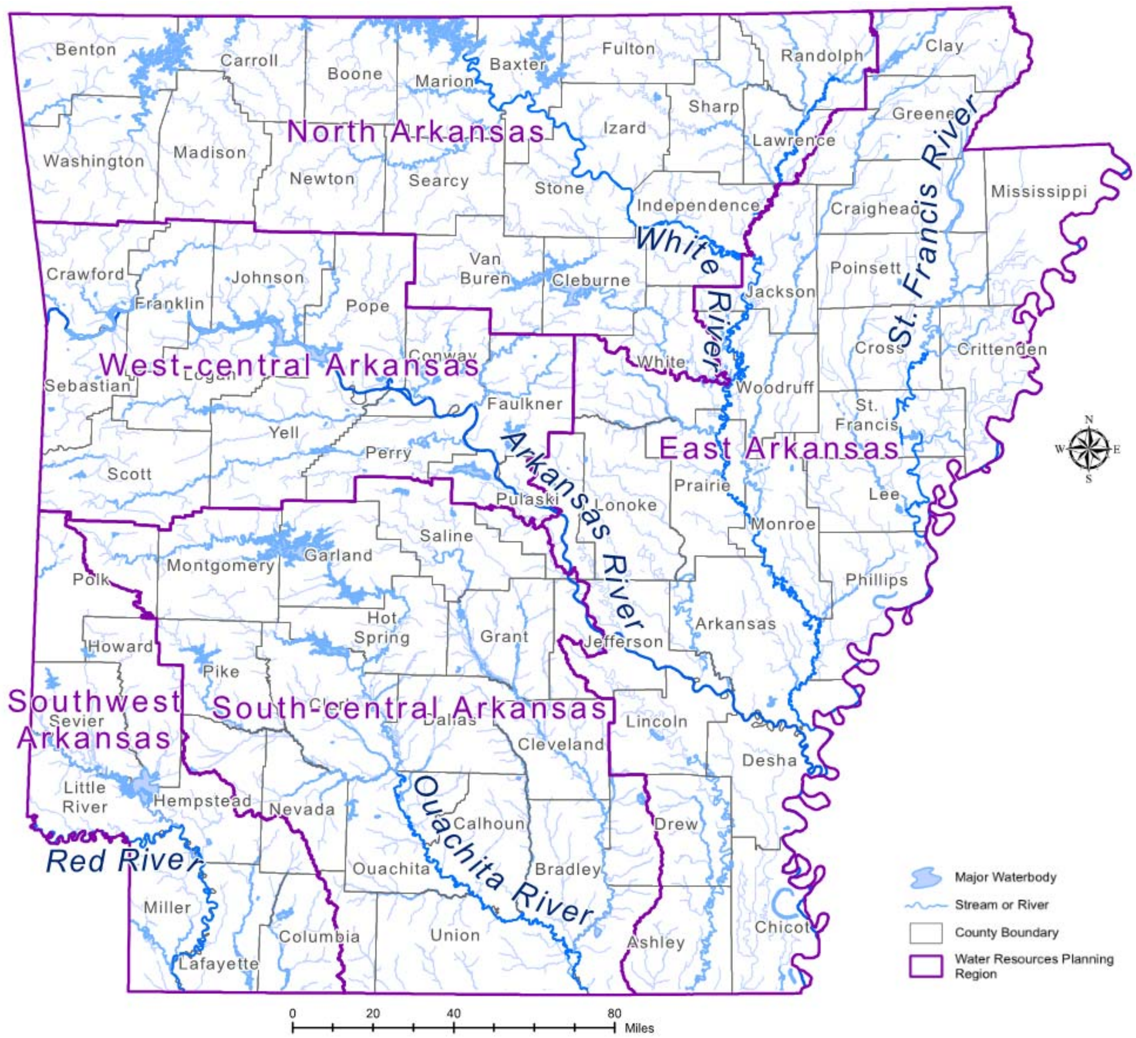
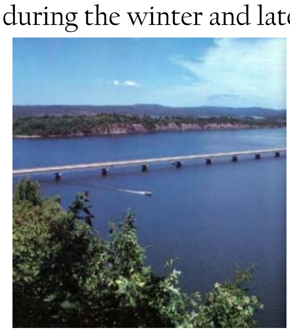


Figure 5-2. Surface Waters of Arkansas

Four of the nine major rivers have their flow regulated by dams including the Arkansas River, White River, Ouachita River, and Red River. Streamflow is generally lowest in Arkansas streams during June through October; the period of highest water demand and lowest precipitation. Streamflow is generally highest during the winter and late spring months; the period of lowest water demand and highest precipitation. Long-term flow records in the state were analyzed for this AWP 2014 Update and are reported in the Water Availability Report (Appendix C) and the Gap Analysis Report (Appendix F).



White River– *Photo courtesy of USDA-NRCS*

Impoundments

There are approximately 110,500 impoundments in Arkansas with a combined surface area of over 515,000 acres and storage of over 15 million AF. These include 25 AGFC impoundments, 10 U.S. Forest Service (USFS) impoundments, and 25 USACE impoundments (AGFC 2010, Arkansas Soil and Water Conservation Commission [ASWCC] 1981).[23, 24] The majority of remaining impoundments in the state are small farm ponds (ASWCC 1981).[23] **Table 5-2** lists the largest reservoirs in Arkansas, along with the planning basin in which each one is located and the surface area and storage area of each one.

[23] AGFC, Policies on Land Use Around Arkansas Game and Fish Commission Lakes, 12 (2010).
[24] ASWCC, Arkansas State Water Plan, Lakes of Arkansas, 142 (1981).

Table 5-2. Largest Reservoirs in Arkansas

Reservoir Name	Surface Area (acres)	Volume (10^6 AF)	Owner	Water Resource Planning Region
Bull Shoals Lake	45,440	3.04	USACE	North
Lake Ouachita	40,100	2.76	USACE	South-central
Greers Ferry Lake	31,500	1.91	USACE	North
Beaver Lake	28,220	1.65	USACE	North
Norfork Lake	22,000	1.25	USACE	North

Wetlands

Wetlands perform important functions, including storage of floodwaters, filtering of water to improve water quality, and storage of carbon. In addition, wetlands provide habitat for a number of important bird and animal species (AGFC 2006, Ramsar Convention 2013).[25, 26] Several classes of wetlands exist in all parts of the state including mountaintop depressions, flats, fringe, riverine, and slope wetlands.

The majority of the state's remaining bottomland hardwood wetland areas are located in the White River and Cache River National Refuges. In these areas, conservation and restoration efforts have increased the amount of wetlands since the 1990 AWP Update. Other wetland areas in the state include the Felsenthal National Wildlife Refuge, areas along tributaries of the Red River, areas within the Arkansas River Basin, and mountaintop areas in the Ozark National Forest, and wet tall grass prairie areas.

Cut-off Creek – *Photo courtesy of ANRC*

Surface Water Quality

A summary of the quality of surface water on a statewide basis is presented here. A detailed description of surface water quality is presented in the Water Availability Report (Appendix C). In the mountainous areas of the Interior Highlands, surface waters tend to naturally have high DO levels and low biochemical oxygen demand (BOD), and low concentrations of nutrients. Geology in these mountainous areas tends to influence surface water alkalinity, hardness, and total dissolved solids (TDS) concentrations (Woods et al. 2004).[27]

Surface water quality in the Gulf Coastal Plain, and the Arkansas River Valley in the Interior Highlands, tends to be more influenced by soil types and land cover. In particular, surface waters in these areas generally have naturally higher levels of turbidity and total suspended solids (TSS). In addition, DO levels are relatively lower, and BOD is relatively higher (Woods et al. 2004).[26]

The 2008 Integrated Water Quality Monitoring and Assessment Report states that 59 percent of assessed stream miles and 64 percent of assessed lake acres support all uses (ADEQ 2009).[28] Sediment and organic enrichment and low DO (caused by nutrients) are the pollutants most often identified as causing surface waters to not support uses. Throughout the state, agricultural activities impact surface water quality. In some areas of the state, most typically northwest and central Arkansas, water quality is affected by changes from traditional land uses and accelerated urbanization. Point source wastewater discharges and activities such as resource extraction are water quality issues in localized areas of the state.

[25] AGFC ARKANSAS WILDLIFE ACTION PLAN, 1190 (ed. 2006).
[26] Ramsar Convention, RAMSAR SITES INFORMATION SERVICE, http://ramsar.wetlands.org/Database/SearchforRamsarsites/tabid/765/Default.aspx (last visited June 28, 2013)
[27] A. J. Woods, et al., Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs), U.S. GEOLOGICAL SURVEY, poster (2004).
[28] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

5.2.2 Groundwater

Groundwater is an important water resource for the state and constitutes about 71 percent of the total water use in Arkansas. The groundwater report, "Aquifers of Arkansas – Protection, Management, and Hydrologic and Water-Quality Characteristics of Arkansas's Groundwater Resources" (Kresse et al. 2014), divides aquifers into the two major physiographic regions of the state—Interior Highlands and Coastal Plain—and their respective subdivisions.[29] Besides the visual differences in the mountainous upland regions as compared to extensive flat-lying, lowland, and valley areas, these two regions have differences in underlying rock type, geologic structure, and depositional history, which have produced aquifers having very different capabilities for storing and transporting underground water. These capabilities, combined with various land uses associated with both regions, have resulted in aquifers that have differing well yields and uses, water-quality conditions, and vulnerability to various land-use activities. A more detailed description of groundwater occurrence and quality is provided in the Water Availability Report (Appendix C).

Major Aquifers

There are significant differences in the availability of groundwater from the aquifers present across the state. The largest and most productive of the state's major aquifers are in the Gulf Coastal Plain (**Figure 5-3**). Major aquifers in the Gulf Coastal Plain include the Nacatoch, Wilcox, Sparta/Memphis, Cockfield, and Mississippi River Valley alluvial aquifers.

The hydrogeology of the Gulf Coastal Plain can be described as layers of unconsolidated silt, sand, and gravel that contain aquifers yielding large quantities of water to wells. These aquifers are separated by clays that store greater volumes of water but have relatively low hydraulic conductivity, and therefore do not yield adequate volumes of water to wells.

Aquifers of the Interior Highlands are represented by a thick sequence of highly fractured, well lithified formations dominated by carbonates (limestone and dolostone) in the Ozark Plateaus, and shale and sandstone lithologies in the Boston Mountains and Ouachita Mountains. Generally, the hydrogeology of the Interior Highlands can be described as an area of fractured formations resulting in secondary porosity that yield relatively low volumes of water to wells.

The most noted aquifers within the Interior Highlands are the Ozark aquifer and the Bigfork Chert and Arkansas Novaculite aquifers in the central Ouachita Mountains.

Groundwater Quality

ADEQ classifies groundwater quality in Arkansas aquifers as good to very good (ADEQ 2009).[30] The chemistry of groundwater in Arkansas ranges from calcium bicarbonate to sodium bicarbonate water types. Groundwater in the Mississippi River Valley alluvial aquifer tends to have high iron concentrations (up to 70 milligrams per liter [mg/L]) as well as high manganese concentrations. Elevated chloride concentrations (100 to 300 mg/L) occur in many individual aquifers in the Coastal Plain associated with poor flushing of residual salinity in clayey parts of the aquifer, upwelling of high-salinity water from underlying formations, and evapotranspiration in poorly drained backswamp areas (Kresse et al. 2014).[29] High levels of radon occur in some areas of the Ozark Aquifer (ADEQ 2009, Todd, et al. 2009).[30, 31]

[29] Kresse, Timothy M.; Hayes, Phillip D.; Merriman-Hoehne, Katherine R.; Gillip, Jonathan A.; Fugitt, D. Todd; Spellman, Jane L.; Nottmeier, Anna M.; Westerman, Drew A.; Blackstock, Joshua M.; Battreal, James L., *Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical Characteristics of Arkansas's Groundwater Resources*, U.S. Geological Survey USGS Scientific Investigations Report: 2014-5149 (2014).

[30] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

[31] R. Todd, et al., *State of the Ground Water Report*, U.S. Environmental Protection Agency, Region 6, A-4 (2009).

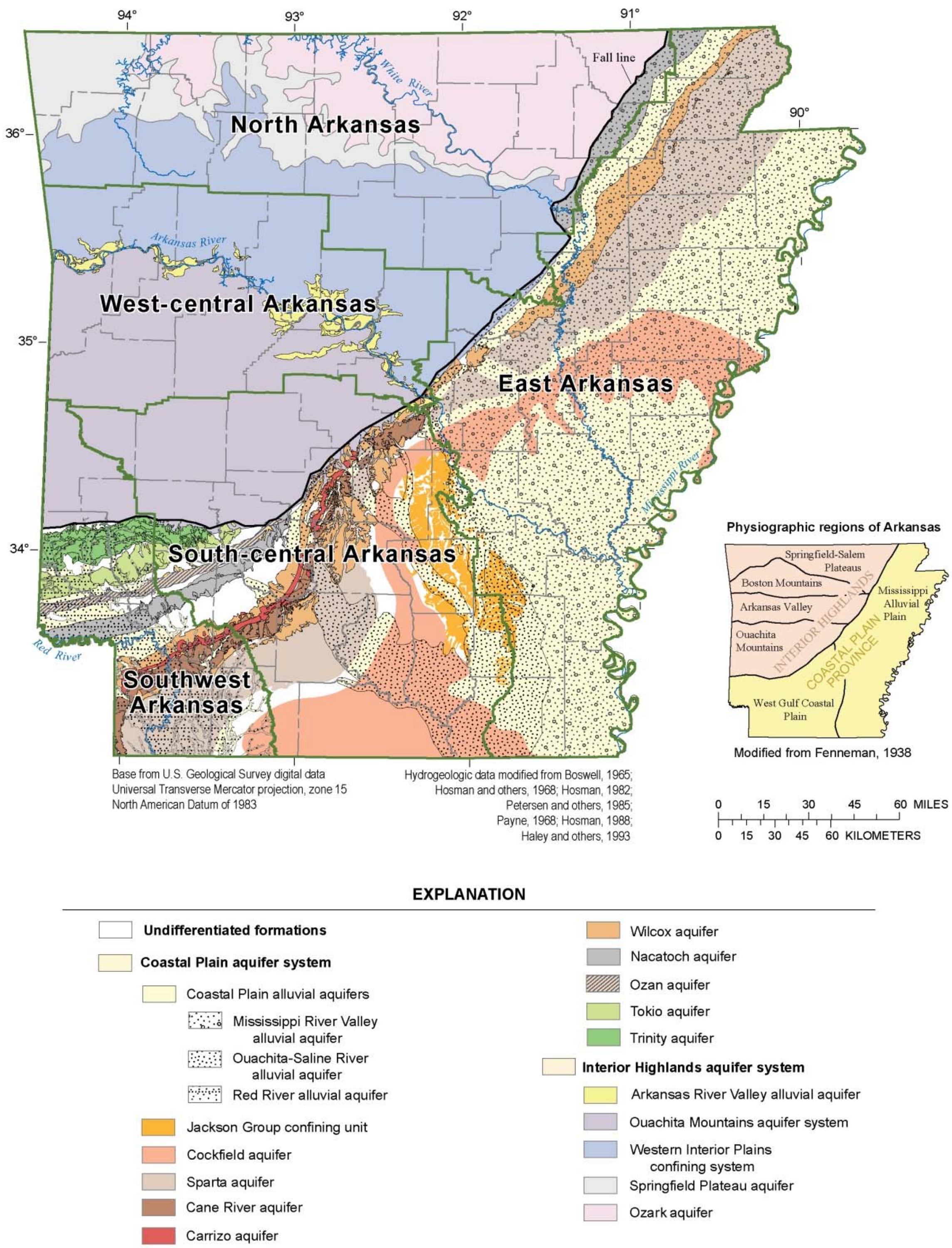


Figure 5-3. Aquifers of Arkansas

5.2.3 Navigation

Arkansas has two navigation systems that allow for commercial navigation, but provide many other benefits as well—the McClellan-Kerr Arkansas River Navigation System (MKARNS) and the Ouachita and Black Rivers Navigation Project.

THESE NAVIGATION SYSTEMS PROVIDE MULTIPLE BENEFITS TO OUR STATE—HYDROPOWER, RECREATION, ENVIRONMENT, AQUIFER RECHARGE, AND AGRICULTURE.

Navigation and the pools for navigation on both the Ouachita and the MKARNS play a critical part in providing much needed water resources to the State of Arkansas. Navigation pools provide the water for many of the irrigation projects described in Section 4—Plum Bayou, the Bayou Meto Water Management Project, and the Grand Prairie Area Demonstration Project.

Navigation pools on the MKARNS also assist with aquifer recovery in critical groundwater areas of the state southeast of Pine Bluff. The Boeuf-Tensas Irrigation Project, a newly proposed irrigation project in Southeast Arkansas, will also depend on a navigation pool on the MKARNS to provide their water supply.

McClellan-Kerr Arkansas River Navigation System

The MKARNS extends 445 miles from the Mississippi River to Tulsa, Oklahoma. This year-round transportation corridor enables commercial shipping and the economic benefits that go with it. Little Rock District manages the Arkansas portion—13 locks and dams and 308 miles of channel. A map of the MKARNS is shown in **Figure 5-4**.

Navigation pool at MKARNS lock and dam #9 –
Photo courtesy of Kelly Collins

The Arkansas River is very shallow through Arkansas and was naturally incapable of supporting river traffic through most of the year. Before the locks and dams were built, it was not uncommon to see a nearly dry riverbed a person could wade across. The locks and dams created stable navigation pools that also support commercial, recreational, and cultural waterfront development. An additional benefit of higher navigation pools has been observed in long-term aquifer recharge trends.

Construction was started in 1963 on a system of channels and locks to connect the many reservoirs along the length of the Arkansas River. The first section, running from the Mississippi to Little Rock, opened on January 1, 1969. The first barge to reach the Port of Catoosa Oklahoma arrived in early 1971.

The locks on the MKARNS are the standard size for much of the Mississippi River waterway, 110 feet wide and 600 feet long. **Table 5-3** shows the names and locations of the locks on the MKARNS in Arkansas.

Table 5-3. Locks on the McClellan-Kerr Arkansas River Navigation System

Lock #	Lock Name	River Mile	Location
Mississippi River Lock	Montgomery Point	0.5	White River
1	Norrell	10.3	Arkansas Post Canal
2	Lock 2	13.3	Arkansas Post Canal
3	Joe Hardin	50.2	Jefferson County
4	Emmett Sanders	66.0	Pine Bluff
5	Col. Charles D. Maynard	108.1	Pulaski County
6	David D. Terry	108.1	Pulaski County
7	Murray	125.4	Little Rock
8	Toad Suck Ferry	155.9	Conway
9	Arthur V. Ormond	176.9	Morrilton
10	Dardanelle	205.5	Russellville
12*	Ozark-Jeta Taylor	256.8	Ozark
13	James W. Trimble	292.8	Barling

* Lock 11 was originally planned, but never built.

Figure 5-4. Map of the McClellan-Kerr Arkansas River Navigation System

Ouachita and Black Rivers Navigation Project

The Ouachita River runs south and east through Arkansas. **Figure 5-5** is a map of the Ouachita and Black Rivers Navigation Project, which starts near Camden where dredging for navigational purposes begins. The tributaries to Ouachita River in this stretch include Smackover Creek and Saline River. South of the Saline, the Ouachita flows into Lake Jack Lee, a reservoir created by the Ouachita and Black River Project. The Felsenthal National Wildlife Refuge encompasses the Ouachita from the Saline River to Lake Jack Lee's mouth.

The Ouachita and Black Rivers Navigation Project provides a minimum 9-foot deep by 100-foot wide navigable channel along 337 miles of the Ouachita and Black Rivers from the Red River to Camden, Arkansas. Congress designated Arkadelphia, Arkansas, as the head of navigation on the Ouachita River. The navigation pool above the H.K. Thatcher lock and dam plays a vital role in the Ouachita River Alternative Water Supply Project in Union County (Section 4.1.2).

Congress authorized the original Ouachita and Black Rivers Navigation Project in 1902. Construction of six locks and dams began in 1905, and the waterway was fully operational in 1926. Four locks and dams were built to replace the antiquated six locks and dams and also provide for the minimum 9-foot navigation depth. The present locks were designed with a navigation pass located beside each dam. This feature allows vessels to pass when the locks become inundated by floodwaters. The USACE is authorized to develop recreational facilities on the waterway.

5.3 Socioeconomic Environment

The socioeconomic characteristics of Arkansas are examined by reviewing information on income and the industries that support the state's economy. More detailed information on the socioeconomic environment is provided in Appendix J. Recent information is compared to information from the early 1990s, at the time of the previous AWP, to identify how things have changed since then. Understanding these changes provides insight into changes in the demand for water resources in Arkansas.

Figure 5-5. Map Showing the Location of the Ouachita and Black Rivers

5.3.1 Demographics

Demographic information was developed from 2010 U.S. Census and is described in detail in Appendix J. Census data includes population totals as well as age and racial composition of people living in urban and rural areas. This information was compared with 1990 census data to identify population changes that have occurred since the 1990 AWP.

War Eagle Mills – *Photo courtesy of ANRC*

Population changes affect the need and demand for water resources; not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure upgrades, expansion, and repairs. The state population increased approximately 24 percent between the 1990 and 2010 census. In addition, 4.2 percent more of the population was living in urban areas in 2010 than in 1990. Increased development and increased demands on water utilities accompanied these population increases.

The median household income in Arkansas in 2011 was $41,302, which is 8.7 percent higher than it was in 1990 and unemployment is 1.8 percent lower than it was in

1990 (comparison made in 2011 dollars).[32] Poverty levels have decreased only slightly since 1990.

There are a variety of industries active in Arkansas's economy. These industries vary in their demands on the state water resources. Currently, tourism and service industries are important contributors to the state economy. This was not the case at the time of the 1990 AWP. The two largest contributors to the Arkansas economy are agriculture and industry, which both rely on water. Another important water-dependent industry is resource extraction (i.e., mining and oil and natural gas production). Water demands of the different water use sectors are described in the Water Demand Forecast Report (Appendix E).

5.3.2 Land Use

Topography and soil type are the principal factors governing the use of land. Steep slopes and thin soils, which frequently occur in the Interior Highlands, preclude the development of cropland and favor the growth of forests, grassland, and pasture. Conversely, the flat terrain and deep soils in eastern Arkansas are conducive to agricultural uses. The majority of Arkansas is covered by forest while approximately one-third of the state land area is used for agricultural purposes, such as pasture or cropland. The majority of the water used in Arkansas is used for crop irrigation (Funkhouser, Eng, and Moix 2008).[33]

Furrow Irrigation – *Photo courtesy of USDA-NRCS*

5.4 Water Resources Management

Water management and use is governed by a complicated mix of federal, state, and local laws and regulations. The legal and regulatory framework is the subject of a detailed description in Appendix K.

5.4.1 Legal Framework

The legal framework for management and use of water resources in the state is based on state and federal case law, state and federal statutes, and rules and regulations enacted by state and federal agencies. In addition to water quality matters, federal legislation and programs also deal with other aspects of management of Arkansas water resources, such as quality, conservation, and protection of waterbodies; flood control; water-based recreation; and navigation. Arkansas is also a member of two interstate water compacts—the Arkansas Oklahoma Arkansas River Compact and the Red River Compact. States negotiate interstate water compacts, then must seek congressional approval. More detailed information on the interstate water compacts is provided in Appendix C.

Arkansas water use law is based on the riparian doctrine. Riparian landowners own land touching a water body. They have a property right to use that water to the extent that they do not unreasonably diminish flow or quality of the water available to other riparian users. The riparian doctrine historically prohibits the use of water beyond the riparian tract.

Landowners have the right to reasonable use of groundwater under their property, as long as that use does not unreasonably affect the ability of other landowners to use the groundwater.

Since the 1990 AWP Update, Arkansas has adopted a body of administrative laws that address water use questions previously dealt with through case-by-case adjudication. Thus, water use rights in Arkansas are more regulated than in the past. In addition to water rights related to water withdrawals and consumptive use, Arkansas regulations address water rights related to public recreational uses of surface water such as boating and fishing (ANRC 2011).[34]

There are also local regulations that influence management of water resources. These can include zoning laws; regulations promulgated by municipalities, counties, and water and wastewater utilities; and regulations promulgated by irrigation, levee, drainage, water, and sewer districts.

[32] U.S. Census Bureau, "Table H-8," *Median Household Income by State, Historical Income Tables: Households*, U.S. DEPARTMENT OF COMMERCE, U.S. CENSUS BUREAU (2012).

[33] J. E. Funkhouser, K. Eng, and M. W. Moix, Low-flow Characteristics and Regionalization of Low-flow Characteristics for Selected Streams in Arkansas, Scientific Investigations Report 2008-5065, U.S. GEOLOGICAL SURVEY, 1 (2008).

[34] Arkansas Natural Resources Commission, WATER LAW IN ARKANSAS, 1, 37 (2011).

6 Framework for Water Management

To provide an answer to the question—"How much water do we currently use and how much will we need in the future?"—several major steps must be completed. This includes the quantification of current and future water demand, availability, and the gaps between them. The estimates of future water demands, availability, and gaps are intended for statewide and regional planning purposes, and are not intended to replace local water resource planning efforts.

It should be noted that while every effort was made to use the best available data for the supply and demand analyses in the AWP 2014 Update, the analyses are based on projections to the year 2050. Projections are inherently uncertain and as a result, the analyses results have a recognized level of uncertainty; however, they are considered adequate for statewide planning purposes.

6.1 Statewide Overview

The methods and data used to quantify current and future water demand and availability for the state are described in detail in Water Availability Report (Appendix C) and Water Demand Forecast Report (Appendix E) and summarized below. This information is used to develop a complete statewide, county, and regional quantification of current and future water needs by source of supply (surface water and groundwater) and by various demand sectors.

6.1.1 Water Demand Forecasts for the AWP Update

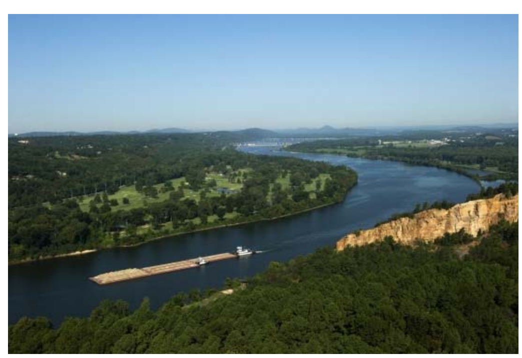
Current and future water demands of each county are estimated by water using sectors. Data assembled to provide an estimate of base period use vary by sector and data availability but generally represent the period from 2008 to 2010. The future water use of each sector is determined by the growth of a "driver" (e.g., population, employment, etc.) that is appropriate for each sector and either available from an acceptable source or projected into the future in a manner acceptable to the Demand Technical Workgroup.

Municipal (Public-supply) and Domestic Self-supplied Water Use

Water use among publicly-supplied municipal water users (includes all publicly-supplied users) by county is projected into the future based upon the rate of growth of the county population. Base period water use for each county was obtained from either the ADH Sanitary Survey or the Water Use Registration Program (ANRC Water Use Database [WUDBS]) data. Where publicly-supplied municipal water withdrawals are identified for mining or industrial use, these water volumes are subtracted from the volume of municipal water use and are accounted for in their respective sector demand estimates. The reported municipal water volume is divided by the reported population served to derive a gallon per capita per day (gpcd) rate of use for each municipality, which is then weighted by the respective population served to derive a county average gpcd. The weighted average per capita use for each county includes some imbedded commercial and industrial water use, as well as distribution system losses.

Watershed dam – *Photo courtesy of USDA-NRCS*

USGS 2010 data on the percent of population that is publicly-supplied and domestic self-supplied for each county is used to disaggregate county population projections. USGS data is used to determine county self-supplied gpcd. Domestic self-supplied water use is projected into the future based upon the rate of county population growth.



Arkansas River barge – *Photo courtesy of Arkansas Department of Parks and Tourism*

Self-supplied Commercial Water Use

Water use among self-supplied commercial water users (i.e., campgrounds, resorts, stores) by county is projected into the future based upon the rate of growth of the county population. Base period water use for each county was obtained from either the WUDBS data or the ADH Sanitary Survey. The WUDBS average and ADH available data are summed to represent the base period self-supplied commercial water use for each county. Future self-supplied commercial water demands are calculated by applying the county population rate of growth to base year county commercial water demands.

Cassatot River– *Photo courtesy of ANRC*

Industrial Water Use

Water use among industrial water users by county is projected into the future based upon the rate of growth of the county employment. Base period water use for each county was obtained from the WUDBS data for self-supplied industrial use and from municipally-supplied industrial use, which are averaged to provide an average base period water use for each county. Entities in the WUDBS determined to be industrial water users may be classified within the WUDBS as: (a) industrial users, (b) municipally-supplied withdrawals identified for industrial use, (c) noncommunity systems with corporate names, or (d) commercial self-supplied withdrawals determined to be industrial users (e.g., bottling company).

Future industrial water demands are calculated by applying the county employment rate of growth (rate of growth can be positive or negative) to base year county industrial water demands. The employment growth rates are derived from: (1) the Arkansas Department of Workforce Services projections of employment from 2008 to 2018 by Workforce Investment Area (WIA), and (2) Woods & Poole employment at the county level to the year 2040.

Self-supplied Mining Water Use

Water use among self-supplied mining water users by county is projected into the future based upon the rate of growth of the county mining employment. Base period water use for each county was obtained from the WUDBS data and averaged across years for each county. Future self-supplied mining water demands are calculated by applying the county mining employment (North American Industry Classification System 212) rate of growth to base year county mining water demands. The mining forecast includes one notable demand in Izard County. Izard County produces a unique sand type that is used in the hydraulic fracturing of mineral development wells. The employment data show employment growth through the planning horizon so mining water use grows at that rate of employment growth. It is not known if the demand for this sand type will mirror trends in Arkansas shale development or other national demand for this type of sand. If it is tied more closely to Arkansas shale development, then the rate of growth would be expected to trend more closely with the shale gas forecast, which projects full development by 2024 - 2025.

Pocahontas, Arkansas flooding – *Photo courtesy of ANRC*

Self-supplied Shale Gas Water Use

Water use for self-supplied shale gas development and associated water use by county is projected into the future based upon assumptions developed in coordination with the Demand Technical Workgroup. The primary water dependent activity in shale gas development is the hydraulic fracturing process. Data from shale gas companies was provided to ANRC and used to develop a value for the amount of water used (4.73 mgd) to fracture a well. This average water use assumes that all water associated with a given well is used in the year that the well is drilled, and no re-hydraulic fracturing (returning to further develop the well) occurs after the initial year of development. The forecasted water demand does not include any estimate of reuse water recovered after hydraulic fracturing or "produced" water encountered in the well drilling/development process.

Big Maumelle River – *Photo courtesy of ANRC*

It was estimated that a total of approximately 14,000 wells could be developed in the Fayetteville shale formation. This is about 10,000 more wells than are currently active. It is estimated that about 500 wells could be drilled per year over the next approximately 20 years. If there is a significant increase in natural gas prices, this estimate should be revised.

Geographic information system analysis of the Fayetteville shale formation was used to determine the approximate area of potential development per county for the nine counties that overlay the formation. A density of seven wells per square mile was used to determine a maximum potential number of wells per county. The assumed increase of 500 new wells per year is distributed proportionally among the nine counties based on 2012 existing distribution. The cumulative number of wells per county reaches the maximum potential number of wells for each county at about the year 2025. Thus it is assumed that the demand for water for shale gas development will end.

The source of self-supplied shale gas water is 100 percent from surface water. The water is assumed to remain deep within the shale formation. Some information suggests that a small to moderate percent (5 to 35 percent) of water used in the hydraulic fracturing process may be recoverable, depending upon the operating procedures and site-specific conditions. This excludes any "produced" water that may have entered the well from penetrated aquifers.

The shale gas boom in Arkansas was not anticipated during the 1990 AWP. In light of this unforeseen increase demand for water, the planning team reviewed literature and mineral resource data for the state to identify possible unknown future emerging resource development that might significantly affect water use. Two potential resources were identified—Lignite and the Lower Smackover Brown Dense Formation (an unconventional oil reserve). In both cases information was not identified to provide an understanding of the feasibility, rate of possible development, and rate of water use. Information on these resources should be tracked over the coming years to determine more specific information on possible water use needs and development potential.

Self-supplied Thermoelectric Power Water Use

Water use among self-supplied thermoelectric power (power) water users by county is estimated for each major power generating facility in the state, and projected into the future taking into consideration fuel type, prime mover, cooling method, and three scenarios of regional projections of future power generation. Plant specific withdrawal and consumption factors were developed using data from the WUDBS and input from thermoelectric energy producers in Arkansas. Base period water use for each generating unit of each facility was estimated with water withdrawal and water consumption factors developed with guidance from the Demand Technical Workgroup. These water use factors (in gallons per megawatt hour [MWh]) are multiplied by the annual power generation (in MWh) for each unit, and then converted to mgd. Thus, a withdrawal mgd and consumption mgd is estimated for each generating unit. Nearly all water use is from surface water sources and is almost all returned to surface water.

Future self-supplied thermoelectric power water demands are based upon Department of Energy, Energy Information Agency (EIA) projections of power generation by regional pool and fuel type. Power generating facilities in Arkansas are in one of two regional power pools. The rate of growth in power generation by fuel type by pool was assigned to the Arkansas facilities by fuel type and location. EIA projections of power generation from 2010 - 2035 were extended to 2050 using the growth rate from 2034 - 2035 by power pool and fuel type. However, each facility has a maximum generating capacity, which was developed with guidance from the workgroup. If the assigned allocated power generation in a given future year exceeds the facility maximum capacity, then no additional power generation is assigned at that facility and the "overload" is reassigned to all other facilities of the same fuel type that are not at maximum capacity. The allocation of projected power generation by facility was then multiplied by the withdrawal and consumptive use requirements of each generating unit to derive the estimated future water demand by facility.

Crop Irrigation Water Use

Water use for crop irrigation by county is estimated based upon number of acres irrigated by crop type and an application rate per acre by crop type. The base year number of irrigated acres is estimated to increase for most crops in most counties based upon historical trends up to a reasonable maximum level as determined by analysis of available tillable acreage that is not currently under irrigation. The base period (2010) and historical (2000 - 2010) irrigated acreage and crop irrigation water application rates for each county were obtained from two sources. Irrigated acres in cotton, corn, and miscellaneous crops were obtained from the WUDBS. Irrigated acres in soybean and rice were obtained from the USDA - County Agricultural Production Survey (CAPS) data. A total of 37 counties were identified as having irrigated acres in the four primary crops (soybeans, rice, corn, and cotton), which comprise 98 percent of all crops grown in Arkansas. Other crops were also forecasted and include berries, unclassified cash grains, orchards, hay, milo, oats, pastures, peanuts, sorghum, tobacco, vegetables, and wheat. Calculations also included water used for crop reservoir and crop maintenance.

Arkansas River from Pinnacle Mountain – *Photo courtesy of Kelly Collins*

The water application rate was determined from the analysis of WUDBS crop irrigation records in which a single crop was irrigated from a single source of supply. Thus, application rates were determined by crop, month, and county. Irrigation volumes reported in November and December are outside the typical irrigation season and were assumed to be withdrawals associated with the waterfowl management water use. Note that the average application rate includes system losses and irrigation inefficiencies as the application rate is based upon water withdrawal data. The application rate by county, crop, and month is multiplied by the acres irrigated per county by crop to estimate the irrigation water demand by county, crop, and month for the 37 counties irrigating these primary crops.

The trends in historical irrigated acres by crop by county were used to determine the future irrigated acreage. Irrigated acres in soybeans, rice, cotton, corn, and "other" were summed for each county and year. For each county, the total tillable row crop acreage was deemed as the maximum number of irrigable acres within each county that were most likely to become irrigated during the forecast period. Twenty of the 37 counties that irrigate the primary crops are projected to reach the maximum irrigable acres before 2050.

Self-supplied Waterfowl Management Water Use

Water use for waterfowl management by county is estimated based upon number of acres flooded and an application rate per acre. The source of water used for this purpose is primarily groundwater. WUDBS data for this sector includes self-supplied duck clubs, self-supplied commercial habitat maintenance (AGFC reports water use for maintaining reservoir levels and habitat maintenance), and a component of self-supplied crop irrigation from November to December. The base year volume of water is assumed constant into the future.

Livestock Water Use

Water use among agricultural livestock water users by county is projected into the future based on USDA National Agricultural Projections through 2022. Some specific exceptions to this methodology are made by animal type based on Demand Technical Workgroup suggestions.

Grazing land – *Photo from USDSA-NCS*

Baseline animal counts were obtained based on 2012 statewide USDA, National Agricultural Statistics Services (NASS) CAPS animal counts for dairy cows, beef cattle, and hogs and pigs. These statewide animal counts were disaggregated to the county level using the ratio of county to state animal count taken from 2007 USDA NASS Census of Agriculture (COA). Baseline animal counts at the county level for chickens, turkeys, sheep, goats, and horses were obtained from the 2007 COA.

Daily water use requirements by animal type were estimated using data from USGS and Arkansas NRCS. Daily water requirements for each livestock group include water used for drinking water, cooling, and sanitation and wastewater removal requirements. To determine base period water use, the baseline animal count by animal type by county is multiplied by the daily water requirement.

Future livestock animal counts are calculated based on USDA National Livestock Projections livestock growth projections for beef cattle and chickens and turkeys through 2022. Lack of data or specific input from the Demand Technical Workgroup regarding historical trends resulted in the baseline count of other animal types remaining constant throughout the forecast period.

The livestock water demand is assumed equally distributed across the county and distributed proportionally among planning regions in cases where counties cross regional planning boundaries.

Aquaculture Water Use

Water use among aquaculture water users by county is quantified by species type and number of acres used for fish cultivation, in combination with water application rates per species type. Overall, with the exception of catfish, aquaculture water demands did not show significant past trends and no major drivers for growth were identified. Consequently, for planning purposes demands are held constant for all species types over the forecast period. Base period water use for each county was estimated using (1) aquaculture acreage data from the WUDBS in combination with USDA NASS 2012 statewide information, and (2) water application rates by species from the Demand Technical Workgroup. The species application rate for each species is multiplied by the acres per species by county to derive the aquaculture water demand by county. All water for aquaculture purposes is obtained from groundwater to ensure conformance with regulation, and to control parasites and disease as surface water has the potential to introduce contaminants into the ponds.

Future aquaculture water demands are extremely vulnerable to environmental regulations, international markets, and other factors, such that the future of aquaculture in the state is uncertain. Future water demands for aquaculture are held constant at baseline period levels for planning purposes.

Summary of Statewide Water Demands

Water demands by sector are aggregated statewide and summarized in **Figures 6-1 and 6-2** and **Table 6-1**.

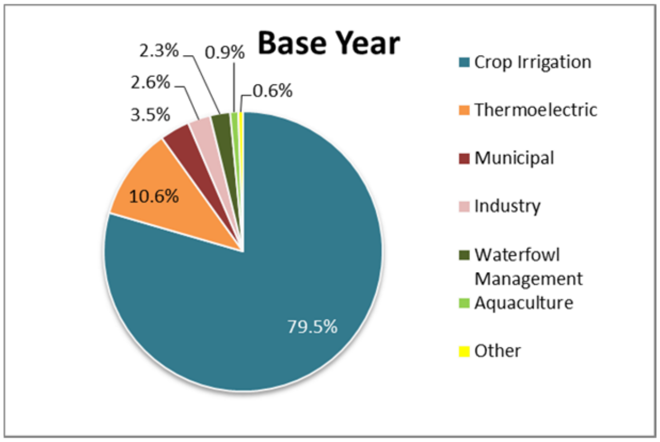


Figure 6-1. AWP Water Demand Forecast by Sector for the Base Year (2010)

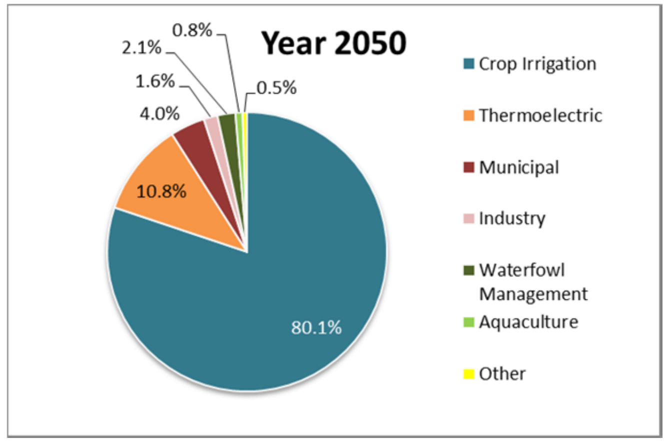


Figure 6-2. AWP Water Demand Forecast by Sector for the Year 2050

Table 6-1. AWP Water Demand Forecast in AFY

Sector	Base Year	2015	2020	2025	2030	2035	2040	2045	2050
Crop Irrigation	9,874,000	10,260,000	10,648,000	10,891,000	11,134,000	11,178,000	11,222,000	11,234,000	11,245,000
Thermoelectric	1,318,000	1,409,000	1,427,000	1,485,000	1,497,000	1,508,000	1,511,000	1,514,000	1,518,000
Municipal	433,000	444,000	457,000	472,000	486,000	504,000	523,000	544,000	569,000
Industrial	325,000	315,000	305,000	292,000	279,000	264,000	251,000	237,000	225,000
Duck Habitat	295,000	295,000	295,000	295,000	295,000	295,000	295,000	295,000	295,000
Aquaculture	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000
Livestock	30,000	30,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Self-supplied Domestic	15,000	15,000	15,000	15,000	15,000	15,000	15,000	16,000	16,000
Shale Gas	12,000	11,000	10,000	9,000	0	0	0	0	0
Mining	7,000	7,000	7,000	8,000	10,000	11,000	12,000	13,000	16,000
Self-supplied Commercial	6,000	7,000	7,000	7,000	7,000	7,000	8,000	8,000	9,000
TOTAL	**12,430,000**	**12,908,000**	**13,318,000**	**13,621,000**	**13,870,000**	**13,929,000**	**13,984,000**	**14,008,000**	**14,039,000**

6.1.2 Surface Water Availability

This section describes the process for estimating surface water availability for the planning horizon of 2050 and characterizing surface water quality for the state. Surface water calculations were completed for 9 major river basins and 35 subbasins. Data from 51 streamflow and gaging stations were used to assess surface water availability. **Figure 6-3** shows the statewide total annual quantities of surface water based on data from streamflow and gaging stations.

Methodology and Approach

The amount of surface water available for nonriparian use is quantified using the definition of excess surface water, which comes from Arkansas Code 15-22-304 and is implemented in ANRC Title 3, Rules for the Utilization of Surface Water. Title 3 specifies that *excess surface water* is calculated from average annual basin yield, existing use, instream flow, and future water demand. **Figure 6-4** illustrates components of average annual basin yield that are considered when determining excess surface water. Excess surface water is quantified as 25 percent of the total available water summarized in the AWP 2014 Update and detailed in the AWP Gap Analysis (Appendix F). Total available water is the amount of water over and above what is required to meet the "in-stream" and "out-of-stream" water needs shown in Figure 6-4.

Projected future riparian use was determined by using the demand forecast methods briefly described in Section 6.1.1 and detailed in the Water Demand Forecast Report (Appendix E). Instream requirements were estimated using protocols described in the Water Availability Report (Appendix C).

Excess surface water is quantified on an average annual basis and does not provide insight into availability for a given time of year or under a specific flow condition. The Arkansas Method (Filipek et al. 1987) is used to estimate the annual fish and wildlife "in-stream need" to determine excess surface water as depicted in Figure 6-4.[35]

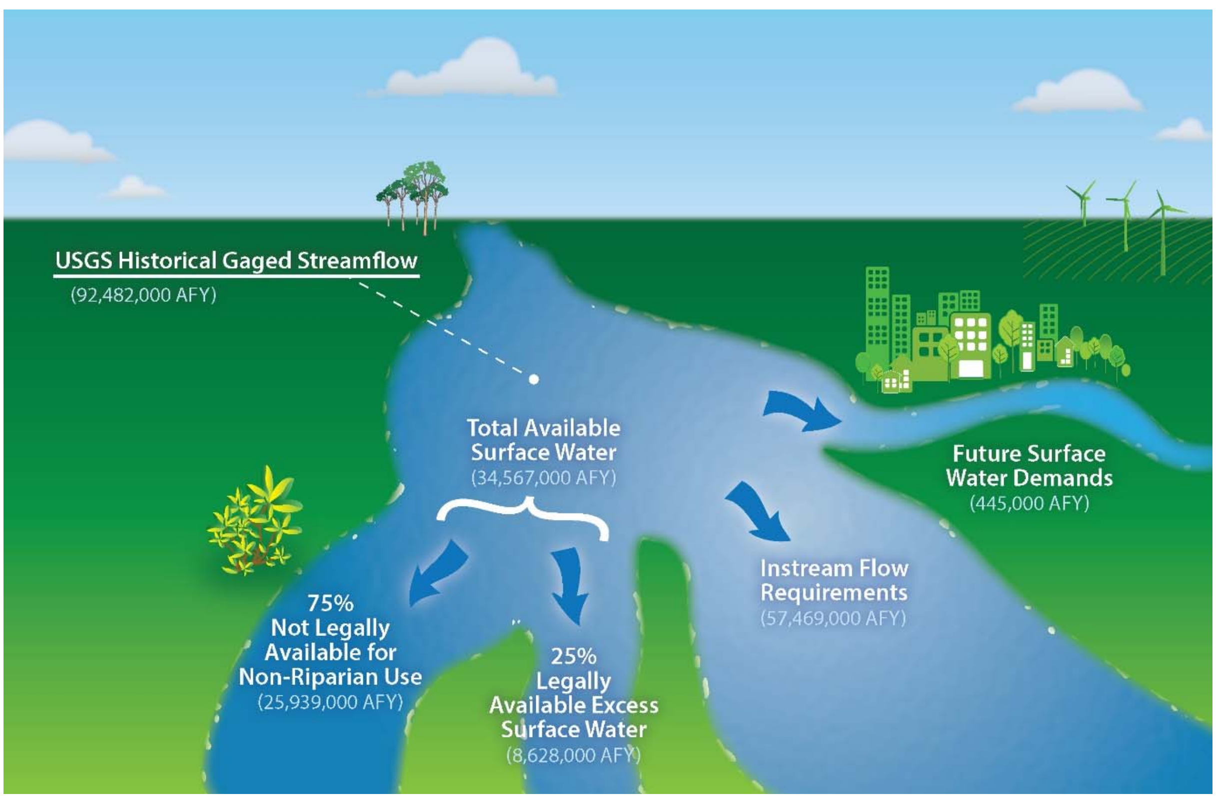


Figure 6-3. Statewide Average Annual Streamflow

[35] S. Filipek, W.E. Keith, and J. Giese, *The Status of the Instream Flow Issue in Arkansas*, 1987 PROCEEDINGS ARKANSAS ACADEMY OF SCIENCE, 1987, pp. 43-48

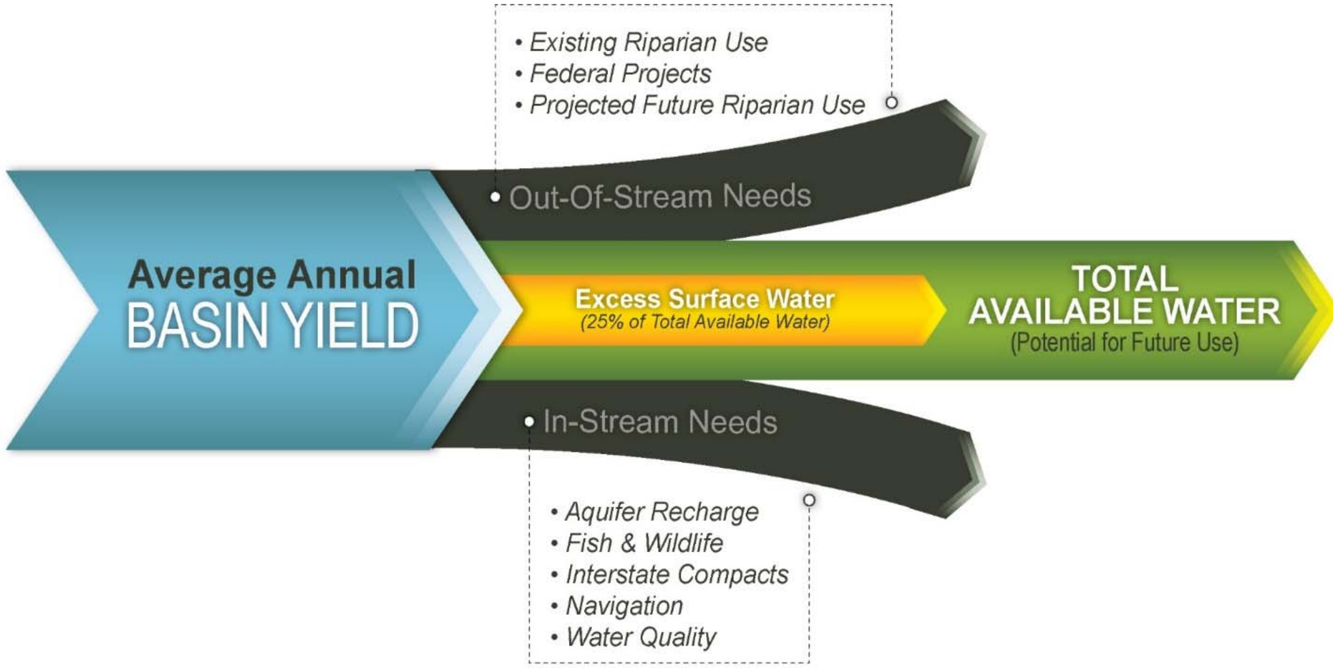


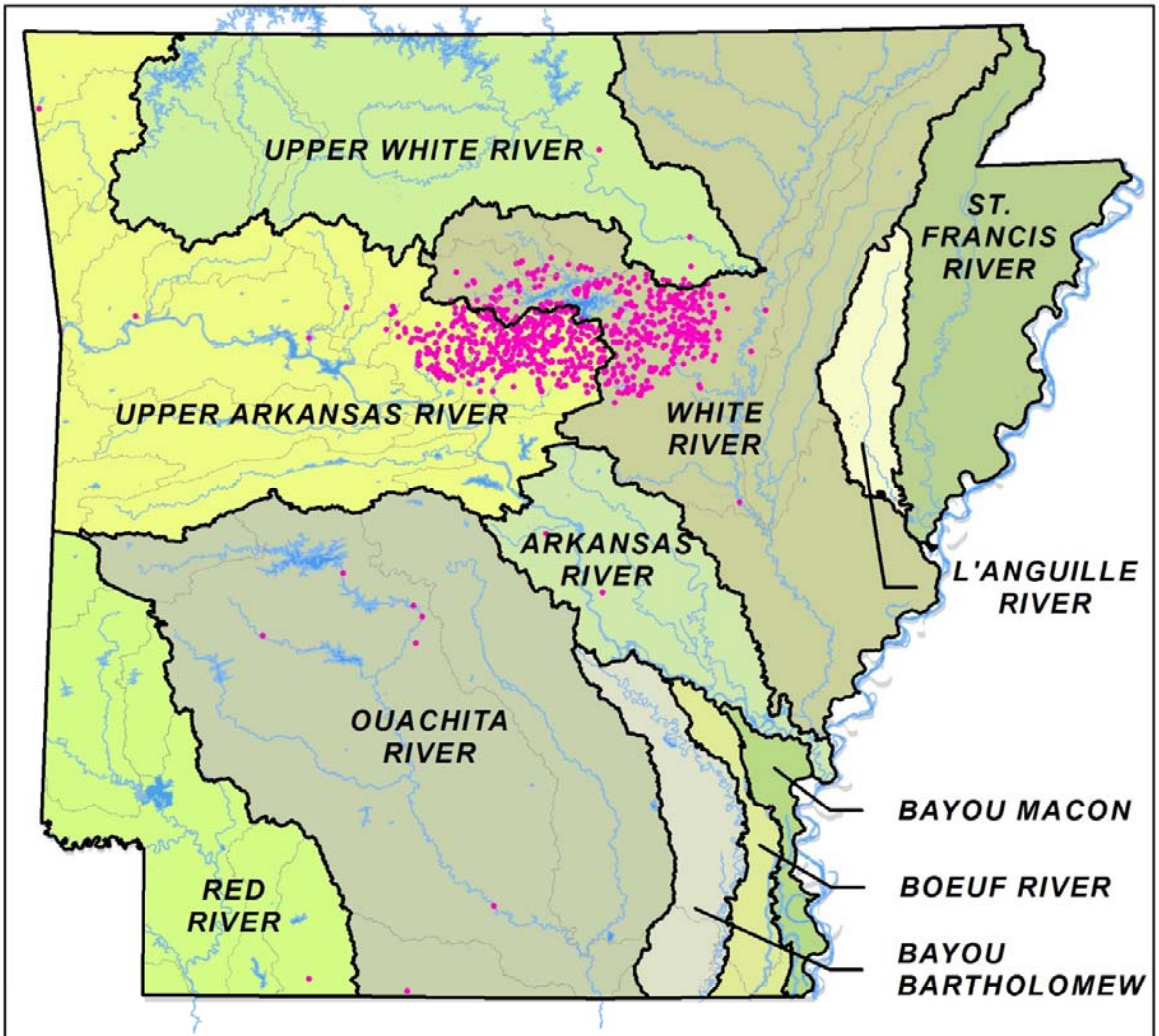
Figure 6-4. Factors included in Calculating Excess Surface Water

The ANRC will use acceptable, up-to-date science-based methods and approaches to inform decision-making where localized conditions or low flows warrant analyses beyond the average annual calculations. Completion of additional studies to develop new science-based methods and alternative approaches is recommended in Section 3.5 of this AWP 2014 Update.

Surface Water Quantities

Excess surface water available in the 9 major basins and 35 subbasins is shown in **Table 6-2**. The location and amount of excess surface water currently permitted for nonriparian withdrawals is shown in **Figure 6-5**. The abundance of excess surface water shown in Table 6-2 is based on an average annual basis. The demands on surface water vary seasonally and can be highest when streamflows are lowest. To understand the seasonal availability of surface water, monthly flow data were used to evaluate availability at different times of the year as described in the Gap Analysis Report (Appendix F).

The monthly surface water analysis included scenarios for statutory excess surface water, i.e., 25 percent of total available water, and total available surface water. All major river basins, with the exception of the Boeuf, had sufficient availability on a monthly basis under both total available surface water and excess surface water scenarios. As is the case today, the projected availability in the Boeuf River Basin will not be sufficient to meet demands during the summer months (June, July, and August) in 2050 (for more detail, please see the Gap Analysis Report in Appendix F).



RIVER BASIN	Total Available Surface Water (ac-ft/yr)	Excess Surface Water for NRWU/Interbasin Transfer (ac-ft/yr)	2014 Permitted NRWU (ac-ft/yr)
Arkansas River (Total)	13,230,000	3,308,000	100,400
Upper Arkansas River	13,027,000	3,257,000	71,400
White River (Total)	8,525,000	2,131,000	678,000
Upper White River[1]	3,322,000	831,000	7,700
L'Anguille River	363,000	90,800	0
St. Francis River	2,682,000	670,000	0
Red River	4,887,000	1,222,000	7
Ouachita River	4,106,000	1,027,000	148,000
Bayou Bartholomew	458,000	115,000	0
Beouf River[2]	207,000	38,000	0
Bayou Macon	108,500	27,100	0

NRWU = Non-Riparian Water Use

[1] Near Newport, above confluence with Black River

[2] Analysis of the Beouf River on a monthly basis showed that Total Available Surface Water was not present in June, July, and August (i.e., negative). For this reason, the 25% factor to determine Excess Surface Water was not applied for these months because it would artificially reduce this negative value.

Figure 6-5. Nonriparian Water Use Permits

Table 6-2. Calculated Excess Surface Water

Stream/Watershed	Excess Surface Water (AFY)
St. Francis River	670,500
L'Anguille River	90,800
White River	2,131,300
White River above the Cache River	1,769,100
Upper White River	830,600
Cache River	160,900
Kings River	42,300
Black River	694,500
South Fork of Little Red River	36,900
Middle Fork of Little Red River	36,300
Devil's Fork of Little Red River	24,600
Arkansas River	3,307,600
Arkansas River – Upper (at Murray Dam)	3,256,900
Spavinaw Creek (and tribs)	19,200
Flint Creek	3,200
Illinois River	48,200
Baron Fork	5,800
Lee Creek	23,500
Poteau River	26,700
Poteau River Tributaries	15,600
Mulberry River	42,600
Big Piney Creek	39,100
Illinois Bayou	41,700
Point Remove Creek	41,900
Cadron Creek	82,100
Petit Jean River	81,700
Fourche La Fave River	101,500
Red River[1]	1,221,700,
Little River	378,700
Saline River	38,700
Kelly Bayou	4,700
Bodcau Creek	34,600
Bayou Dorcheat	42,600
Mountain Fork	30,500
Ouachita River[1]	1,026,600
Upper Ouachita River	61,900
Saline River	272,200
Ouachita River Tributaries-East	2,900
Ouachita River Tributaries-West	46,200
Bayou Bartholomew[1]	114,500
Bayou Bartholomew Tributaries	25,500
Boeuf River	38,000
Boeuf River Tributaries	9,500
Bayou Macon	27,100

[1] Includes excess surface water from subbasin watersheds within Arkansas that are not tributary to the main stream within Arkansas.

Surface Water Quality

Water quality is characterized in terms of its suitability for the various uses. Nine of the water use sectors have requirements with regard to both the volume and quality of water needed, summarized in **Table 6-3**. Current surface water quality is evaluated using the state list of impaired waters that is prepared by the ADEQ in fulfillment of the requirements of Section 303(d) of the CWA. Changes in water quality since the 1990 AWP are identified through discussion of historical biennial water quality assessments conducted by ADEQ (as required by Section 305(b) of the CWA) and analysis of water quality data. In addition, long-term changes in water quality are assessed at sites where the data record spans at least 30 years (Appendix C). Although water quality assessments were submitted to EPA in 2010 and 2012, the 2008 assessment is the most recent state water quality assessment that has been approved by EPA, which oversees the assessment program. Therefore, the 2008 water quality assessment and list of impaired waterbodies are used to describe current surface water quality in the state.

A second source of information on water quality is the 2011 - 2016 NPS Pollution Management Plan. This plan identifies the 10 NPS pollution priority watersheds, and is closely aligned with Arkansas's List of Impaired Waterbodies (303(d) List) and the Water Quality assessment (305(b)) report. ANRC is responsible for the NPS Pollution Management Plan and ADEQ is responsible for developing water quality standards, monitoring water quality, and preparing the biennial Water Quality Assessment Report and List of Impaired Waterbodies.

Table 6-3. Summary of Water Use Sector Water Supply Needs

Water Use Sector	Surface Water Volume Needs	Surface Water Quality Considerations
Thermoelectric energy	Thermoelectric power generation facilities (e.g., gas and coal-fired power plants) require water for cooling.	Chemicals in water can affect cooling systems through corrosion, increased temperature, clogging, or encouraging growth of biologicals such as algae or zebra mussels that clog the system.
Navigation	In rivers where commercial goods are transported by barge, there is a minimum water depth that must be maintained for barges to be able to travel.	Sediment in rivers and streams can fill in navigation channels. The more sediment in a river, the quicker the navigation channel will fill, and the more frequently dredging will be required.
Industrial	Water is used in a variety of industrial processes, in mining and natural gas extraction, and for cooling at some industrial facilities.	Chemicals in water can affect industrial processes, machinery, and cooling systems.
Agricultural	Crops and livestock require adequate water to survive and thrive. In eastern Arkansas, many farmers flood their fields after crops are harvested in fall and winter to provide habitat for migrating ducks and other waterfowl.	High levels of some metals or chloride (salt) in water can harm crop plants. Chemicals and pathogens in water can cause illness in livestock and waterfowl. Chemicals and pathogens in water can also cause illness in aquaculture fish directly or indirectly by causing changes in water chemistry, such as pH or DO levels.
Drinking water	Adequate water for drinking is essential for human health.	Chemicals and pathogens in water can cause illness in humans. Nutrients in drinking water reservoirs can cause blooms of algae that lead to problems with water filtration, taste and odor, and toxins; and increase disinfection byproduct precursors.
Interstate water compacts	Arkansas is a member of two interstate compacts: Red River and Arkansas River. The compacts were negotiated to ensure equitable apportionment and development of the interstate waters. These compacts require that specific volumes be allowed to flow to each state.	Each state involved in the compact has the duty and responsibility to maintain water quality in rivers that cross state lines, in order to prevent adverse effects on downstream states.[1]
Fish and wildlife support	All wildlife requires water, and those creatures that live in water, such as fish and shellfish, require specific minimum water levels and flow rates to be healthy and successfully reproduce.	Pathogens, nutrients, and other chemicals in water can cause illness in aquatic organisms directly or indirectly by causing changes in water chemistry, such as pH or DO levels.
Recreation	There are minimum water depth requirements for use of recreational boats.	Pathogens and chemicals in water can make swimmers ill. At high enough levels, these same pathogens and chemicals may harm boaters and fishermen. Pollution in water and/or sediments can be transferred to fish in high enough levels that eating the fish is harmful to human health. In addition, water quality can affect the aesthetics of waterbodies and their desirability for recreation (e.g., brown water, presence of scum, or algae mats).
Minimum flows for water quality	In Arkansas, the minimum flow that must be maintained in state rivers and streams for dilution of wastewater discharges is usually the 7Q10 flow. The 7Q10 flow is determined for each stream based on historical flow records, and is the minimum 7-day average flow that occurs, on average, every 10 years.	Dischargers must consider flow and quality of receiving waters so that effluent concentrations do not contribute to exceedences of water quality standards.

1 http://www.oscn.net/applications/oscn/deliverdocument.asp?id=97778&hits=

In 2008, almost 10,000 miles of streams and over 350,000 acres of lakes in the state were assessed for water quality by ADEQ. Fifty-nine percent of the assessed stream miles and 64 percent of the assessed lake acreage were determined to be meeting numeric water quality criteria and supporting all of their designated uses. **Table 6-4** summarizes the impaired waters in Arkansas and their impaired uses. Note that in the 305(b) report and the 303(d) list, the agricultural water supply and industrial water supply designated uses are combined, and support of these designated uses is not assessed separately. Sediment and nutrients/organic enrichment/low DO are the pollutants most often identified as the cause of water quality impairment.

6.1.3 Groundwater Availability

This section summarizes the process for estimating groundwater availability and characterizes groundwater quality for the state. Currently, about 71 percent of the water supply in the state is provided from groundwater sources.

Methodology and Approach

The amount of groundwater available for use is assessed using the latest version of the Mississippi Embayment Regional Aquifer Study (MERAS) model, a hydrologic model developed by the USGS. The part of Arkansas that is in the MERAS model is shown on **Figure 6-6**. The MERAS model covers the eastern portion of the state, where the most significant groundwater development occurs. The MERAS model was used to assess the impact of meeting current and future demands with groundwater.

The MERAS model includes 10 primary hydrogeologic units, including the two aquifers—the Mississippi River Valley alluvial aquifer and the Sparta aquifer—that provide most of the groundwater in eastern Arkansas. For the AWP 2014 Update, the MERAS model was used as set up by the USGS, with the exception of updating groundwater demands and extending the model simulation period through 2050.

In order to extend the MERAS model to the 2050 planning horizon, two types of model inputs had to be changed—the projected demands and the recharge estimates. The baseline (2010) demands are the same as the USGS estimates for current production. The 2050 demand projections for groundwater in the MERAS area aquifers were updated using the demands in the Water Demand Forecast Report (Appendix E). The recharge input to the model, which comes from projected streamflow, also had to be updated to the 2050 planning horizon. The recharge input values were based on datasets from the 2009 and 2011 versions of the model, which were projected to 2050 for the AWP 2014 Update.

The total groundwater demand across all aquifers is about 8.7 million AFY in 2010, increasing to 9.9 million AFY in 2050. Production from the Mississippi River Valley alluvial aquifer comprises 97.5 percent of the total pumping, with about 2 percent from the Sparta aquifer and the remaining 0.5 percent from the Wilcox aquifer.

Table 6-4. Summary of 2008 Impaired Waters in Arkansas (ADEQ 2008)[1]

Designated Use	Water Demand Sector Use	Impaired Stream Miles/% of Total Assessed	Impaired Lake Acres/% of Total Assessed
Fish consumption[2]	Recreation	363.3 / 3%	23,637 / 6%
Aquatic life	Fish and Wildlife	2,439.9 / 25%	11,248 / 3%
Primary contact	Recreation	564.8 / 6%	0
Secondary contact	Recreation	7.0 / 0.007%	0
Domestic water supply	Drinking Water	448.3 / 4%	97,105 / 27%
Ag and Industrial water supply	Agriculture, Industrial	967.7 / 10%	0
Total miles (acres) impaired		**4,086.5 / 41%**	**127,520 / 36%**
Total miles (acres) assessed		**9,849.7**	**357,896**

1 ADEQ, List of Impaired Waterbodies, 303(d) List (2008).

2 Fish consumption is not a designated use included in APCEC Regulation No. 2, but waterbodies can be designated as impaired if sportfish in a waterbody are not safe for human consumption.

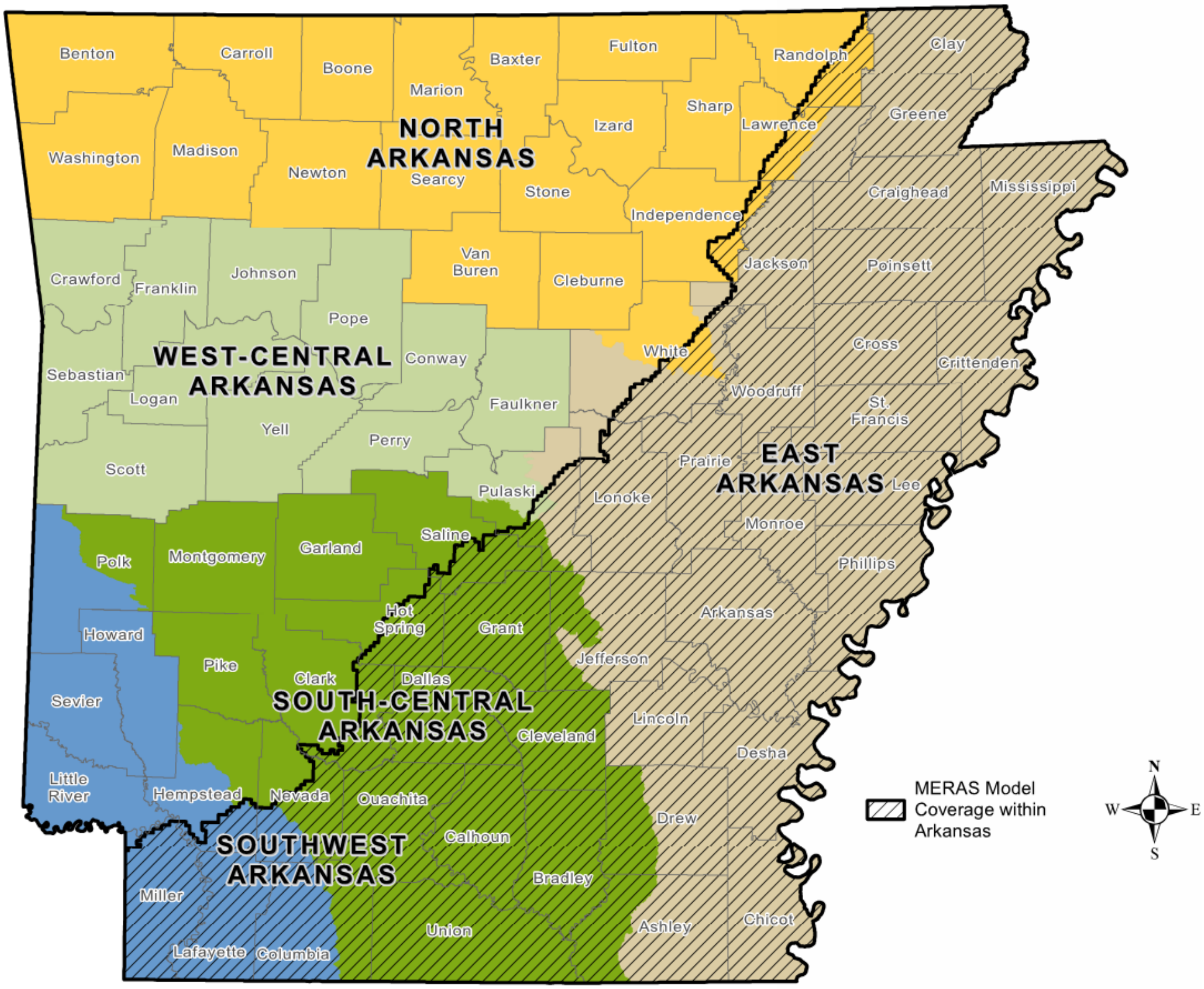


Figure 6-6. The MERAS Model Boundary with Respect to the Water Resource Planning Regions

The MERAS model was run using four scenarios to assess the availability of groundwater by aquifer and location. The four scenarios are combinations of two different climatic conditions (wet, dry) and two different pumping scenarios (sustainable, mining). The climatic conditions are based on combinations of historical periods that had drier and wetter conditions. In the sustainable pumping scenario, the model shuts off pumping when the simulated water level reaches half of the original (pre-pumping) water level in the aquifer. In the mining scenario, the model allows pumping of water from the aquifer until the aquifer is dry. The results of modeling all four scenarios are presented in the Water Availability Report (Appendix C), but only the results from the sustainable pumping under dry climate conditions scenario are described in this AWP 2014 Update. The groundwater availability predicted by modeling with this combination of climate and pumping represent prudent conditions for statewide planning purposes.

On a statewide basis, the projected 2050 groundwater demand is about 10 million AFY, but the available groundwater is 1.9 million AFY, leaving a water supply gap of 8.2 million AFY. **Figure 6-7** displays the groundwater gap by major basin assuming sustainable pumping under dry climatic conditions.

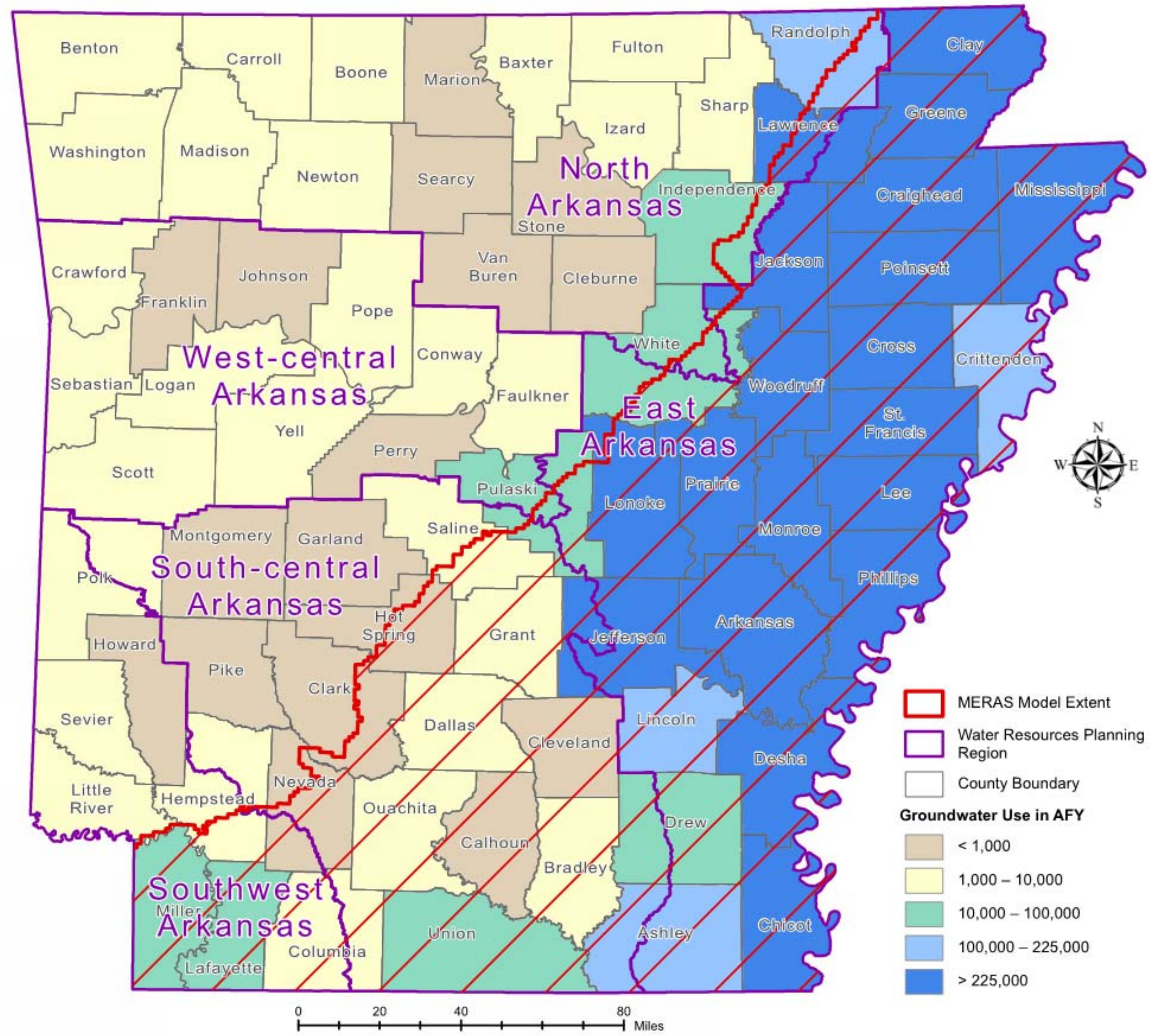


Figure 6-7. Groundwater Use in Arkansas

The modeling results show that current and projected demands for groundwater in the Mississippi Embayment in eastern Arkansas are not sustainable – the demand for water cannot be met by groundwater. This is the same result reported by the USGS in their modeling evaluations. Pumping at higher rates are possible for some time into the future by mining groundwater that is stored in pore space in the aquifer. However, once the water stored in the pore spaces of the aquifer is pumped out, it is not recharged fast enough to meet demands and significant damage to the aquifer could result. Even with this mining approach to groundwater development, production rates decline rapidly as pore space storage is depleted.

The sustainable pumping approach, where the groundwater levels are maintained at half of the pre-development levels, will eventually reach a condition where pumping rates are about equal to the quantity of recharge entering the aquifers. Under the sustainable scenario for pumping levels, all of the demand for groundwater cannot be met and the areas of high agricultural use are the most impacted. **Figure 6-8** displays the projected decline in water level between the base period and 2050 for the Mississippi River Valley alluvial aquifer with sustainable pumping. Even under sustainable pumping scenario, the predicted decline is up to 40 feet in Chicot County and Saint Francis County and up to 75 feet in Mississippi County.

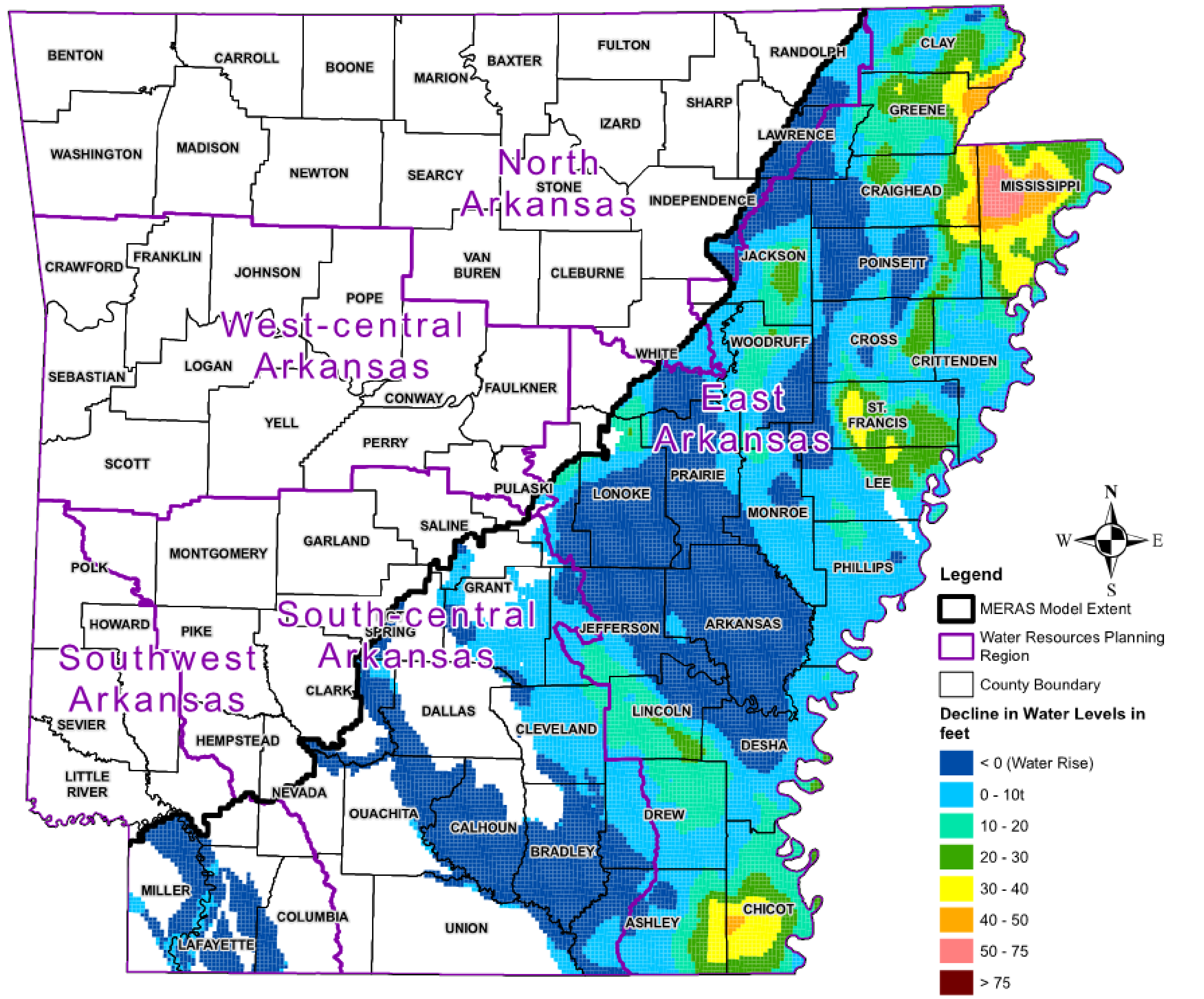


Figure 6-8. Decline in Water Levels between the Base Period and 2050 for the Alluvial Aquifer

These modeling results point out that groundwater demands cannot be met (i.e., there is a gap) and the water levels will continue to decline, even under sustainable pumping conditions. This conclusion serves to highlight the importance of replacing groundwater with surface water to meet demands. The Grand Prairie and Bayou Meto projects are important because they will convert about 15 percent of the East Arkansas Region irrigated acres from groundwater to surface water.

The model is a regional-scale model that is not capable of assessing small-scale conditions, but does provide a reasonable means to assess the availability of groundwater at the scale of this study.

The availability of groundwater outside the MERAS model area is based on a qualitative evaluation of water supply availability completed by the USGS and described in the "Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical

Characteristics of Arkansas's Groundwater Resources" (Kresse et al. 2014) (Appendix D).[36]

The Interior Highlands of Arkansas have less reported groundwater use than other areas of the state, reflecting a combination of effects—prevalent and increasing use of surface water, less intensive agricultural uses, lower population and industry densities, lesser potential yield of the resource, and lack of detailed reporting.

As such, the overall lower yields of aquifers of the Interior Highlands result in domestic supply as the dominant use, with minor industrial, small municipal, and commercial supply use. Where greater volumes are required for growth of population and industry, surface water is the greatest supplier of these water needs in the Interior Highlands.

Groundwater Quality

The information on groundwater quality comes entirely from the "Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical Characteristics of Arkansas's Groundwater Resources" (Kresse et al. 2014).[35] Groundwater quality information was compiled from more than 500 historical and recent publications and from greater than 8,000 sites with groundwater quality data. The water quality data measurements were obtained from the USGS National Water Information System (NWIS) database and the ADEQ and entered into a spatial database to investigate distribution and trends in groundwater quality constituents for each of the aquifers. The water quality characteristics of 16 aquifers in Arkansas that currently serve or have served as important sources of water supply have been described.

The Mississippi River Valley alluvial aquifer is one of the most important aquifers in terms of total groundwater use in the state. Water quality generally is good throughout the extent of the aquifer; however, elevated iron concentrations in most areas preclude use of the aquifer for commercial, industrial, and municipal use without treatment. Elevated salinity additionally occurs in different areas of eastern Arkansas.

The Sparta aquifer is the second most important aquifer in terms of volume of use in Arkansas. Groundwater from the Sparta aquifer generally is of very high quality; isolated areas contain slightly elevated chloride concentrations resulting from upwelling of high-salinity water from underlying formations.

Other aquifers of the Coastal Plain—including the Cane River, Carrizo, Wilcox, Nacatoch, Ozan, Tokio, and Trinity aquifers—generally are used as important local sources of domestic, industrial, and municipal supply. These aquifers all exhibit increasing salinity at various distances downdip from the outcrop areas that renders the groundwater unusable for most purposes. However, where there is a higher percentage of sand in the formations comprising these aquifers, for example, in the northeast part of the state, the aquifers are of high quality and result in greater use.

The Interior Highlands region of western Arkansas has less reported groundwater use than other areas of the state. Spatial trends in groundwater geochemistry in the Interior Highlands differ greatly from trends noted for aquifers of the Coastal Plain.

In the Ozark and Springfield Plateaus, the high degree of connectivity between the surface and groundwater—expressed in the occurrence of sinkholes, solution fractures, caves, losing streams, large springs, and other karst features—leads to nutrients, bacteria, and other surface-derived contaminants associated with agricultural activities posing the greatest threat to groundwater quality. A direct correlation was noted for increasing nitrate concentrations with increasing percentage of agricultural land use for the Springfield Plateau and Ozark aquifers.

6.1.4 Gap Analysis

This section describes the process for estimating the gaps between water availability and water demand and the infrastructure necessary to use the available water. Areas in the state with water supply gaps and an estimate of the magnitude of those gaps are identified. Infrastructure needs at the provider level

[36] Kresse, Timothy M.; Hayes, Phillip D.; Merriman-Hoehne, Katherine R.; Gillip, Jonathan A.; Fugitt, D. Todd; Spellman, Jane L.; Nottmeier, Anna M.; Westerman, Drew A.; Blackstock, Joshua M.; Battreal, James L., *Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical Characteristics of Arkansas's Groundwater Resources*, U.S. Geological Survey USGS Scientific Investigations Report: 2014-5149 (2014).

are also described. A detailed description of the gap analysis is provided in Appendix F.

Methodology and Approach

To determine the water supply gaps, two types of water sources were analyzed throughout all the AWP 2014 Update technical studies—surface water and groundwater. Both of these sources were evaluated to determine where the most significant potential for supply limitations may exist in the future. The methodology for calculating excess surface water and total surface water available were described in Section 6.1.2. For the gap analysis, excess and total available surface water is based on the major basin and thus all flow upstream is included. This assumption means that the gap analysis is based on the accumulated flow in each major basin and the calculated excess surface water for the sub-basins shown in Section 6.1.2 are not simply summed.

Groundwater gaps were calculated as a function of modeled groundwater yields for areas within the MERAS model. Groundwater gaps for the state are based on projected changes in groundwater demands. In areas where a groundwater gap is projected, the gap analysis assumes the surface water could be used to fill the groundwater supply gap. A combined source gap occurs when there is insufficient excess surface water or total available surface water to fill the groundwater supply gap. Conversely, a combined source surplus occurs when more supplies are available than are required to meet all demand within a river basin. For all areas, even those where no combined source gap is projected, it is important to note that the appropriate infrastructure may not be in place to utilize all of the available supply.

The infrastructure gap was assessed based on surveying state, public water, and wastewater providers within the state. The survey collected information on planning efforts, asset management and strategies, current and planned funding sources, and estimated costs to meet the identified needs. The infrastructure survey was sent to all 699 public, community providers in the ANRC database. Of the 699 surveys distributed, 261 providers responded to the survey, for an overall response rate of 38 percent, representing an estimated 67 percent of the population with supplied water and wastewater services. Response rates were representative across regions and providers of different sizes, ensuring that the survey data was representative of different provider circumstances and needs across the state. Overall, $5.74 billion in infrastructure needs was identified through 2024 for all water providers. Similarly, wastewater providers are estimated to need $3.76 billion in infrastructure improvements through 2023.

Results

The annual average 2050 groundwater gap across the state is estimated to be approximately 8.2 million AFY assuming sustainable groundwater pumping. On an annual average basis there is "excess surface water" and "total available surface water" on a statewide basis; however, on a monthly basis the projected excess and total available surface water varies seasonally such that there is less available in the high demand months of June, July, and August.

At the major basin level, the results of the water supply gap analysis are summarized below and shown in **Figure 6-9**. All groundwater gaps are based on the assumption of sustainable pumping:

- **Arkansas River**—the Arkansas River Basin has a projected groundwater gap of over 750,000 AF in 2050; however, due to the substantial amount of excess surface water and total available water in the basin, there is a combined source surplus that ranges from 2,500,000 AF to 12,500,000 AF depending on the amount of surface water assumed available for development. An insignificant groundwater gap was identified for just the upper portion of the Arkansas River and a substantial combined source surplus was identified due to large amounts of available surface water supplies available in this upper portion.
- **Bayou Bartholomew**—the Bayou Bartholomew Basin's groundwater gap is estimated to be nearly 150,000 AF in 2050. This gap could be nearly filled with excess surface water leaving a combined source gap of 30,000 AF. If total available surface water is used, the combined source gap has potential to become a surplus greater than 300,000 AF.

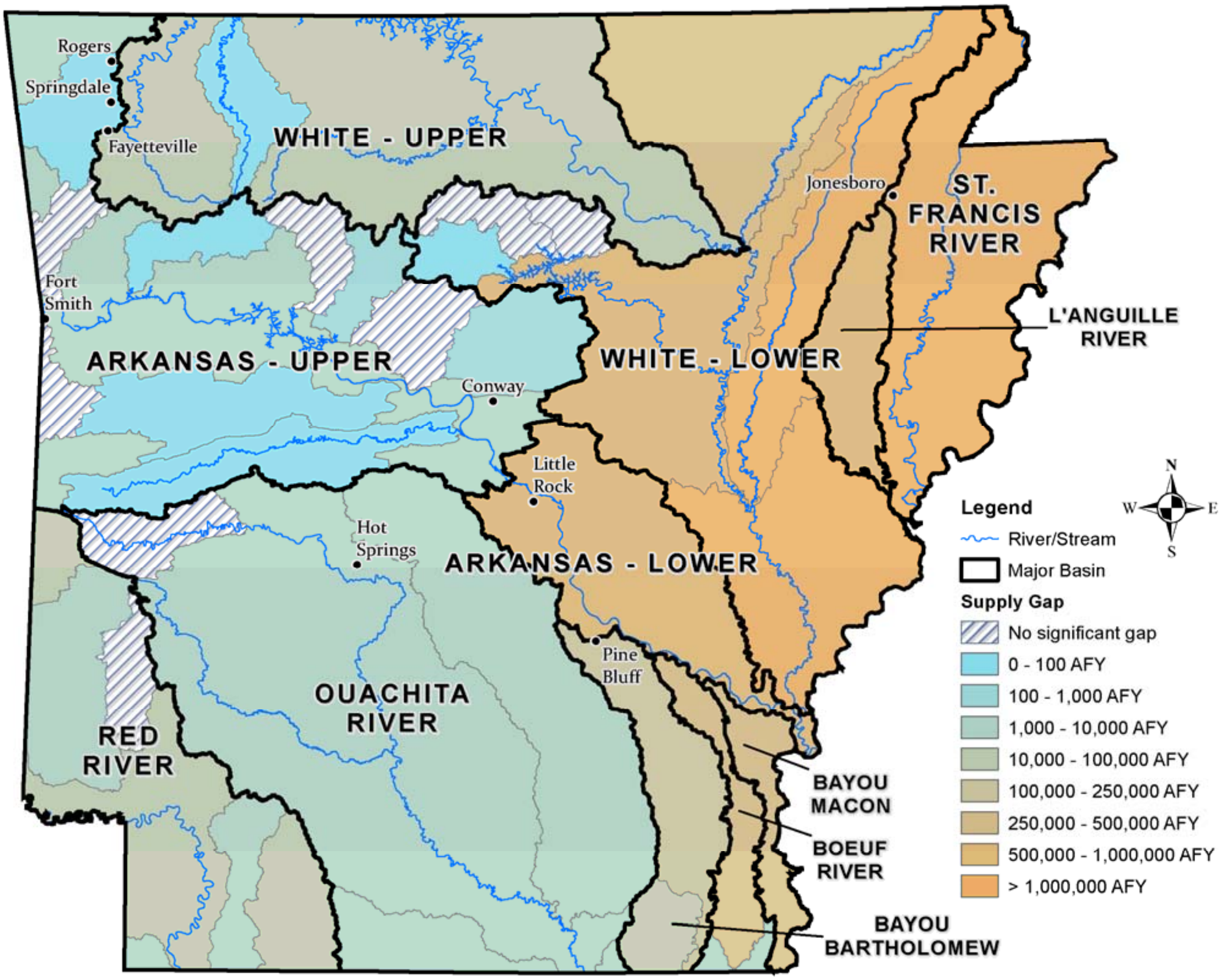


Figure 6-9. 2050 Groundwater Gap by Major Basin and Subbasin Assuming Sustainable Pumping Under Dry Climatic Conditions

- **Bayou Macon**—Bayou Macon's groundwater gap is projected to be 275,000 AF by 2050. The gap analysis determined that even under the assumption of developing total available surface water, a combined source gap of 170,000 AF remained in the basin.

- **Boeuf River**—the Boeuf River Basin is projected to have a groundwater gap greater than 300,000 AF. Similar to Bayou Macon, use of total available surface water would still leave a combined source gap of 110,000 AF. If only excess surface water were used, the combined source gap would be 280,000 AF.

- **L'Anguille River**—the L'Anguille River's groundwater gap is estimated to be over 900,000 AF in 2050. A large amount of groundwater demand in a relatively small basin results in a combined source gap ranging between 560,000 AF and 830,000 AF depending on the amount of surface water assumed available for development.

- **Ouachita River**—The Ouachita River Basin's groundwater gap was identified to be fairly insignificant. This fact, coupled with a large amount of available surface water, results in a combined source surplus ranging between 1,000,000 AF and 4,000,000 AF.

- **Red River**—The Red River's groundwater gap is projected to be just over 70,000 AF in 2050; however, ample surface water supplies exist and this gap can be fully eliminated. The combined source surplus assuming only excess surface water is available is greater than 1,000,000 AF.

- **St. Francis River**—The St. Francis River has the second largest groundwater gap, by basin, at an estimated 1,900,000 AF. Use of all available excess surface water would lessen this gap to 1,200,000 AF while use of total available water would create a surplus in the basin of nearly 800,000 AF.
- **White River**—the White River has a projected groundwater gap in excess of 3,750,000 AF. However; due to the large amount of surface water in this basin, the gap can be eliminated by developing all total available surface water leaving a surplus of over 4,750,000 AF. If only excess surface water is assumed available in the basin, a combined source gap of greater than 1,600,000 AF is projected to exist. In the upper portion of the White River basin, the water supply gap is small due to a low amount of groundwater demand and a large amount of available surface water.

6.2 Regional Water Resource Planning Areas

The water resource planning regions have been identified as a framework to quantify and compare available water supply with demands. Water demand, availability, quality, and gaps are provided for each of the five water resource planning areas. The overall purpose of the water resource planning regions is to group areas of the state with shared resources and similar economic, social, and institutional characteristics in order to facilitate the water resource planning process and to devise basin- and resource-focused planning needs, goals, and management practices/solutions to address local and regional needs. Reports on the five Water Resource Planning Regions with detailed information on the regions are provided in Appendix B.

6.2.1 East Arkansas Region

The East Arkansas Region encompasses approximately 15,900 square miles in eastern Arkansas. All or parts of 25 counties are included in this region. Major cities in the region include Jonesboro, Paragould, Pine Bluff, Forrest City, West Memphis, Blytheville, Stuttgart, and Helena. There are approximately 44,000 miles of rivers, streams, and ditches in the East Arkansas Region, approximately 680 miles of waterways used for commodity transport, and over 150,000 acres of impounded water (ASWCC 1981, Arkansas Waterways Commission 2013, USGS 2013a).[37, 38, 39] Groundwater in the East Arkansas Region represents one of the most valuable natural resources in the state. The primary water use of these aquifers is for agriculture, with crop irrigation accounting for 92 percent of water used in 2005 (USGS 2009).[40] There are eight recognized aquifers in the East Arkansas Region with crop agriculture as the largest industry. Tourism also contributes significantly to the regional economy. In addition to the agriculture economic sector, crop agriculture generates revenue in the manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors, and generates jobs in all of the economic sectors. Tourism generates revenue and jobs in many of the economic sectors including recreation, accommodation, and food services; retail trade; and real estate. Transport of commodities on the Arkansas and White Rivers in the East Arkansas Region is important to both the regional and the state economy.

Surface Water Availability

The East Arkansas Region contains all or a portion of seven major basins. These basins have total excess surface water of over 6.3 million AFY and a total water availability of nearly 25.5 million AFY. **Table 6-5** presents these basins and identifies the portion of the basin that is within the East Arkansas Region. Because the total excess surface water numbers shown in Table 6-5 represents the entirety of all seven basins, this water may not be available for development strictly within the East Arkansas Region.

Groundwater Availability

The East Arkansas Region is projected to have groundwater availability in 2050 between approximately 1.8 million AFY. **Table 6-6** summarizes the projected groundwater availability for the East Arkansas Region.

[37] ASWCC, ARKANSAS STATE WATER PLAN, LAKES OF ARKANSAS, 142 (1981).
[38] Arkansas Waterways Commission, 2011-2012 BIENNIAL REPORT, 6 (2013).
[39] U.S. Geological Survey, COMPLETED NATIONAL HYDROGRAPHY DATASET (NHD), SURFACE WATER, ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/NHDH_AR_931v210.zip (last visited October 19, 2013).
[40] USGS (2009).

Table 6-5. East Arkansas Region Summary of Surface Water Availability by Major Basin

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Excess Surface Water (AFY)	Total Available Surface Water (AFY)
Bayou Bartholomew	1,534	1,527	114,517	458,068
Bayou Macon	570	570	27,132	108,529
Boeuf River	773	773	37,967	207,132
L'Anguille River	956	956	90,803	363,214
Arkansas River (Lower + Upper)[1]	12,077	2,048	3,307,616	13,230,466
White River (Lower + Upper)[1]	17,130	6,319	2,131,256	8,525,023
St. Francis River	3,512	3,512	670,461	2,681,844
TOTAL	**36,552**	**15,704**	**6,379,753**	**25,574,275**

[1] The Upper and Lower basins are hydrologically connected. See Gap Analysis Report (Appendix F) for detailed description of methodology.

Table 6-6. East Arkansas Region Groundwater Availability (AFY)

Pumping Level Limitation	Climate Assumption	Baseline	2020	2050
Minimum water elevation equal to half the aquifer thickness in the alluvial aquifer and the top of formation in the confined aquifers	Dry	3,538,946	2,413,647	1,809,405

Water Quality

In the East Arkansas Region, water quality of 3,075 miles of streams and 15,578 acres of lakes were evaluated for the 2008 biennial assessment. Table 6-7 summarizes the extent of waterbodies in the East Arkansas Region that do not support designated uses and use sectors. The aquatic life designated use was not supported in the majority of impaired stream miles (81 percent) and all of the impaired lake acreage. Low DO (nutrients) of an unknown source is associated with over half of the impaired waters in the planning region, and chloride and sediment from agriculture are associated with over one-third each of the impaired waters.

Sediment from row crop agriculture is believed to be the primary NPS issue for this region. There are three NPS pollution priority watersheds within the region—Bayou Bartholomew, Cache River, and L'Anguille River. NPS pollutants of concern in these watersheds include sediment/turbidity, pathogens, chloride, sulfate, nutrients, and low DO.

Groundwater quality in the East Arkansas Region is generally adequate for agricultural use; however, elevated iron concentrations in most areas preclude use of the groundwater for commercial, industrial, and municipal use without treatment. Elevated salinity additionally occurs in different areas of eastern Arkansas.

Table 6-7. Impaired Waters in the East Arkansas Region in 2008 (ADEQ 2009)[1]

Designated Use Not Supported	Water Use Sector Impacted	Miles of Assessed Streams	Acres of Assessed Lakes
Aquatic life	Fish and wildlife	1,420.5	5,817
Fish consumption	Recreation	104.5	0
Primary contact recreation	Recreation	263.4	0
Secondary contact recreation	Recreation	7	0
Domestic water supply	Drinking water	65.4	0
Agricultural and industrial water supply	Agricultural and/or industrial	420.1	0
Total		**1,758.6**	**5,817**

[1] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

Projected Demand

Water demand in the East Arkansas Region is projected to increase over 13 percent from approximately 10 million AFY to just over 11.2 million AFY in 2050. The current split between groundwater and surface water sources is 81 percent and 19 percent, respectively. In 2050, the East Arkansas Region is projected to represent 80 percent of the statewide water demand. The regional increase is related to anticipated development of irrigable acres. Other demand sectors are projected to remain relatively constant with little to no growth. **Figure 6-10** and **Table 6-8** show the projected water demand change over time for all demand sectors combined and also for noncrop irrigation demand sectors only.

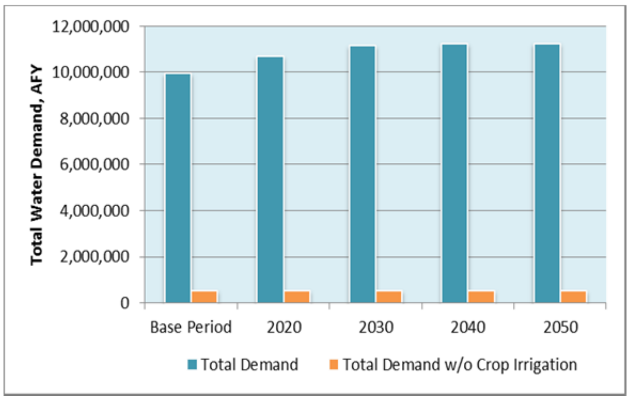


Figure 6-10. East Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals

Supply and Infrastructure Gaps

A summary of the demand, supply availability, and the groundwater gaps for the East Arkansas Region are presented in **Figure 6-11**. Figure 6-11 highlights that while the regional groundwater gap is projected to be over 7 million AF in 2050, there is more than enough total available surface water from the rivers that flow through the East Arkansas Region to fill the gap. However, there is not enough excess surface water available.

As was noted in Sections 6.1.2 and 6.1.4, the Boeuf River, Bayou Macon, and L'Anguille River do not have sufficient total available surface water to close the groundwater gaps within their basins. **Table 6-9** shows the combined source gap assuming the respective surface water resources are fully developed. The combined source gap shown in Table 6-9 highlights that under dry climatic conditions and sustainably pumped groundwater that even if all available excess surface water were utilized, a total combined source gap of over 4.2 million AFY would exist for the Bayou Bartholomew, Bayou Macon, Boeuf River, L'Anguille River, St. Francis River, and Lower White River basins. If groundwater augmentation is not limited to excess surface water, but instead if all total available surface water is developed, the combined source gap in the Bayou Bartholomew, St. Francis River, and Lower White River basins is eliminated and the combined source gap associated with Bayou Macon, Boeuf River, and L'Anguille River is reduced to less than 850,000 AFY.

Surface water availability, represented as excess surface water and total available surface water, are based on summing the available surface water in major basins that intersect the East Arkansas Region. For this reason, the surface water availability quantity shown may not be fully developed within the East Arkansas Region alone but instead shared amongst all the planning regions that intersect a particular basin. Similarly, groundwater gaps are summed for the major basins that intersect the East Arkansas Region to be spatially consistent with the surface water availability.

The infrastructure gap in the East Arkansas Region was also assessed. A total of 203 water providers are located in the East Arkansas Region. The projected water infrastructure gap for the East Arkansas Region is estimated to be approximately $1.58 billion, or approximately 27 percent of the identified total state infrastructure need. The East Arkansas Region had 69 surveys submitted, which represents 34 percent of water providers in the region.

Table 6-8. East Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals (AFY)

With or Without Crop Irrigation?	Base Period	2020	2030	2040	2050
With Crop Irrigation	9,927,680	10,666,880	11,128,320	11,207,840	11,222,400
Without Crop Irrigation	535,360	537,360	530,880	528,640	527,520

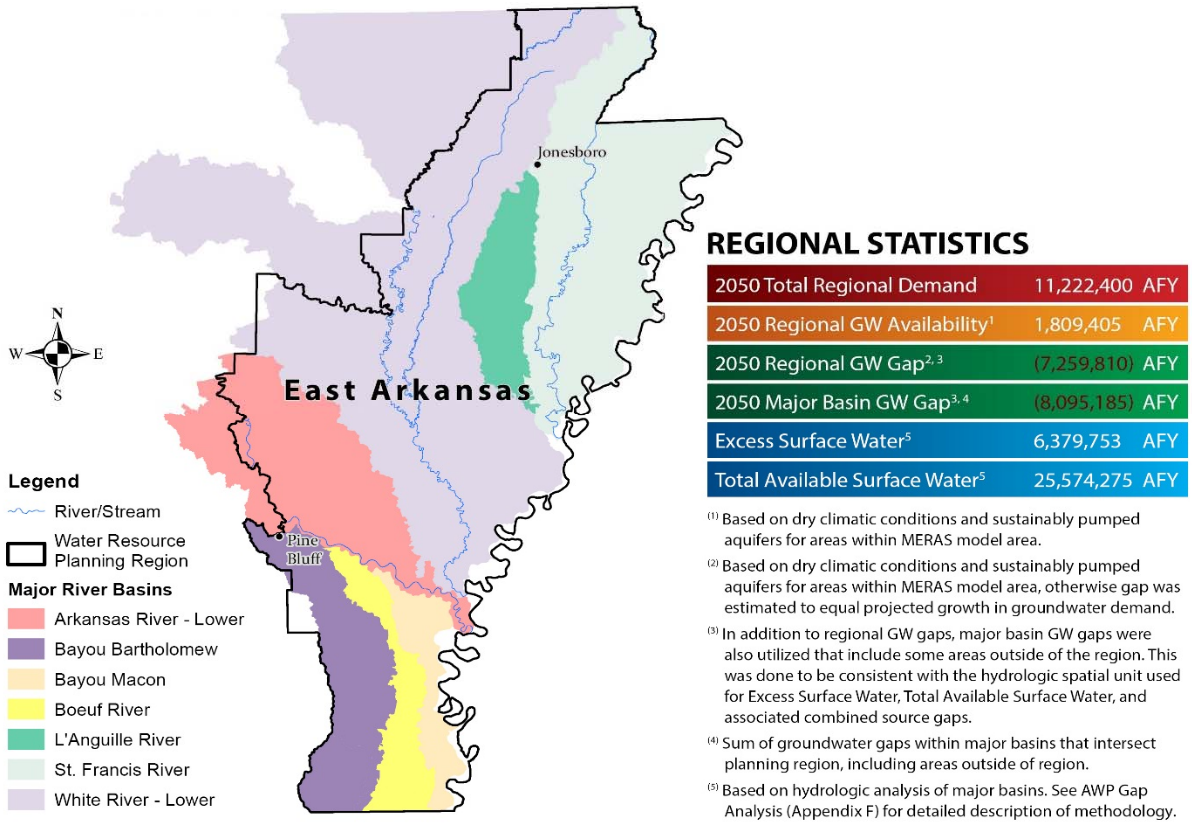


Figure 6-11. East Arkansas Region Regional Watershed Statistics

Table 6-9. East Arkansas Region Summary of 2050 Supply Gap by Major Basin Assuming Sustainable Pumping Under Dry Climatic Conditions

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Groundwater Supply Gap (AFY)	Groundwater Source Supply Gap w/Excess Surface Water (AFY)	Combined Source Supply Gap w/Total Available Surface Water (AFY)
Bayou Bartholomew	1,534	1,527	144,619	(30,102)[3]	313,449
Bayou Macon	570	570	(278,740)	(251,608)	(170,211)
Boeuf River	773	773	(317,879)	(279,912)	(110,748)
L'Anguille River	956	956	(926,719)	(835,915)	(563,505)
Arkansas River (Lower + Upper)[1]	12,077	2,048	(757,581)	2,550,035	12,472,885
White River (Lower + Upper)[1]	17,130	6,319	(3,772,536)	(1,641,280)	4,752,487
St. Francis River	3,512	3,512	(1,897,110)	(1,226,649)	784,733
Total	**36,552**	**15,704**	**(8,095,185)**	**(1,715,432)**	**17,479,090**

[1] The Upper and Lower basins are hydrologically connected. Because of this the lower basin's excess surface water and total available surface water also includes the upper basin's excess surface water and total available surface water. To be consistent, groundwater gaps for both the upper and lower basins are also included in the lower basins total. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

6.2.2 North Arkansas Region

The North Arkansas Region encompasses approximately 12,400 square miles in northern Arkansas. All or parts of 19 counties are located within this region. Major cities in the region include Bentonville, Rogers, Springdale, and Fayetteville. There are approximately 19,620 miles of rivers, streams, and ditches in the North Arkansas Region and 25,170 acres of impounded water (USGS 2009, ASWCC 1981).[41, 42] There are two primary aquifers that provide groundwater in the North Arkansas Region. The primary use of the Springfield Plateau aquifer is for domestic and livestock supply while the primary use of the Ozark aquifer is public water supply. The North Arkansas Region economy depends mostly on retail, manufacturing, and wholesale trade.

Surface Water Availability

The North Arkansas Region contains all or a portion of three major basins—the White River-Lower, the White River-Upper, and the Arkansas River-Upper. These basins have total excess surface water of 5.4 million AFY and a total water availability of nearly 21.5 million AFY. **Table 6-10** presents these basins and identifies the portion of the basin that is within the North Arkansas Region. Because the total excess surface water numbers shown in Table 6-10 represent the entirety of all three basins, this water may not be available for development strictly within the North Arkansas Region.

Groundwater Availability

The North Arkansas Region is mostly outside the MERAS model area, but the eastern edge of the region is within the model (Figure 6-6). The groundwater availability in the North Arkansas Region is the sum of MERAS model projected groundwater and available groundwater based on 2010 demands. The North Arkansas Region is projected to have groundwater availability in 2050 of approximately 78,000 AFY. **Table 6-11** summarizes the projected groundwater availability for the North Arkansas Region.

Water Quality

In 2008, 2,324 miles of streams and 129,691 acres of lakes were assessed for water quality by ADEQ in the North Arkansas Region. **Table 6-12** summarizes the extent of waterbodies in the region that do not support designated uses and use sectors. Approximately 63 percent of impaired stream miles and 98 percent of impaired lake acreage in this planning region do not support the aquatic life designated use (i.e., fish and wildlife water use sector). Sediment from erosion and low DO from unknown sources or hydropower are the pollutants most frequently identified as causing lakes and streams to

Table 6-10. North Arkansas Region Summary of Surface Water Availability by Major Basin

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Excess Surface Water (AFY)	Total Available Surface Water (AFY)
White River (Lower + Upper)[1]	17,130	10,809	2,131,256	8,525,023
Arkansas River – Upper[1]	9,544	1,767	3,256,854	13,027,414
TOTAL	**26,674**	**12,576**	**5,388,109**	**21,552,437**

[1] The Upper and Lower basins are hydrologically connected. Upper and Lower Basins have been combined for explanatory purposes and to avoid double counting. See Gap Analysis Report (Appendix F) for detailed description of methodology.

Table 6-11. North Arkansas Region Groundwater Availability (AFY)

Pumping Level Limitation	Climate Assumption	Baseline	2020	2050
Minimum water elevation equal to half the aquifer thickness in the alluvial aquifer and the top of formation in the confined aquifers	Dry	179,536	79,068	78,782

[41] U.S. Geological Survey, COMPLETED NATIONAL HYDROGRAPHY DATASET (NHD), SURFACE WATER, ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/NHDH_AR_931v210.zip (last visited October 19, 2013).
[42] ASWCC, Arkansas State Water Plan, Lakes of Arkansas, 142 (1981).

not support the aquatic life use. Approximately 46 percent of the impaired stream miles do not support primary contact recreation due to high pathogen levels. Urban runoff and a wastewater treatment plant are identified as the sources of pathogens causing some of these impairments.

Table 6-12. Impaired Waters in the North Arkansas Region in 2008 (ADEQ 2009)[1]

Designated Use Not Supported	Water Use Sector Impacted	Miles of Assessed Streams	Acres of Assessed Lakes
Aquatic life	Fish and wildlife	561	2,031
Fish consumption	Recreation	2	50
Primary contact recreation	Recreation	411	0
Secondary contact recreation	Recreation	0	0
Domestic water supply	Drinking water	17	0
Agricultural and industrial water supply	Agricultural and/or industrial	196	0
Total impaired		**896**	**2,081**

[1] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

Excess sediment and nutrients from pastures are believed to be the primary NPS issues for this region. There are three NPS pollution priority watersheds within this region—Beaver Reservoir, Illinois River, and Strawberry River. NPS pollutants of concern in these watersheds include total suspended solids (TSS), sediment/turbidity, low DO, nutrients, and pathogens.

Groundwater quality in the North Arkansas Region is generally of good quality. Because of the steep topography and poor soils in the Ozarks, agriculture in the form of cattle (beef and dairy), swine, and poultry operations accounts for the greatest land use activity in this region, and nutrients, bacteria, and pesticides from agricultural activities, home septic systems, and infiltration of urban runoff are the dominant threats to groundwater quality in the aquifer.

Projected Demand

Water demand in the North Arkansas Region is projected to increase from approximately 1 million AFY to just over 1.2 million AFY in 2050; an increase of over 18 percent. The current split between groundwater and surface water sources is 82 percent and 38 percent, respectively. In 2050, the North Arkansas Region is projected to contain 9 percent of the statewide water demand. **Figure 6-12** and **Table 6-13** show the projected water demand change over time for all demand sectors combined and also for non-crop irrigation demand sectors only.

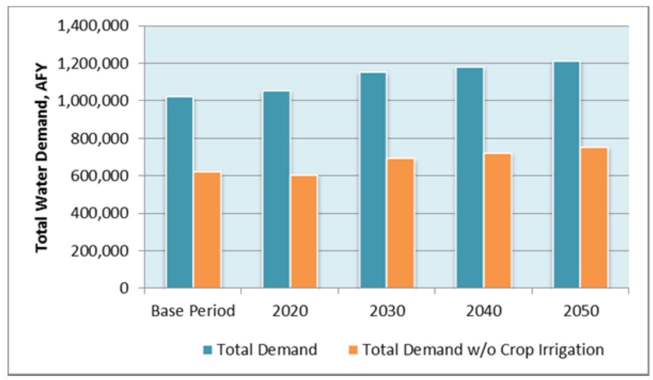


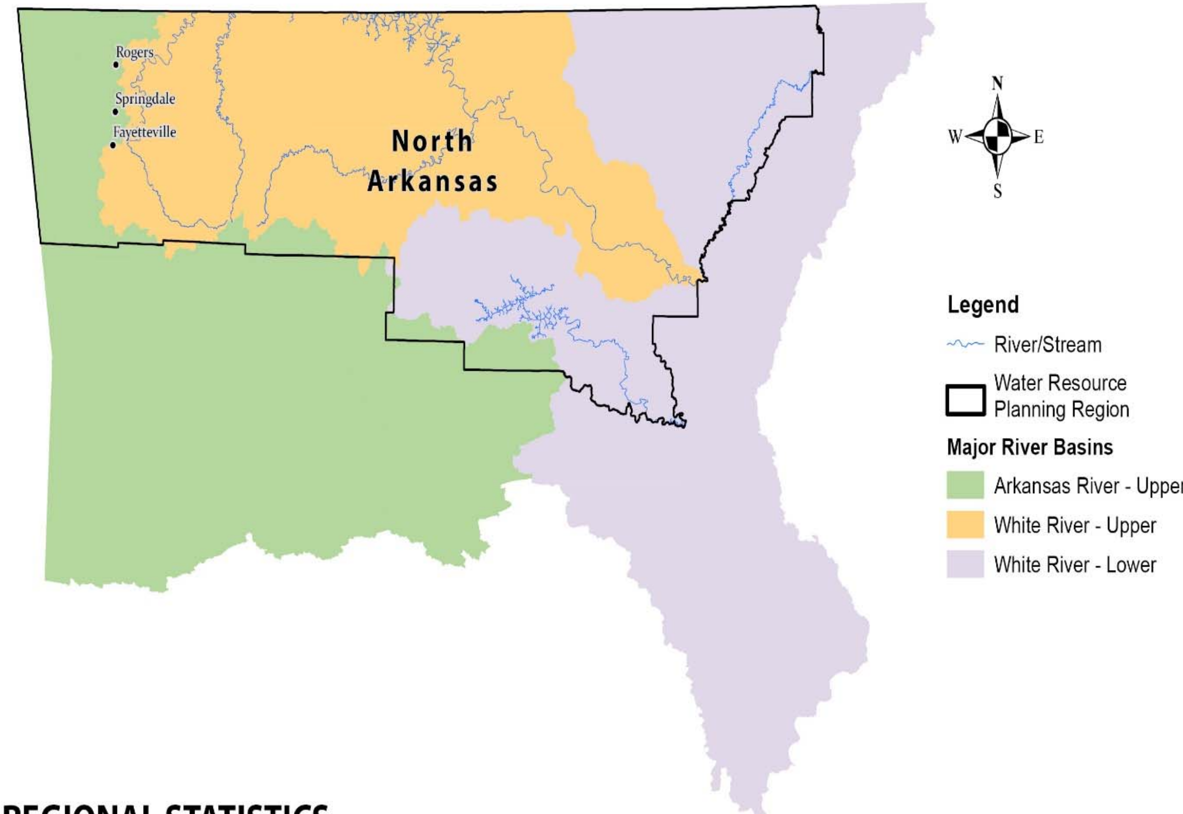
Figure 6-12. North Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals

Supply and Infrastructure Gaps

A summary of the demand, supply availability, and the groundwater gap are presented in **Figure 6-13**. Figure 6-13 highlights that while the regional groundwater gap is projected to be just under 700,000 AF in 2050, there is more than enough excess surface water and total available surface water from the rivers that flow through the North Arkansas Region to fill the gap.

Table 6-13. North Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals (AFY)

With or Without Crop Irrigation?	Base Period	2020	2030	2040	2050
With Crop Irrigation	1,022,560	1,052,800	1,151,360	1,180,480	1,212,960
Without Crop Irrigation	619,360	603,680	691,040	720,160	752,640



REGIONAL STATISTICS

2050 Total Regional Demand	1,212,960	AFY
2050 Regional GW Availability[1]	78,782	AFY
2050 Regional GW Gap[2, 3]	(661,869)	AFY
2050 Major Basin GW Gap[3, 4]	(3,774,454)	AFY
Excess Surface Water[5]	5,388,109	AFY
Total Available Surface Water[5]	21,552,437	AFY

(1) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area.

(2) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area, otherwise gap was estimated to equal projected growth in groundwater demand.

(3) In addition to regional GW gaps, major basin GW gaps were also utilized that include some areas outside of the region. This was done to be consistent with the hydrologic spatial unit used for Excess Surface Water, Total Available Surface Water, and associated combined source gaps.

(4) Sum of groundwater gaps within major basins that intersect planning region, including areas outside of region.

(5) Based on hydrologic analysis of major basins. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Figure 6-13. North Arkansas Region Regional Watershed Statistics

Surface water availability, represented as excess surface water and total available surface water, are based on the summation availability in major basins that intersect the North Arkansas Region. For this reason, the surface water availability quantity shown may not be fully developed within the North Arkansas Region alone but instead shared amongst all the planning regions that intersect a particular basin. Similarly, groundwater gaps are summed for the major basins that intersect the North Arkansas Region to be spatially consistent with the surface water availability.

Table 6-14 shows the combined source gap assuming the respective surface water resources are fully developed. The combined source gap shown in Table 6-14 highlights that if all excess surface water were used, a total combined source gap of over 1.6 million AFY would exist for the White River Basin (lower and upper combined). If groundwater augmentation is not limited to excess surface water, but instead if all total available surface water is developed, the combined source gap is eliminated and instead a surplus would exist of more than 4.7 million AFY.

Table 6-14. North Arkansas Region Summary of 2050 Supply Gap by Major Basin Assuming Sustainable Pumping Under Dry Climatic Conditions

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Groundwater Supply Gap (AFY)	Groundwater Source Supply Gap w/Excess Surface Water (AFY)	Combined Source Supply Gap w/Total Available Surface Water (AFY)
White River (Lower + Upper)[1]	17,130	10,809	(3,772,536)	(1,641,280)	4,752,487
Arkansas River – Upper[1]	9,544	1,767	(1,918)	3,254,935	13,025,496
Total	**26,674**	**12,576**	**(3,774,454)**	**1,613,655**	**17,777,983**

[1] The Upper and Lower basins are hydrologically connected. Because of this the lower basin's excess surface water and total available surface water also includes the upper basin's excess surface water and total available surface water. To be consistent, groundwater gaps for both the upper and lower basins are also included in the lower basins total. See Gap Analysis Report (Appendix F) for detailed description of methodology.

The infrastructure gap in the North Arkansas Region was also assessed. A total of 179 water providers are located in the North Arkansas Region. The projected water infrastructure gap for the North Arkansas Region is estimated to be approximately $1.5 billion, or approximately 25 percent of the identified total state infrastructure need. The North Arkansas Region had 71 surveys submitted, which represents 40 percent of water providers in the region.

6.2.3 West-central Arkansas Region

The West-central Arkansas Region encompasses approximately 7,800 square miles in western Arkansas. Eleven counties and part of Pulaski County fall within this region. Major cities in the region include Fort Smith, Little Rock, North Little Rock, Conway, and Russellville. There are over 1,780 miles of streams in the West-central Arkansas Region. The Arkansas River, which flows through this region, is one of the state's major rivers. The West-central Arkansas Region encompasses the Boston Mountains Plateau and a portion of the Arkansas River Valley in which there are no formally-recognized aquifers. The dominant use of groundwater is domestic supply, with minor industrial, small-municipal, and commercial-supply uses (Kresse, et al. 2014).[43] This planning region has a diverse economic base, which includes industry, agriculture (livestock, poultry, eggs, and crops), tourism, and coal and gas extraction.

Surface Water Availability

The West-central Arkansas Region contains a portion of two major basins—the Arkansas River-Lower and the Arkansas River-Upper. These basins have total excess surface water of 3.3 million AFY and a total water availability of over 13.2 million AFY. **Table 6-15** presents these basins and identifies the portion of the basin that is within the West-central Arkansas Region. Because the total excess surface water numbers shown in Table 6-15 represent the entirety of both basins, this water may not be available for development strictly within the West–central Arkansas Region.

Groundwater Availability

The West-central Arkansas Region is mostly outside the MERAS model area, but a small portion of Pulaski County is within the model (Figure 6-6). The groundwater availability in the West-central Arkansas Region is the sum of MERAS model projected groundwater and available groundwater based on 2010 demands. The West-central Arkansas Region is projected to have groundwater availability in 2050 of approximately 10,000 AFY. **Table 6-16** summarizes the projected groundwater availability for the West-central Arkansas Region.

[43] Kresse, Timothy M.; Hayes, Phillip D.; Merriman-Hoehne, Katherine R.; Gillip, Jonathan A.; Fugitt, D. Todd; Spellman, Jane L.; Nottmeier, Anna M.; Westerman, Drew A.; Blackstock, Joshua M.; Battreal, James L., *Aquifers of Arkansas: Protection, Management, and Hydrologic and Geochemical Characteristics of Arkansas's Groundwater Resources*, U.S. Geological Survey USGS Scientific Investigations Report: 2014-5149 (2014).

Table 6-15. West-central Arkansas Region Summary of Surface Water Availability by Major Basin

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Excess Surface Water (AFY)	Total Available Surface Water (AFY)
Arkansas River (Lower + Upper)[1]	12,077	7,801	3,307,616	13,230,466
TOTAL	**12,077**	**7,801**	**3,307,616**	**13,230,466**

[1] The Upper and Lower basins are hydrologically connected. Upper and Lower Basins have been combined for explanatory purposes and to avoid double counting. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Table 6-16. West-central Arkansas Region Groundwater Availability (AFY)

Pumping Level Limitation	Climate Assumption	Baseline	2020	2050
Minimum water elevation equal to half the aquifer thickness in the alluvial aquifer and the top of formation in the confined aquifers	Dry	7,443	7,600	9,900

Water Quality

In the West-central Arkansas Region, ADEQ assessed water quality in 1,379 miles of streams and 76,237 acres of lakes for the 2008 305(b) report. **Table 6-17** summarizes the extent of waterbodies in the West-central Arkansas Region that do not support designated uses and use sectors. The greatest proportion of impaired stream miles in this region (78 percent) do not support the aquatic life designated use, most often as a result of low DO, high sediment levels, and/or metals (copper and zinc). Fairly equal proportions of the impaired lake acreage in this region do not support the aquatic life designated use due to sediment, and the fish consumption designated use due to mercury levels in some fish species. Sources of these pollutants are not identified by ADEQ.

Table 6-17. Impaired Waters in the West-central Arkansas Region in 2008 (ADEQ 2009)

Designated Use Not Supported	Water Use Sector Impacted	Miles of Assessed Streams	Acres of Assessed Lakes
Aquatic life	Fish and wildlife	307.5	2,900
Fish consumption	Recreation	8.7	3,946
Primary contact recreation	Recreation	68.2	0
Secondary contact recreation	Recreation	0	0
Domestic water supply	Drinking water	50.4	0
Agricultural and industrial water supply	Agricultural and/or industrial	39.4	0
Total impaired		**394.1**	**6,846**

[1] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

Excess nutrients from livestock production are believed to be the primary NPS issue for this region. There are two NPS pollution priority watersheds within this region—Lake Conway Point Remove, and Poteau River. NPS pollutants of concern in these watersheds include sediment/turbidity, nitrogen, and total phosphorous.

Groundwater derived from alluvial deposits of the Arkansas River is one of the most important sources of water in the Arkansas Valley section of the Ouachita Province and provides a valuable source of irrigation and municipal water supply. Groundwater in the Arkansas River Valley alluvial aquifer is of overall good water quality, with the exception of elevated iron concentrations, which often requires treatment for use as a municipal supply system. Chloride concentrations can be slightly elevated; however, only 4 of 661 samples with chloride analyses exceeded the federal secondary drinking water regulation of 250 mg/L.

Projected Demand

Water demand in the West-central Arkansas Region is projected to increase from approximately 1 million AFY to just over 1.1 million AFY in 2050, an increase of over 10 percent. The current split between groundwater and surface water sources is 7 percent and 93 percent, respectively. In 2050, the West-central Arkansas Region is projected to contain 8 percent of the statewide water demand. **Figure 6-14** and **Table 6-18** show the projected water demand change over time for all demand sectors combined and also for noncrop irrigation demand sectors only.

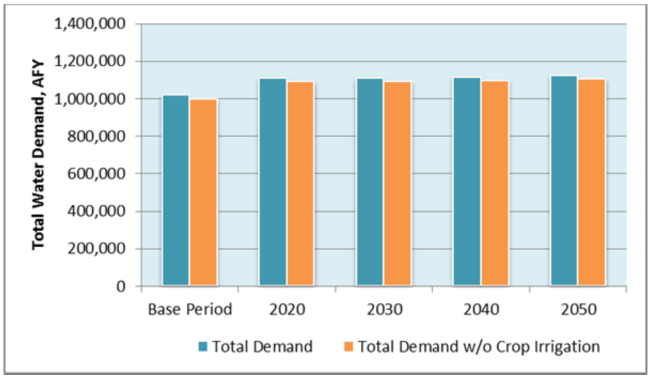


Figure 6-14. West-central Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals

Supply and Infrastructure Gaps

A summary of demand, supply availability, and the groundwater gap are presented in **Figure 6-15**. Figure 6-15 highlights that while the regional groundwater gap is projected to be just over 55,000 AF in 2050, there is more than enough excess surface water and total available surface water from the rivers that flow through the West-central Arkansas Region to fill the gap.

Surface water availability, represented as excess surface water and total available surface water, are based on the summation availability in major basins that intersect the West-central Arkansas Region. For this reason, the surface water availability quantity shown may not be fully developed within the West-central Arkansas Region alone but instead shared amongst all the planning regions that intersect a particular basin. Similarly, groundwater gaps are summed for the major basins that intersect the West-central Arkansas Region to be spatially consistent with the surface water availability that is potentially available for development in the planning region.

Table 6-19 shows the combined source gap assuming the respective surface water resources are fully developed. The combined source gap shown in Table 6-19 highlights that under dry climatic conditions and sustainably pumped groundwater that if all available excess surface water were utilized, a total combined source surplus of over 2.5 million AFY would exist for the Arkansas River basins (upper and lower combined). If groundwater augmentation is not limited to excess surface water, but instead if all total available surface water is developed, the combined source surplus would increase to more than 12.5 million AFY.

The infrastructure gap in the West-central Arkansas Region was also assessed. A total of 109 water providers are located in the West-central Arkansas Region. The projected water infrastructure gap for the West-central Arkansas Region is estimated to be approximately $1.2 billion, or approximately 21 percent of the identified total state infrastructure need. The West-central Arkansas Region had 42 surveys submitted, which represents 39 percent of water providers in the region.

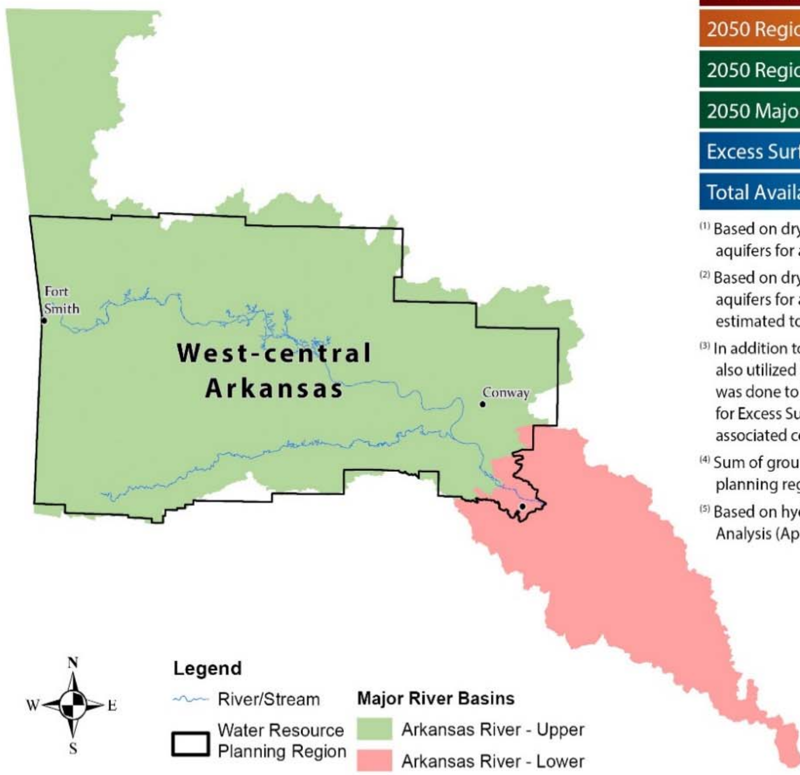
Table 6-18. West-central Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals (AFY)

With or Without Crop Irrigation?	Base Period	2020	2030	2040	2050
With Crop Irrigation	1,019,200	1,108,800	1,109,920	1,115,520	1,123,360
Without Crop Irrigation	999,040	1,090,880	1,092,000	1,097,600	1,105,400

Table 6-19. West-central Arkansas Region Summary of 2050 Supply Gap by Major Basin Assuming Sustainable Pumping Under Dry Climatic Conditions

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Groundwater Supply Gap (AFY)	Groundwater Source Supply Gap w/Excess Surface Water (AFY)	Combined Source Supply Gap w/Total Available Surface Water (AFY)
Arkansas River (Lower + Upper)[1]	12,077	7,801	(757,581)	2,550,035	12,472,885

[1] The Upper and Lower basins are hydrologically connected. Because of this the lower basin's excess surface water and total available surface water also includes the upper basin's excess surface water and total available surface water. To be consistent, groundwater gaps for both the upper and lower basins are also included in the lower basins total. See Gap Analysis Report (Appendix F) for detailed description of methodology.



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2050 Total Regional Demand	1,123,360	AFY
2050 Regional GW Availability[1]	9,900	AFY
2050 Regional GW Gap[2, 3]	(56,932)	AFY
2050 Major Basin GW Gap[3, 4]	(757,581)	AFY
Excess Surface Water[5]	3,307,616	AFY
Total Available Surface Water[5]	13,230,466	AFY

(1) Based on dry climatic conditions and sustainbly pumped aquifers for areas within MERAS model area.

(2) Based on dry climatic conditions and sustainbly pumped aquifers for areas within MERAS model area, otherwise gap was estimated to equal projected growth in groundwater demand.

(3) In addition to regional GW gaps, major basin GW gaps were also utilized that include some areas outside of the region. This was done to be consistent with the hydrologic spatial unit used for Excess Surface Water, Total Available Surface Water, and associated combined source gaps.

(4) Sum of groundwater gaps within major basins that intersect planning region, including areas outside of region.

(5) Based on hydrologic analysis of major basins. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Figure 6-15. West-central Arkansas Region Regional Watershed Statistics

6.2.4 South-central Arkansas Region

The South-central Arkansas Region encompasses approximately 12,000 square miles in south central Arkansas. All or parts of 21 counties are included in this region. Major cities in the region include Benton, Hot Springs, Malvern, Arkadelphia, Camden, and El Dorado. There are approximately 9,710 miles of rivers and streams in the South-central Arkansas Region and 38,010 acres of impounded water (ASWCC 1981; USGS 2009).[44, 45] The major river in the region is the Ouachita River. The largest impoundments in this region are Lake Ouachita, Lake Hamilton, and Lake Catherine. The South-central Arkansas Region is located primarily in the West Gulf Coastal Plain, where the largest and most productive of the state's major aquifers are located. Of the many aquifers located in this region, the Sparta aquifer is the most important, yielding 82 percent of the groundwater used in this section of the region in 2010. The primary water use of these aquifers is for domestic, industrial, and public water supply. Timber, tourism, agriculture, and resource extraction are important economic drivers in the South-central Arkansas Region (Association of Arkansas Counties 2013).[46] Transportation of goods on the Ouachita River downstream of Camden also contributes to the regional economy.

[44] Arkansas Soil and Water Conservation Commission, ARKANSAS STATE WATER PLAN, LAKES OF ARKANSAS, 142 (1981).

[45] U.S. Geological Survey, COMPLETED NATIONAL HYDROGRAPHY DATASET (NHD), SURFACE WATER, ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/NHDH_AR_931v210.zip (last visited October 19, 2013).

[46] Association of Arkansas Counties, http://www.arcounties.org/ (Retrieved October 16, 2013).

Surface Water Availability

The South-central Arkansas Region contains a portion of two major basins—the Arkansas River-Lower and the Ouachita River. These basins have total excess surface water of 4.3 million AFY and a total water availability of over 17.3 million AFY. **Table 6-20** presents these basins and identifies the portion of the basin that is within the South-central Arkansas Region. Because the total excess surface water numbers shown in Table 6-20 represent the entirety of both basins, this water may not be available for development strictly within the South-central Arkansas Region.

Groundwater Availability

A little more than one-half of the South-central Arkansas Region is within the MERAS model area (Figure 6-6). The groundwater availability in the South-central Arkansas Region is the sum of MERAS model projected groundwater and available groundwater based on 2010 demands. The South-central Arkansas Region is projected to have groundwater availability in 2050 of approximately 38,500 AFY. **Table 6-21** summarizes the projected groundwater availability for the South-central Arkansas Region.

Water Quality

ADEQ assessed the water quality of 1,820 miles of streams and 90,071 acres of lakes in the South-central Arkansas Region for the 2008 biennial assessment. **Table 6-22** summarizes the extent of waterbodies in the South-central Arkansas Region that do not support designated uses and use sectors. In this region, aquatic life is the designated use not supported in 86 percent of the impaired stream miles. Metals from resource extraction, primarily zinc and copper, are identified as the cause of the majority of the aquatic life impairments in this region. The fish consumption designated use is not supported in 98 percent of the impaired lake acreage in the planning region due to mercury levels in some fish species.

Table 6-22. Impaired Waters in the South-central Arkansas Region in 2008 (ADEQ 2009)[1]

Designated Use Not Supported	Water Use Sector Impacted	Miles of Assessed Streams	Acres of Assessed Lakes
Aquatic life	Fish and wildlife	652.8	300
Fish consumption	Recreation	319.6	319.6
Primary contact recreation	Recreation	22.5	0
Secondary contact recreation	Recreation	0	0
Domestic water supply	Drinking water	60.5	0
Agricultural and industrial water supply	Agricultural and/or industrial	225.9	0
Total impaired		**754.1**	**17,145**

[1] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

Excess nutrients from livestock production (poultry and cattle) are believed to be the primary NPS issue for this region. There are two NPS pollution priority watersheds located within this region—Lower Ouachita Smackover and Upper Saline. NPS pollutants of concern in these watersheds include sediment, nutrients, and pathogens.

Table 6-20. South-Central Arkansas Region Summary of Surface Water Availability by Major Basin

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Excess Surface Water (AFY)	Total Available Surface Water (AFY)
Arkansas River (Lower + Upper)[1]	12,077	442	3,307,616	13,230,466
Ouchita River	11,559	11,309	1,026,619	4,106,478
Total	**23,636**	**11,751**	**4,334,236**	**17,336,943**

[1] The Upper and Lower basins are hydrologically connected. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Table 6-21. South-Central Arkansas Region Groundwater Availability (AFY)

Pumping Level Limitation	Climate Assumption	Baseline	2020	2050
Minimum water elevation equal to half the aquifer thickness in the alluvial aquifer and the top of formation in the confined aquifers	Dry	31,709	33,740	38,560

Groundwater in the South-central Arkansas Region comes from the Ouachita Mountains aquifer in the northern part of the region and from the Sparta aquifer in the southern part of the region. The Ouachita Mountains aquifer is a shallow saturated section in the thick sequence of Paleozoic rock formations in the Ouachita Mountains. It serves as an important source of groundwater supply for domestic users, in addition to a limited number of small commercial- and community-supply systems. The Ouachita Mountains aquifer extends north to the Arkansas River, west to the state line, and south and east to the boundary with the Coastal Plain Province.

Groundwater quality in the Ouachita Mountains aquifer is good with respect to federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users.

The quality of groundwater from the Sparta aquifer throughout the state is very good; however, the South-central Arkansas Region is located in the outcrop area of the Sparta aquifer and there is elevated iron and nitrate groundwater concentrations in that area. Areas of high salinity are noted in isolated areas of the Sparta aquifer, predominantly as a result of inferred upwelling from high-salinity groundwater in underlying formations.

Projected Demand

Water demand in the South-central Arkansas Region is projected to increase from approximately 240,000 AFY to just over 260,000 AFY in 2050, an increase of over 10 percent. The current split between groundwater and surface water sources is 65 percent and 35 percent, respectively. In 2050, the South-central Arkansas Region is projected to contain 2 percent of the statewide water demand. **Figure 6-16** and **Table 6-23** show the projected water demand change over time for all demand sectors combined and also for noncrop irrigation demand sectors only.

Supply and Infrastructure Gaps

A summary of the demand, supply availability, and the groundwater gap are presented in **Figure 6-17**. Figure 6-17 highlights that while the groundwater gap is projected to be just over 130,000 AF in 2050, there is more than enough excess surface water and total available surface water from the rivers that flow through the South-central Arkansas Region to fill the gap. Surface water availability, represented as excess surface water and total available surface water, are based on the summation availability in major basins that intersect the South-central Arkansas Region. For this reason, the surface water availability quantity shown may not be fully developed within the South-central Arkansas Region alone but instead shared amongst all the planning regions that intersect a particular basin. Similarly, groundwater gaps are summed for the major basins that intersect the South-central Arkansas Region to be spatially consistent with the surface water availability.

Table 6-24 shows the combined source gap assuming the respective surface water resources are fully developed. The combined source gap shown in Table 6-24 highlights that under dry climatic conditions and sustainably pumped groundwater that if all available excess surface water were utilized, a total combined source surplus of over 3.5 million AFY

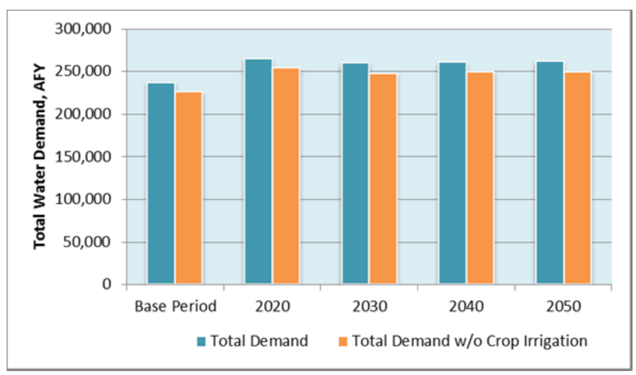
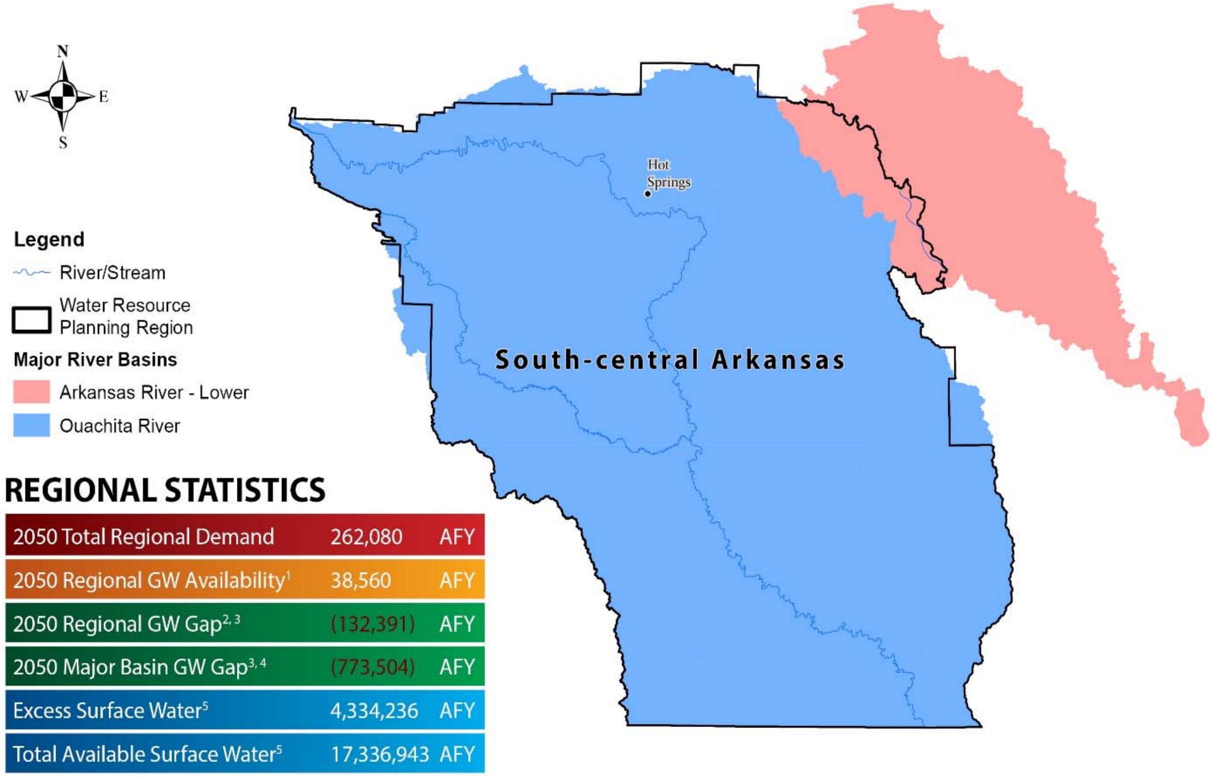


Figure 6-16. South-central Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals

Table 6-23. South-central Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals (AFY)

With or Without Crop Irrigation?	Base Period	2020	2030	2040	2050
With Crop Irrigation	237,440	265.440	259,840	260,960	262,080
Without Crop Irrigation	226,240	254,240	247,520	249,760	249,760



(1) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area.

(2) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area, otherwise gap was estimated to equal projected growth in groundwater demand.

(3) In addition to regional GW gaps, major basin GW gaps were also utilized that include some areas outside of the region. This was done to be consistent with the hydrologic spatial unit used for Excess Surface Water, Total Available Surface Water, and associated combined source gaps.

(4) Sum of groundwater gaps within major basins that intersect planning region, including areas outside of region.

(5) Based on hydrologic analysis of major basins. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Figure 6-17. South-central Arkansas Region Regional Watershed Statistics

Table 6-24. South-central Arkansas Region Summary of 2050 Supply Gap by Major Basin Assuming Sustainable Pumping Under Dry Climatic Conditions

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Groundwater Supply Gap (AFY)	Groundwater Source Supply Gap w/Excess Surface Water (AFY)	Combined Source Supply Gap w/Total Available Surface Water (AFY)
Arkansas River (Lower + Upper)[1]	12,077	442	(757,581)	2,550,035	12,472,885
Ouachita River	11,559	11,309	(15,923)	1,010,696	4,090,555
Total	**23,636**	**11,751**	**(773,504)**	**3,560,732**	**16,563,439**

[1] the Upper and Lower basins are hydrologically connected. Because of this the lower basin's excess surface water and total available surface water also includes the upper basin's excess surface water and total available surface water. To be consistent, groundwater gaps for both the upper and lower basins are also included in the lower basins total. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

would exist for the Arkansas River-Lower and Ouachita basins. If groundwater augmentation is not limited to excess surface water, but instead if all total available surface water is developed, the combined source surplus would increase to more than 16 million AFY.

The infrastructure gap in the South-central Arkansas Region was also assessed. A total of 142 water providers are located in the South-central Arkansas Region. The projected water infrastructure gap for the South-Central Region is estimated to be approximately $1.1 billion, or approximately 19 percent of the identified total state infrastructure need. The South-Central Region had 52 surveys submitted, which represents 37 percent of water providers in the region.

6.2.5 Southwest Arkansas Region

The Southwest Arkansas Region encompasses approximately 4,500 square miles in southwest Arkansas. All or parts of nine counties fall within the region. Major cities in the region include Texarkana, Magnolia, Hope, Ashdown, and DeQueen. There are approximately 3,200 miles of rivers and streams in the Southwest Region, and over 85,000 acres of impounded water. Major rivers in the region include Red River, Little River, Cossatot River, Saline River, Bodcau Creek, Sulphur River, and Bayou Dorcheat. The largest impoundment in the region is Millwood Lake. There are 11 recognized aquifers in the Southwest Region where some of these aquifers are designated as regional aquifers and encompass parts of several states, whereas a few of these aquifers are considered minor and are only important as local sources of water. The water withdrawn from these aquifers are used primarily for domestic, industrial, irrigation, and public-water supply use. Agriculture, timber, and tourism are important economic drivers in the Southwest Region (Association of Arkansas Counties 2013).

Surface Water Availability

The Southwest Arkansas Region is almost entirely made up of the Red River major basin. The Red River basin has a total excess surface water of 1.2 million AFY and a total water availability of over 4.9 million AFY. **Table 6-25** presents these basins and identifies the portion of the basin that is within the Southwest Arkansas Region. Because the total excess surface water numbers shown in Table 6-25 represent the entirety of both basins, this water may not be available for development strictly within the Southwest Arkansas Region.

Groundwater Availability

A little less than one-half of the Southwest Arkansas Region is within the MERAS model area (Figure 6-6). The groundwater availability in the Southwest Arkansas Region is the sum of MERAS model projected groundwater and available groundwater based on 2010 demands. The Southwest Arkansas Region is projected to have groundwater availability in 2050 of approximately 3,600 AFY. **Table 6-26** summarizes the projected groundwater availability for the Southwest Arkansas Region.

Table 6-25. Southwest Arkansas Region Summary of Surface Water Availability by Major Basin

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Excess Surface Water (AFY)	Total Available Surface Water (AFY)
Red River	4,440	4,439	1,221,666	4,886,664

Table 6-26. Southwest Arkansas Region Groundwater Availability (AFY)

Pumping Level Limitation	Climate Assumption	Baseline	2020	2050
Minimum water elevation equal to half the aquifer thickness in the alluvial aquifer and the top of formation in the confined aquifers	Dry	4,210	2,637	3,642

Water Quality

In the Southwest Arkansas Region, approximately 962 miles of streams and 44,020 acres of lakes were assessed for water quality by ADEQ in 2008. **Table 6-27** summarizes the extent of waterbodies in the Southwest Arkansas Region that do not support designated uses and use sectors. Notably, 53 percent of these streams failed to support agriculture and industrial water supply uses, whereas 50 percent failed to support aquatic life uses. TDS, sulfate, and chloride from unknown sources were identified as causing the majority of the impairments of the agricultural and industrial water supply use. Ninety-four percent of the impaired lake acreage in this region does not support the fish consumption designated use due to mercury levels in some fish species.

Table 6-27. Impaired Waters in the Southwest Arkansas Region in 2008 (ADEQ 2009)[1]

Designated Use Not Supported	Water Use Sector Impacted	Miles of Assessed Streams	Acres of Assessed Lakes
Aquatic life	Fish and wildlife	247.1	300
Fish consumption	Recreation	50.6	2950
Primary contact recreation	Recreation	40.1	0
Secondary contact recreation	Recreation	0	0
Domestic water supply	Drinking water	28.7	0
Agricultural and industrial water supply	Agricultural and/or industrial	262.7	0
Total impaired		**492.1**	**3,150**

[1] ADEQ, Integrated Water Quality Monitoring and Assessment Report 2008 Pursuant to Sections 305(b) and 303(d) of the Federal Water Pollution Control Act. ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY WQ08-04-01 (2009).

Excess nutrients from livestock production (poultry and cattle) are believed to be the primary NPS issue for this region. There are no current NPS pollution priority watersheds within this region.

Groundwater quality in the Southwest Arkansas Region is very similar to the South-central Arkansas Region water quality. Groundwater quality in the Ouachita Mountains aquifer is good with respect to federal primary drinking water standards. Problems in regard to taste, staining, and other aesthetic properties are related to elevated levels of iron, which is a common complaint among domestic users.

The quality of groundwater from the Sparta aquifer throughout the state is very good; however, the Southwest Arkansas Region is located in the outcrop area of the Sparta aquifer and there is elevated iron and nitrate groundwater concentrations in that area. Areas of high salinity are noted in isolated areas of the Sparta aquifer, predominantly as a result of inferred upwelling from high-salinity groundwater in underlying formations.

Projected Demand

Water demand in the Southwest Arkansas Region is projected to decrease from approximately 225,000 AFY to just over 217,000 AFY in 2050, a decrease of 3 percent. The current split between groundwater and surface water sources is 35 percent and 65 percent, respectively. In 2050, the Southwest Arkansas Region is projected to contain 2 percent of the statewide water demand. **Figure 6-18** and **Table 6-28** show the projected water demand change over time for all demand sectors combined and also for noncrop irrigation demand sectors only.

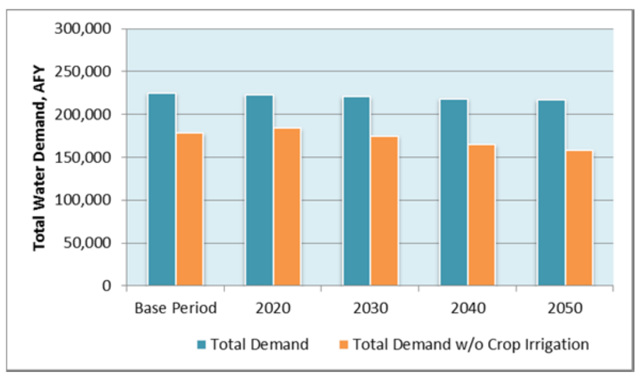


Figure 6-18. Southwest Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals

Table 6-28. Southwest Arkansas Region Water Demand by Region, including Thermoelectric Power Withdrawals (AFY)

With or Without Crop Irrigation?	Base Period	2020	2030	2040	2050
With Crop Irrigation	225,120	222,880	220,640	218,400	217,280
Without Crop Irrigation	178,080	183,680	174,720	164,640	157,920

Supply and Infrastructure Gaps

A summary of demand, supply availability, and the groundwater gap are presented in **Figure 6-19**. Figure 6-19 highlights that while the groundwater gap is projected to be just over 70,000 AF in 2050, there is more than enough excess surface water and total available surface water from the rivers that flow through the Southwest Region to fill the gap. Unlike other planning regions whose major basins intersect other planning regions on a moderate to significant level, the Southwest Arkansas Region is largely coincident with the Red River major basin. As a result the surface water availability shown in Figure 6-19 is, more or less, solely within the Southwest Arkansas Region (not considering the potential for transbasin diversions to other planning regions). **Table 6-29** shows the combined source surplus assuming the respective surface water resources are fully developed. The combined source surplus shown in Table 6-29 highlights that under dry climatic conditions and sustainably pumped groundwater, that if all available excess surface water were utilized, a total combined source surplus of over 1.1 million AFY would exist for the Red River Basin. If groundwater augmentation is not limited to excess surface water, but instead if all total available surface water is developed, the combined source surplus would increase to more than 4.8 million AFY.

The infrastructure gap in the Southwest Arkansas Region was also assessed. A total of 56 water providers are located in the Southwest Arkansas Region. The projected water infrastructure gap for the Southwest Arkansas Region is estimated to be approximately $390 million, or approximately 7 percent of the identified total state infrastructure need. The Southwest Arkansas Region had 56 surveys submitted, which represents 39 percent of water providers in the region.

Table 6-29. Southwest Arkansas Region Summary of 2050 Supply Gap by Major Basin Assuming Sustainable Pumping Under Dry Climatic Conditions

Major Basin Name	Major Basin Area (sq. mi.)	Major Basin Area within Planning Region (sq. mi.)	Groundwater Supply Gap (AFY)	Groundwater Source Supply Gap w/Excess Surface Water (AFY)	Combined Source Supply Gap w/Total Available Surface Water (AFY)
Red River	4,440	4,439	(70,115)	1,151,551	4,816,548

[1] The Upper and Lower basins are hydrologically connected. Because of this the lower basin's excess surface water and total available surface water also includes the upper basin's excess surface water and total available surface water. To be consistent, groundwater gaps for both the upper and lower basins are also included in the lower basins total. See Gap Analysis Report (Appendix F) for detailed description of methodology.

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2050 Total Regional Demand	217,280	AFY
2050 Regional GW Availability[1]	3,642	AFY
2050 Regional GW Gap[2, 3]	(70,219)	AFY
2050 Major Basin GW Gap[3, 4]	(70,115)	AFY
Excess Surface Water[5]	1,221,666	AFY
Total Available Surface Water[5]	4,866,664	AFY

(1) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area.

(2) Based on dry climatic conditions and sustainably pumped aquifers for areas within MERAS model area, otherwise gap was estimated to equal projected growth in groundwater demand

(3) In addition to regional GW gaps, major basin GW gaps were also utilized that include some areas outside of the region. This was done to be consistent with the hydrologic spatial unit used for Excess Surface Water, Total Available Surface Water, and associated combined source gaps.

(4) Sum of groundwater gaps within major basins that intersect planning region, including areas outside of region.

(5) Based on hydrologic analysis of major basins. See AWP Gap Analysis (Appendix F) for detailed description of methodology.

Figure 6-19. Southwest Arkansas Region Regional Watershed Statistics

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